A systematic review and thematic synthesis of the barriers and facilitators to physical activity for women after Gestational Diabetes: A socio-ecological approach.

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A systematic review and thematic synthesis of the barriers and facilitators to physical activity for women after Gestational Diabetes: A socio-ecological approach.

Socio-ecological barriers and facilitators to physical activity after Gestational Diabetes

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Abstract

Physical activity can reduce risk of Type 2 Diabetes after Gestational Diabetes. Understanding barriers and facilitators to physical activity, using a socio-ecological approach, could better direct multi-level interventions. The present review aimed to synthesise barriers and facilitators to physical activity, and develop an understanding of where, across the socio ecological model, these factors exist and/or are interrelated. Eligible studies included women with a history of Gestational Diabetes and a discussion around physical activity. A systematic search of MEDLINE, Cochrane Library, Web of Science, CINAHL Complete, and Scopus was conducted in October 2022. Barriers and facilitators to physical activity were thematically analysed and themes organised according to the socio-ecological model. Twenty-nine studies were included. Barriers pertained to leisure time physical activity, while other modes of activity including housework and transport were overlooked, despite being routine. Partner and familial support were vital for engagement with activity, either due to emotional support, or provision of childcare. Most barriers and facilitators at the social and organisational levels were interrelated with those at the individual level. These findings suggest that multi-level physical activity interventions after Gestational Diabetes could be most effective.

Key Words

Physical activity, Gestational Diabetes, Socio-Ecological Model, Type 2 Diabetes, Barriers, Facilitators, Women's health, Maternal health

Key Messages

1) Barriers to physical activity after Gestational Diabetes are wide ranging and not all within an individual's power to change or control.
2) Barriers were focused on leisure physical activity, whereas other domains of activity, such as active transport, were discussed from more achievable and manageable perspectives.

3) Many barriers to physical activity are not specific to having previous Gestational Diabetes and overlap with postnatal barriers to activity.

Abbreviations and acronyms

GDM, Gestational Diabetes Mellitus; IDF, International Diabetes Federation; T2DM, Type 2 Diabetes Mellitus; PA, Physical Activity

Introduction

Gestational Diabetes Mellitus (GDM) occurs during pregnancy, and its prevalence has been steadily increasing, with the IDF reporting a prevalence of 20.6% in the UK in 2021 [1]. A GDM diagnosis increases risk of several long term complications, including increasing the risk of subsequent Type 2 Diabetes Mellitus (T2DM) ten-fold [3,4]. Preventing T2DM after GDM is a clinical priority [5].

Lifestyle changes including diet and physical activity (PA) can reduce risk of T2DM by up to 50% [6–8], including after GDM [9,10]. Therefore, the National Institute for Health and Care Excellence (NICE) recommends promoting healthy lifestyle behaviours after a GDM [9]. In the UK women with previous GDM can access the "Healthier You" National Diabetes Prevention Program. However, this program was designed for the general population, who may not face the unique barriers present for women with young families, like familial commitments, lack of childcare and other responsibilities [10,11]. This could in part explain why people who do engage with these lifestyle programs tend to be over the age of 65 [12] and why GDM participation in prevention interventions is variable [13]. Overcoming engagement barriers to lifestyle changes in this population is therefore important for lasting behaviour change and subsequent T2DM risk management.

The barriers to participation and engaging with PA after GDM may not solely be within an individual's capability to control. The Socio-Ecological Model (SEM) can be used to aid understanding of interrelationships between individuals and factors associated with their surrounding environments, such as social, physical and policy [14]. Viewing barriers and facilitators to PA with an SEM lens could therefore improve understanding of the cultural, social and other contextual factors impacting PA for women after GDM [15,16]. Peng *et al.* used the SEM to explore barriers and facilitators to PA for young adult women and highlighted the wider socio-cultural influences on PA and the need for including multi-level strategies to target women's PA [17]. For example, at wider levels, such as the interpersonal levels, family support was 'crucial' to engaging with PA, while family commitments were the most significant barrier to PA for young adult women. It is therefore important to explore if there are any differences or similarities in the wider barriers and facilitators to PA for women after GDM, to better tailor multi-level strategies aiming to improve PA after GDM.

The most recent, and only, review looking at barriers and facilitators to lifestyle changes postpartum was published in 2019 by Dennison *et al.,* [11]. However, the barriers and facilitators to PA may differ in comparison to those of other lifestyle changes such as diet, due to PA being considered as less important or time constraints limiting PA more [18,19]. Buelo *et al.,* explored PA specific barriers and facilitators as part of a mixed methods review, where the qualitative component organised themes according to Dahlgren and Whitehead's determinants of health model [20]. However, the Dahlgren-Whitehead model was designed to explore impacts on health, while the SEM highlights the interrelated systems surrounding and influencing individual behaviour, and therefore provides the structure for a deeper dive into the wider contexts affecting PA. Therefore, the present review aimed to update these reviews, using a socio-ecological lens, to explore the barriers and facilitators to PA for women after GDM.

Methods

Five databases (MEDLINE, CINAHL, Scopus, Web of Science and Cochrane) and reference lists were searched in October 2022. Three main search themes (combined with 'AND') were constructed with the phenomenon of interest (physical activity and T2DM prevention as two separate themes) and sample (women with a history of GDM). Within these themes, Mesh and search terms were combined with 'OR'. Terms were developed from other reviews of barriers and facilitators [18] and lifestyle interventions after GDM [23–26].

Table 1 summarises the inclusion criteria. The SPIDER tool was used to determine eligibility [27]. While studies did not exclusively explore PA postpartum, PA discussions had to be reported in the results, either as part of a lifestyle intervention or general attitudes for lifestyle changes. Title and abstracts were screened by the first author (EI), with a second round of screening at full-text. A second reviewer (HH) independently processed a random 10% sample of papers at each stage. Disagreements were resolved by discussion. EI used the Critical Appraisal Skills Programmes (CASP) checklist for qualitative research as a quality assessment tool for the studies included in the present review, with a sample discussed with a second reviewer (HH) [28].

