

Integrating psychological support into gestational diabetes self-management: Development of a user-centred digital mindfulness programme

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Abstract

Background: Gestational diabetes mellitus (GDM) presents significant psychological and behavioural challenges, with diagnosis often triggering stress, anxiety, and fear. Despite these burdens, structured psychosocial support remains limited within existing GDM care. Mindfulness-based interventions (MBIs) show promise for reducing distress in perinatal contexts, but few are tailored to the unique needs of individuals with GDM, and digital delivery remains rare. **Objectives:** This study aimed to develop a digitally delivered mindfulness programme tailored to the psychological needs of individuals with GDM using a user-centred, multi-phase design approach. **Design:** A qualitative, multi-phase participatory design study involving needs assessment and co-design workshops, guided by the Obesity-Related Behavioural Intervention Trials (ORBIT) model for behavioural intervention development and Loucks et al.'s evidence-based adaptation framework for Mindfulness-Based Programmes (MBPs). **Methods:** A qualitative needs assessment was conducted through focus groups with individuals with GDM (n=11) and healthcare professionals (n=4) to identify psychological experiences, mental health support, and the feasibility of a digital mindfulness intervention. Findings informed the initial mindfulness programme framework, which was further refined through participatory co-design workshops (n=10) and iterative tailoring of scripts and multimedia content. **Results:** Participants reported high levels of emotional distress following GDM diagnosis, citing a strong desire for brief, flexible, and supportive psychosocial interventions. Co-design feedback highlighted preferences for short audio-guided sessions, soft and calming voice characteristics, and seamless integration into daily routines. The final one-month programme comprised 20 mindfulness exercises, delivered via audio and video for integration within a holistic GDM self-management app. **Conclusion:** A systematically developed, contextually relevant digital mindfulness programme may address critical gaps in GDM care, supporting psychological well-being and self-management.

Plain language summary

Gestational diabetes (GDM) can be stressful and overwhelming, as people are asked to manage blood sugar levels, diet, and medical appointments during pregnancy. Emotional support is not always included as part of routine GDM care, even though stress and anxiety are common and can affect daily self-management. This study describes how a digital mindfulness programme was developed specifically for people with GDM. Mindfulness involves simple practices, such as guided breathing and awareness exercises, that can help people manage stress and feel calmer. Using a user-centred approach, individuals with GDM and healthcare professionals were involved at every stage of development. Their feedback helped shape the content, length, and delivery of the programme to ensure it was practical, supportive, and easy to use during pregnancy. The

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final programme includes short, flexible audio and video mindfulness sessions designed to fit into daily routines without adding extra pressure. This work shows that tailored digital mindfulness programmes are feasible and may help address an important gap in emotional support for people living with gestational diabetes.

Keywords

gestational diabetes mellitus, stress, mindfulness-based interventions, user-centred design, digital mindfulness programme

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1. Introduction

Gestational diabetes mellitus (GDM) is a significant and growing public health concern, affecting approximately 14% of pregnant individuals globally and imposing both immediate and long-term risks for mothers and their offspring.^{1,2} The diagnosis typically occurs between 24–28 weeks of gestation, leaving individuals with a short window to adapt to demanding new routines, including frequent blood glucose monitoring, adherence to strict dietary recommendations, physical activity guidance, medication decisions (insulin/metformin), and regular clinic follow-up.^{3,4} These demands can cause stress and emotional strain, and the diagnosis itself often triggers feelings of shock, guilt, anxiety, and fear of adverse pregnancy outcomes.^{5,6} The global prevalence of anxiety states among individuals with GDM varies substantially, with estimates ranging from approximately 5% to 59%.^{7,8} In this context, stress is not merely psychological. Evidence suggests that stress activates physiological pathways, including cortisol release and insulin resistance, which coupled with intrinsic placental hormone antagonism, can negatively influence glucose levels.⁹ Thus, psychological well-being is not only a mental health concern but may also be an integral component of effective GDM management. However, despite the well-documented prevalence and impact of emotional distress in individuals with GDM, current standards of care remain predominantly focused on biomedical management, nutrition, and glucose monitoring, with limited integration of structured mental health support.¹⁰ Mindfulness-based interventions (MBIs) have emerged as a promising non-pharmacological approach to addressing this psychosocial gap. They encompass structured programmes that incorporate practices such as meditation, breath awareness, and body scanning to promote psychological well-being, enhance emotional regulation, and reduce psychological distress.

In 1979, Jon Kabat-Zinn introduced mindfulness practice to Western medicine through the Mindfulness-Based Stress Reduction (MBSR) programme, which combined structured meditative practices and yoga to relieve chronic pain, cultivate present-moment awareness, and reduce emotional reactivity.¹¹ Another key clinical adaptation, Mindfulness-Based Cognitive Therapy (MBCT), integrates mindfulness techniques with cognitive strategies to prevent depression relapse.¹² Beyond these foundational programmes, a wider range of mindfulness-informed interventions, such as Mindfulness-Integrated Cognitive Behavioural Therapy (MiCBT), Acceptance and Commitment Therapy (ACT), and Dialectical Behaviour Therapy (DBT), are now widely used across clinical settings.¹³ These interventions, delivered through in