Table 1 Summary of Inclusion Criteria

Inclusion Criteria	**Include**	**Exclude**
Sample	Women with a history of GDM.	Women with current/previous T1DM or T2DM or for GDM prevention (versus AFTER)
Phenomenon of Interest	PA as a lifestyle change after GDM to prevent T2DM.	Screening for T2DM, or specific dietary barriers.
Design	Interview or focus groups.	Surveys or questionnaires.
Evaluation	Experiences, attitudes, feelings, barriers, and facilitators.	-
Research Type	Qualitative or mixed method.	Quantitative.

Table provides a summary for the eligibility criteria of the present review. Each inclusion criteria was separated by the review questions being addressed. GDM, Gestational Diabetes Mellitus; T1DM, Type 1 Diabetes Mellitus; T2DM, Type 2 Diabetes Mellitus; PA, Physical Activity.

A reflexive thematic analysis was employed, where multiple coders aided reflexivity in interpretations and sense-making from themes [29]. Open coding was used inductively, and data was extracted as reported results or participant quotes. Descriptive themes were then organised according to the Socio-ecological Model [15]. Themes were grouped into respective levels depending on where they were actionable. This helped view barriers and facilitators in the lens of wider contexts, their influences on individual behaviour [14] and enabled identification of relationships between themes (interrelationships) i.e. where themes appeared to act across more than one level. Nvivo 12 was utilised by the research team to aid the process of thematic analysis, as the team were all familiar with the software and were able to share the files so all authors could access and review the data and coding.

Results

Twenty-nine studies were included (Figure 1). At title and abstract stage, 3603 records were screened and 63 progressed to full-text screening. Articles were excluded if participants were pregnant (n=6), if the studies did not include PA (n=11), if they were quantitative or review papers (n=12).

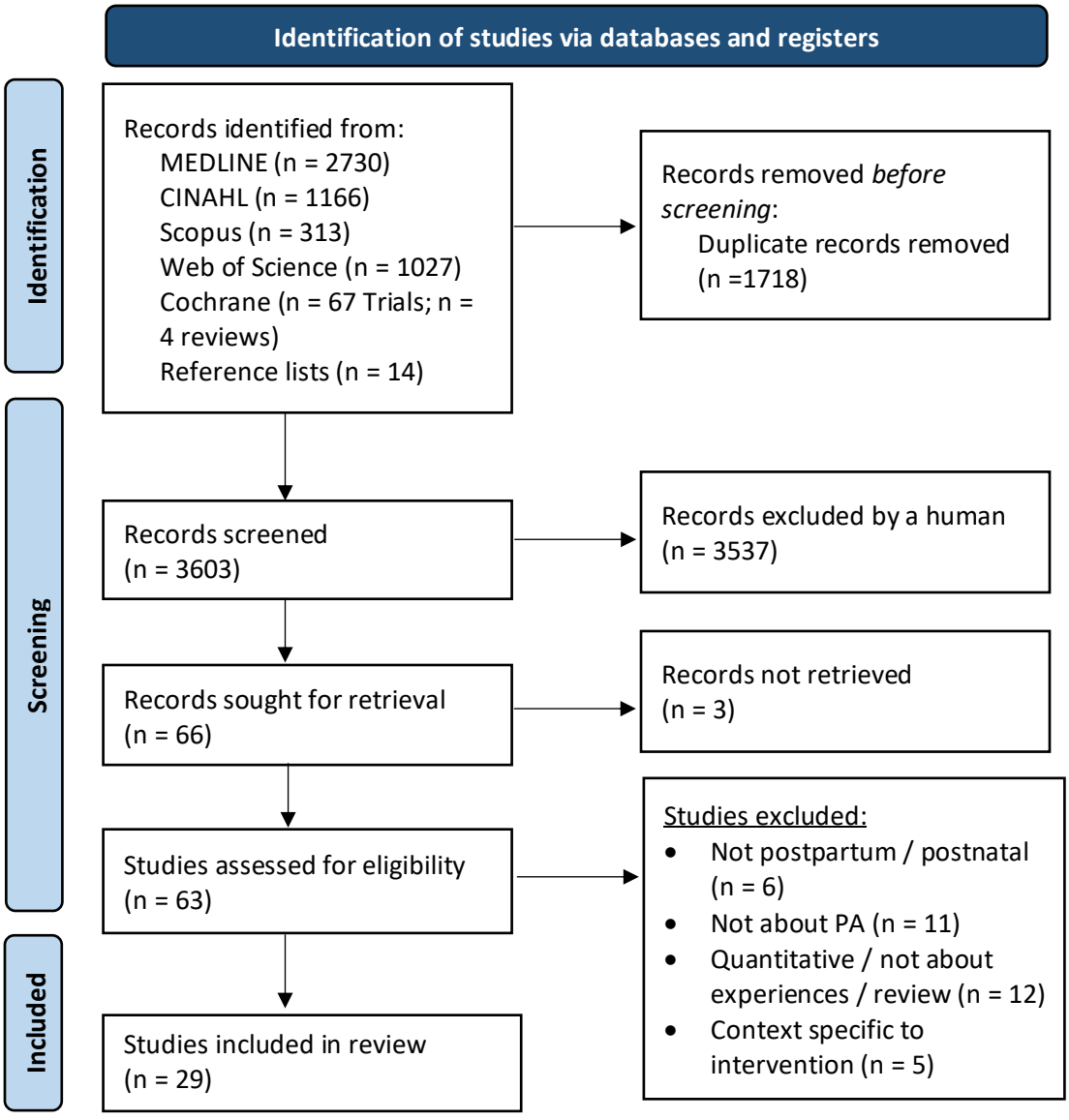

Figure 1 PRISMA 2020 flow diagram for systematic reviews which include searches of databases. From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Since the reviews published by Dennison *et al.* and Buelo *et al.* in 2019 [11,20], nine new papers were identified. A summary of the study characteristics is presented in Table 2. All but four studies

had a CASP study quality rating greater than or including seven (n=25). The lowest quality rating of six was given to two separate studies.

Seven core themes were constructed from the data. Two at the intrapersonal (capability and motivation), three at the social (influence of family, socialising while exercising, support) and four at the organisational level (access, opportunity, healthcare, type of exercise). Table 3 provides an overview of papers contributing to each theme. A summary of main themes and example quotes are displayed in Figures 2 and 3.

Intrapersonal

Capability referred to whether women felt able to engage with PA. Where PA felt achievable and women were confident, this was facilitative. Motivation related to the desire to engage with PA. While most women were aware of the benefits, they highlighted this was not sufficient to overcome other barriers. One sub-theme to emerge under motivation was a weight focus which, in the short-term was motivating, but was debilitative for longer-term, sustainable engagement with PA.

Social

Influence of family was wide-ranging and referred to any effects the family had on PA. For example, commitments and having children were barriers, while role modelling and being well enough to look after children facilitated PA. The presence of support e.g., from families, friends, and partners, was facilitative of PA, while a lack of support was a barrier. Partner support was highlighted as vital for engagement with PA. Taking part in PA with other people was also a facilitator to activity.

Organisational

Availability of opportunities, either local resources or provision of activities facilitated PA, while barriers included cost of activities, safety, lack of childcare and other competing demands on time available. Leisure PA was the focus, despite the emphasis of a general lack of time or inability to undertake leisure PA. However, participation in activities of daily living, such as domestic (chores, housework) or active travel (walking for transport), were acknowledged as easier to undertake and were prioritised.

Community

Support groups, access to resources or sharing responsibilities within a community of people was helpful for creating opportunities for PA. Inhibitive social or cultural norms were barriers to PA.

Interrelationships between themes

Participant quotes and reported results demonstrated links between every level of the SEM. These interrelationships, highlighted through links between themes and sub-themes, are summarised in Figure 4.

161 *Table 2. Summary of included study characteristics.*

Author	Date	Title	Total #	Country	Study Aims	Study Design	Timing	Analysis	CASP
Bandyopadhyay et al.,	2011	Lived experience of GDM mellitus among immigrant South Asian women in Australia	17	Australia	Explore understanding of T2DM risk, risk reduction, management strategies, and attitudes and behaviour (after GDM)	Interviews (face-to-face) in-depth	2 time points: following GDM diagnosis, 6 wks PP.	Thematic analysis - commonalities + divergent + inter-relationship of themes	7
Boyd et al.,	2020	Utility of the COM-B model in identifying facilitators and barriers to maintaining a healthy postnatal lifestyle following a diagnosis of GDM: a qualitative study	27	UK	Explored the use of COM- B framework to code and the socioecological model to contextualise participant responses to better inform intervention development	Semi structured interviews	6 + 12 wks PP	Thematic analysis coded using the COM-B framework.	8
Dasgupta et al.,	2013	Strategies to optimize participation in diabetes prevention programs following GDM: A focus group study.	29	Canada	To identify factors that could enhance participation and engagement in a T2DM prevention program	Focus groups	Within 5 yrs of GDM	Qualitative content analysis	7
Dennison et al.,	2022	Post-GDM support would be really good for mothers": A qualitative interview study exploring how to support a healthy diet and PA after GDM	20	UK	Exploring views of women with history of GDM on possible interventions to support healthy diet and PA to reduce diabetes risk, + own suggestions to identify promising interventions for future development	1-to-1 Semi-structured interview + suggestion cards	12wks to 4yrs PP	Framework + Participants' collective response to each suggestion card	9
Doran	2008	GDM mellitus: perspectives on lifestyle changes during pregnancy and post-partum, PA and	8	Australia	Explore factors that hinder + support women to engage in PA PP to reduce risk of developing future T2DM	Results of GDM survey + subset of interviews	6 - 12 mo PP	Thematic analysis	6.5

		the prevention of future type 2 diabetes							
Doran & Davis	2010	GDM mellitus in Tonga: insights from healthcare professionals and women who experienced GDM mellitus	11	Australia	To gain contextual insights from Tongan healthcare professionals and women who had developed GDM	Semi-structured interviews (face-to-face)	GDM in previous 12 mo	Thematic analysis	6
Evans et al.,	2010	Health behaviours of PP women with a history of GDM	16	Canada	Determine perceived health status and experiences in establishing and maintaining healthy lifestyle changes	Interviews (semi-structured)	Interview4x PP (@ 6 wks, 3, 6 & 12 mo)	Descriptive interpretative analytic approach + concurrent mixed method (convergence of quantitative and qualitative data)	7.5
Gaudreau & Michaud	2012	Cultural factors related to the maintenance of health behaviours in Algonquin women with a history of GDM	15	Canada	To understand cultural factors contributing to maintenance of health behaviours encouraged during GDM pregnancy	Observation (cultural immersion, detailed observations recorded into logbooks) + semi-structured interviews with key + general informants	GDM within 2-10 yrs	Analysed observations in 4 phases, vertical analysis of interviews, horizontal analysis of patterns and context, themes confirmed with informants	7.5
Graco et al.,	2009	Participation in PA: perceptions of women with a previous history of GDM mellitus.	10	Australia	Explore perceptions of PA among women with previous GDM, in context of T2DM prevention	Semi-structured interviews	*Not reported*	Modified grounded theory approach + thematic analysis.	8
Hjelm et al.,	2012	GDM: Prospective interview-study of the	14	Sweden	Explore development over time of beliefs about health,	Semi-structured	3 time points: wks 34–38	The sequential interpretation	9

		developing beliefs about health, illness and health care in migrant women.			illness and health care in migrant women with GDM + study influence on self-care and care seeking	interviews (face-to-face) [qualitative prospective exploratory study]	gestation+ 3, 14 mo PP	technique, interpreting word for word, was used.	
Ingol et al.,	2020	Perceived Barriers to T2DM Prevention for Low-Income Women With a History of GDM: A Qualitative Secondary Data Analysis	12 FG (n= 5-7)	USA	Examine perceived barriers to adoption of lifestyle changes for T2DM prevention among a diverse group of low-income women with a history of GDM	Focus groups (semi-structured)	GDM in the past 10 yrs	Secondary data analysis (iterative content analysis to identify key themes)	7
Jones et al.,	2012	Cardiometabolic risk, knowledge, risk perception, and self-efficacy among American Indian women with previous GDM	17	USA	Describe knowledge, perceptions and self-efficacy beliefs related to preventing cardiometabolic disease	Interviews (not specified) [Mixed methods, cross-sectional, exploratory, descriptive]	History of GDM	Content analysis. Latent content interpreted in final step from 4 major categories into 1 overarching theme	7
Jones et al.,	2015	Identifying PP intervention approaches to reduce cardiometabolic risk among American Indian women with prior GDM, Oklahoma, 2012-2013	26	USA	Elicit perspectives on cardiometabolic risk reduction behaviours to inform the development of a PP lifestyle modification intervention	Interviews (face-to-face, telephone) + focus groups	GDM within 10 yrs	Inductive content analysis to identify codes + overarching themes	7
Krompa et al.,	2020	PP lifestyle modifications for women with GDM: A qualitative study	16	France	Describe + aanalyse feelings and daily lifestyle changes, including PA, among women who experienced GDM + evaluate how GDM diagnosis was followed by lifestyle modifications	Semi-structured interview	6-12 mo PP	Thematic analysis (open coding) following theory of planned behaviour	6

					during the PP period, to prevent T2DM.				
Lie et al.,	2013	Preventing T2DM after GDM: women's experiences and implications for diabetes prevention interventions	phase 1: n=31 phase 2: n=14	UK	Explore factors influencing post-natal health behaviours after GDM + elicit views about feasibility of lifestyle intervention to prevent T2DM 2 yrs after childbirth	Two phases semi-structured interviews: purposive sampling, then theoretical sampling 12-18mo later	Within 2 yrs of GDM	Framework + structured comparative analysis of textual data (directed content analysis)	8
Lim et al.,	2017	Comparing a telephone- and a group-delivered diabetes prevention program: Characteristics of engaged and non-engaged PP mothers with a history of GDM	N=165 Group n= 136 Phone n=29	Australia	To explore the acceptability of a diabetes prevention programme and compare the characteristics associated with programme engagement	Semi-structured interviews (face-to-face and telephone)	Group (3mo + 6 mo PP) Phone (6 mo PP)	Thematically analysed using open coding, processed iteratively using spreadsheets + mind-maps Subthemes categorized based on the Health Action Process	8
Lindmark et al.,	2010	Perception of healthy lifestyle information in women with GDM: A pilot study before and after delivery.	10	Sweden	Investigate how women with GDM perceived information; explore opinions on healthcare provision up to 1yr after delivery; investigate perceptions about lifestyle 1yr after delivery.	Structured Interviews (face-to-face)	1yr after GDM	Text divided into meaning units, condensed then coded. Codes with similar meanings put into categories.	7.5
Muhwava et al.,	2019	Experiences of lifestyle change among women with GDM: A behavioural diagnosis using the COM-B	35	South Africa	To explore women's lived experiences of GDM and the feasibility of sustained lifestyle modification after GDM in a low-income setting	Focus group + interviews	Had GDM 2014-2015	Qualitative content analysis + COM-B model (inductive + deductive)	8.5

		model in a low-income setting							
Nicklas et al.,	2011	Identifying PP intervention approaches to prevent type 2 diabetes in women with a history of GDM	25	USA	Identify barriers and facilitators to healthy lifestyle changes, and approaches to facilitate participation in interventions	Interviews (telephone) + focus groups	GDM within previous 7 yrs	Using grounded theory, open coding to identify themes. For the informant interviews, data analysis consisted of frequency distributions.	8.5
O'Dea et al.,	2015	Can the onset of T2DM be delayed by a group-based lifestyle intervention in women with prediabetes following GDM? Findings from a randomized control mixed methods trial	17	Ireland	Evaluate a 12-week group-based lifestyle intervention programme for women with prediabetes following GDM (give context to quantitative findings)	Semi-structured interviews (face-to-face)	1-3 yrs after GDM	Thematically analysed using inductive approach	7.5
Pace et al.,	2020	Preventing diabetes after pregnancy with GDM in a Cree community: an inductive thematic analysis	13	Canada	Aimed to understand the perspectives of Cree women with prior GDM living in northern Quebec	Semi structured interviews	GDM in previous 5 yrs (2013–2019)	Inductive thematic analysis framework	7.5
Parsons et al.,	2019	A qualitative study exploring women's health behaviours after a pregnancy with GDM to inform the development of a diabetes prevention strategy	50	UK	Inform interventions for women with GDM by exploring factors that influence health behaviours and preferences for lifestyle support.	Focus groups + semi-structured interviews	Within 5 yrs of GDM	Framework (themes derived iteratively from data)	8.5

Razee et al.,	2010	Beliefs, barriers, social support, and environmental influences related to diabetes risk behaviours among women with a history of GDM.	57	Australia	Explore beliefs, attitudes, social support, environmental influences etc. on diabetes risk behaviours; preferred forms of programme delivery to inform health promotion	Semi-structured telephone interviews	GDM 6–36 mo	Coding data by general themes - open-ended then checked against pre constructed codes, then developed into broad themes using constant comparison	8.5
Shang et al.,	2021	Chinese women's attitudes towards PP interventions to prevent type 2 diabetes after GDM: a semi-structured qualitative study	20	China	Explore Chinese women's perspectives, concerns and motivations towards participation in early PP interventions and/or research to prevent the development of T2DM after a GDM- affected pregnancy	Face-to-face semi-structured interviews + focus groups	Within 6 mo PP	Inductive thematic analysis	6.5
Sharma et al.,	2021	Understanding mechanisms behind unwanted health behaviours in Nordic and South Asian women and how they affect their GDM follow-ups: A qualitative study	28	Norway	Aimed to advance the knowledge regarding the mechanisms behind suboptimal follow- up in the Nordic and South Asian women with previous GDM	Focus group interviews	GDM within 1– 3 yrs	Thematic analysis, quotes to support inspired by Lipsky's theory of street-level bureaucracy focusing on mechanisms behind unwanted health behaviours	7
Svensson et al.,	2017	What is the PP experience of Danish women following GDM? A qualitative exploration.	5	Denmark	To examine the experience of transition from a GDM-affected pregnancy to PP	Semi-structured interviews (face-to-face)	3-5 mo after delivery	Qualitative content analysis (inductively) sorted into themes	8.5
Tang et al.,	2015	Perspectives on prevention of type 2 diabetes after GDM: a qualitative study of Hispanic, African	23	USA	Explore T2DM risk perception and motivators and barriers to preventive health behaviours, to inform intervention approaches	Semi-structured interviews (face-to-face)	Within 12 mo PP	Template analysis (health belief model) to code and organize themes	8

		American and White women.							
Tierney et al.,	2015	Factors influencing lifestyle behaviours during and after a GDM mellitus pregnancy	13	Ireland	Examined the healthy lifestyle behaviours undertaken during and after a pregnancy complicated by GDM and the factors that influenced the likelihood of undertaking of such behaviours.	Semi-structured telephone interviews	GDM in the previous 3–7 yrs	Thematic analysis driven by clinical + theoretical interests (semantic approach)	7.5
Zulfiqar et al.,	2017	Barriers to a healthy lifestyle post GDM: An Australian qualitative study.	23	Australia	Experiences, barriers and facilitators of women trying to follow the health advice they received during pregnancy to maintain a healthy lifestyle more than 3yrs after childbirth	Interviews (face-to-face)	3+ yrs after childbirth	Thematic analysis (inductive + deductive coding)	7.5

#, number; IMD / SES, Index Multiple Deprivation / Socio-Economic Status; yrs, years; MSc, Master's Degree; PG, post graduate; IT, information technology; FG, Focus Groups; Uni, university level education; BSc, Bachelor's degree; HE Higher Education; T(#), Tertial; primip, primiparous; multip, multiparous; IMD; index multiple deprivation rank.

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Table 3 Visual representation of theme appearance across included papers

	Intrapersonal					Social				Organisational						Community
	capability		motivation			influence fam	socialising	support		access		health care	opportunity		type ex	support groups
Author (date)	capacity	challenge	knowledge & info	monitoring	weight focus			fam	partner	cost	safety		child care	time		
Bandyopahdyay (2011)	X	X	X		X				X					X	X	
Boyd (2020)	X	X	X	X		X	X	X	X	X		X	X	X	X	X
Dasgupta (2013)	X	X	X	X		X	X	X	X			X	X	X	X	X
Dennison (2022)	X		X	X		X	X	X	X			X		X		X
Doran (2008)		X	X		X	X	X	X	X	X		X	X	X	X	X
Doran (2010)		X	X		X			X				X				
Evans (2010)	X	X	X		X			X		X		X	X	X		
Gaudreau (2012)			X		X		X	X	X			X			X	
Graco (2009)			X		X		X	X		X		X	X	X	X	X
Hjelm (2012)		X	X			X						X	X	X	X	
Ingol (2020)			X				X	X	X	X		X	X	X	X	X
Jones (2012)		X	X													
Jones (2015)	X	X	X		X	X			X	X				X		X
Krompa (2020)	X	X	X		X	X			X					X	X	
Lie (2013)	X		X		X	X		X	X			X	X		X	X
Lim (2017)			X			X			X				X	X		X
Lindmark (2010)		X	X		X							X				X
Muhwava (2019)	X		X		X	X				X	X	X	X	X	X	X
Nicklas (2011)	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
O'Dea (2015)	X	X	X		X				X				X	X		
Pace (2020)			X	X		X		X	X	X		X	X	X	X	X
Parsons (2019)	X	X	X			X				X	X	X	X	X		X
Razee (2010)	X		X										X	X	X	
Shang (2021)		X	X		X							X	X	X		
Sharma (2021)		X	X			X			X	X		X	X	X	X	X
Svensson (2017)	X	X			X	X			X	X		X	X	X		
Tang (2015)			X		X	X						X	X	X	X	
Tierney (2015)			X			X						X	X	X	X	X
Zulfiqar (2017)			X		X			X	X			X		X		

FACILITATORS:

"Everyone has kids at home… maybe something that gives like, let's say every second day half an hour that I could do [PA] even if my kids are around if it's in your house"

"I'm telling you, if I walk with the group here, if there's another large person like me, then I'm going to go."

"We have a community exercise programme in a local hall, so, I started exercising."

"They could get some classes up and running, maybe a walking group. I suppose then if they've got little ones in prams, they could take them along with them"

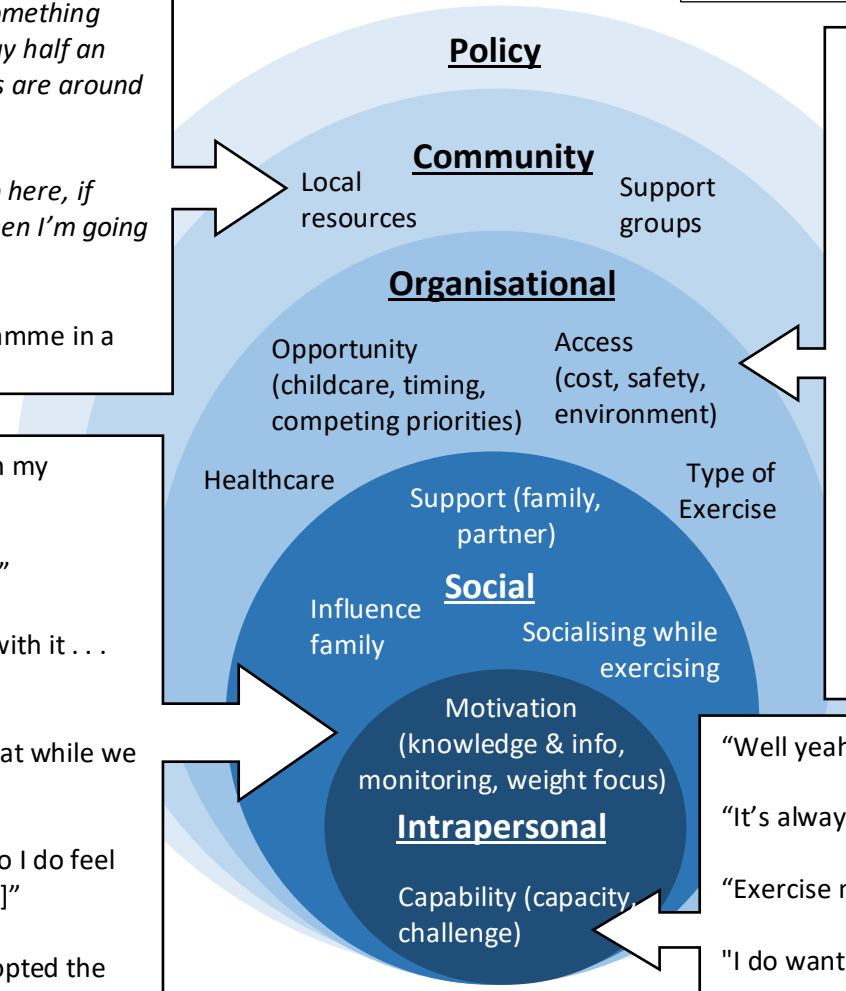
"I take me son to nursery every morning. I walk there and walk back. I go shopping sometimes. I walk to shops"

"I like the idea of a lifestyle coach because it seems more like a partner than someone who will talk down to you. With a coach you are a client, whereas with a doctor you are a patient."

"(Onsite childcare) would be really helpful"

"Something that is flexible, that I could do whenever I liked"

"There's a centre, where they give gym to the ladies that stay at home, every Thursday morning… council pays her"



"Someone there to keep regular checks on my progress - keeping me on track"

"If I had any questions, I'd go to my family"

"My husband is great . . . we're the team with it . . . we support each other."

"I go walking with a friend. We talk and chat while we walk… sometimes I go with my boyfriend"

"We play ball, we ride bikes together . . . so I do feel like I've taken some steps [as a role model]"

"… would be easier if the whole family adopted the changes"

"Well yeah, for weight control, and things like that… "

"It's always nice to see... you've been achieving... spurs you on."

"Exercise makes you feel healthier"

"I do want another baby. That's why I'm looking after myself. I go to gym every Thursday."

"Well, personally, because if I'm not active then I find I don't cope as well with things"

Figure 2 Overview of the themes and subthemes appearing at each level, with some representative quotes of analogous facilitators at each level of an adapted SEM (from McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. Health Educ Q 1988,

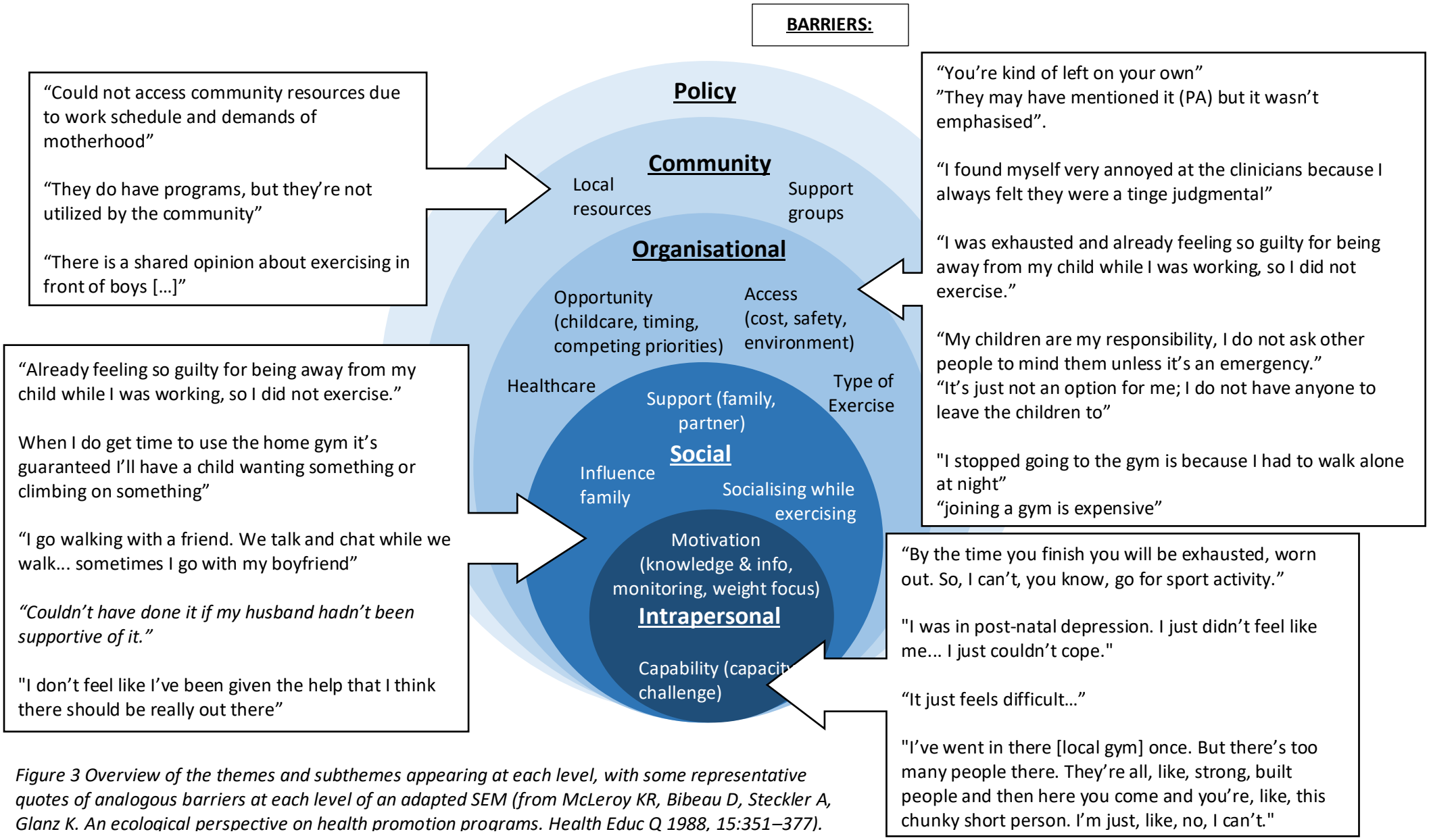


Figure 3 Overview of the themes and subthemes appearing at each level, with some representative quotes of analogous barriers at each level of an adapted SEM (from McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. Health Educ Q 1988, 15:351–377).

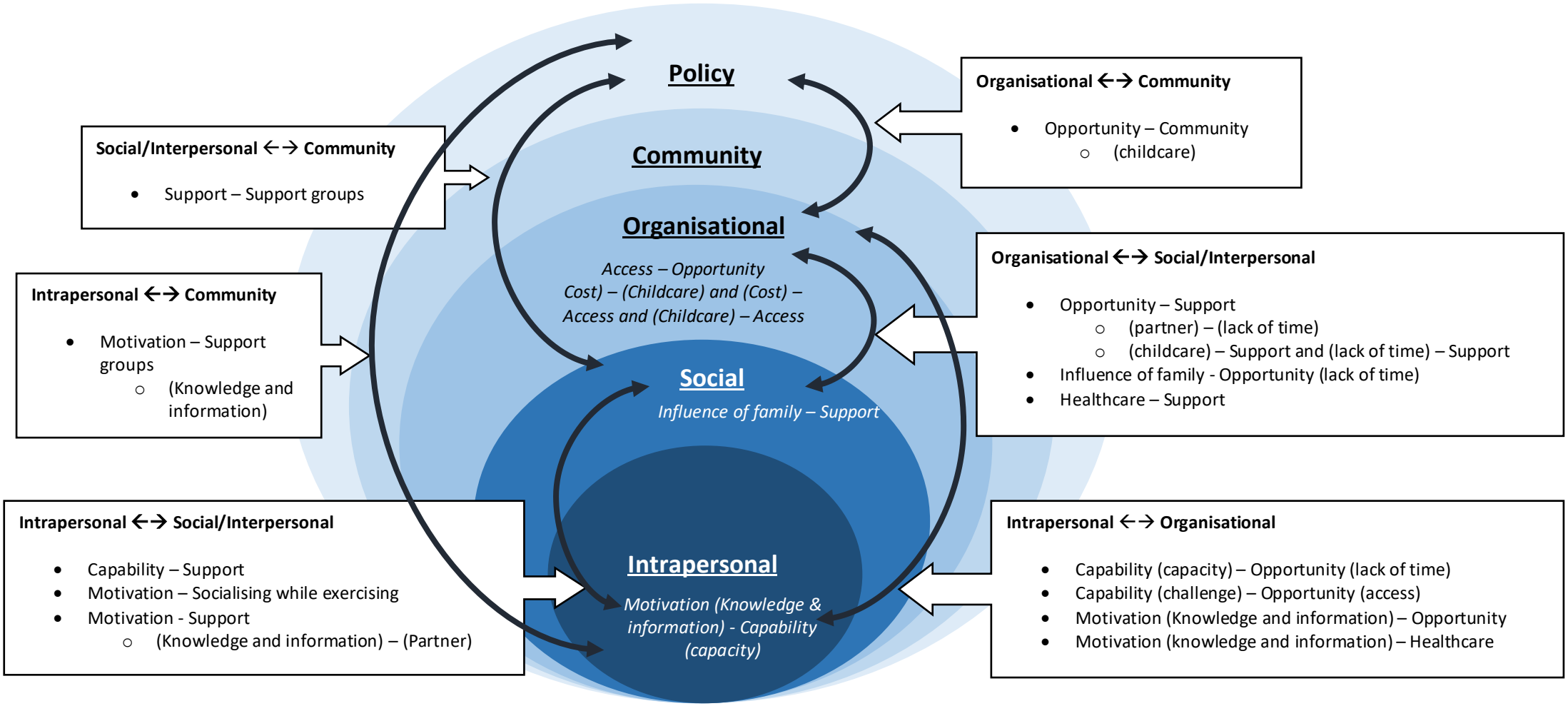


Figure 4 Visual display of the interrelationships identified through the thematic analysis of barriers and facilitators to PA in an adapted SEM (from McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. Health Educ Q 1988, 15:351–377).

Discussion

To the authors knowledge, this is the first review of its kind to classify barriers and facilitators to PA for women with previous GDM according to the SEM. Barriers and facilitators to PA appeared on four levels of the SEM, in addition to interactions within and between these levels, resulting in a complex web of factors that need to be addressed, in combination, for increased PA engagement.

The focus of barriers in the present review was around leisure time purposeful exercise while active transport was identified as achievable and routine [31]. The American Diabetes Association recommends that for populations at high risk of T2DM, at least 150 minutes per week of PA should be undertaken [77]. Active travel could be one such domain of PA encouraged for women after GDM and is still linked to T2DM prevention [78]. Other domains of PA therefore need to be further explored and encouraged, as they may be a more realistic type of PA for women after GDM.

Barriers and facilitators at the social and organisational levels were linked with the interpersonal level, highlighting that behaviour may be compromised by wider barriers [16]. Encouraging individual motivation is not sufficient in the presence of higher-level barriers, therefore targeting system-wide approaches, rather than solely individuals, could be more effective [59]. It is important to consider these wider factors and the subsequent impact on women's ability to undertake PA when planning future PA interventions after GDM. However, findings in young adult women by Peng *et al.,* overlapped with some of the findings in the present review, e.g., accessibility to PA, familial commitments, the physical environment [17]. Defining women by their GDM diagnosis, where women feel abandoned postpartum [33], may not be helpful. Further research is needed to explore how women after GDM define themselves postnatally, and how they may best be targeted or addressed in the context of PA.

At the individual level, themes capability and motivation align well with the COM-B model of behaviour change, which states that individual behaviour change is influenced by opportunity, motivation and capability [60,61]. Within motivation, positioning PA as a method of weight loss was helpful in the short term, but was discouraging for maintaining PA in the long-term [47]. Women with GDM, and general T2DM prevention advice, are recommended to manage their weight [63,64], which could be debilitative for women with unrealistic expectations for their body and weight postpartum [65]. Managing expectations and creating a long-term facilitative PA environment, emphasising broader benefits of PA besides weight-loss, could aid longer-term PA uptake and maintenance. Future interventions should therefore still consider individual tailoring and behaviour change theory, in conjunction with addressing wider barriers to PA.

Familial commitments are a unique and specific barrier to women after GDM compared to the general population at risk of T2DM. Family based interventions can increase PA in children [66], which is important as children of women with GDM are at an increased risk of several metabolic disorders, including insulin resistance, T2DM, hypertension and obesity [67]. PA can help reduce risk of these metabolic disorders in both mothers and their children [68]. Therefore, family-based PA could have multiple benefits across generations. Family-based interventions may also overcome lack of childcare, which was the main organisational barrier identified in the present review. The lack of childcare is a widely cited and known barrier to PA, not solely exclusive to women after GDM, but also true for postpartum women in general [69]. Further research is needed to establish how childcare could be best provided for maximum uptake and helpfulness to enable engaging with PA. The present review identified that childcare was heavily interrelated with the social level of the SEM. For example, childcare as a barrier was overcome with help from family or partner support [42], and was not overcome when partners were busy, or where women did not feel comfortable leaving their children with family for the sake of PA [47,49]. Without partner buy-in, PA uptake and maintenance may not be possible for women after GDM. Therefore, PA interventions should consider targeting couples, including partners to 'tag team', in addition to other forms of childcare, to increase

accessibility of PA for mothers. This is important, as interventions which have addressed childcare when trying to help women be active after GDM could be more successful at increasing PA [70]. Providing childcare opportunities in PA contexts is therefore important, not only for women after GDM but at a wider, systems level, for all (postnatal) women.

At the social level, support was one of the most quoted factors, posing a barrier when not present but a facilitator when present. Partner support and fostering positive PA environments for the whole family was highlighted as instrumental [33,49,71]. When women did not feel supported, they were unable to engage with PA, even if they wanted to. Whereas, when women felt supported, or when they had help from their partner or family, they reported more engagement with PA. Partner support specifically, in agreement with Peng *et al.* was essential in enabling PA [17]. Support was also linked with the concept of non-physical community support [47]. Creating social 'community' and increasing access to PA within communities has been recommended for PA promotion [72]. Community-based interventions could be cost-effective [73] methods to increase PA [74], including for women with previous GDM [70]. Therefore, creating a supportive setting after GDM could partly be achieved by connecting women postpartum. Further research is needed to establish how and what community-based PA intervention could look like, and how it may be implemented for women after GDM.

Strengths and Limitations

The SEM helped frame barriers and facilitators according to wider systems, providing more direction for designing multilevel interventions. To the authors knowledge, it is also the first review of its kind to consider PA after GDM on a wider systems level. However, the contexts of included studies largely varied. Extracted results and conclusions could be specific to these contexts, or not generalisable. Additionally, the results synthesised can only shed light on the topic, and it is important context-specific Patient and Public Involvement (PPI), and/or co-production, is included when tailoring or developing interventions.

Conclusions

Women after GDM consistently face wider-level barriers that are not in their direct control to overcome. Reducing the onus on individual mothers, for example, by addressing organisational level barriers like childcare provision, may be important for long-term PA uptake and maintenance. Supplementing individually targeted interventions with wider multi-level population targets should therefore be the focus for future interventions aiming to increase PA in women after GDM.

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The authors declare that they have no conflicts of interest.

Data Availability
Data sharing is not applicable to this article as no datasets were generated or analysed during the current study. All data used was obtained from published articles.

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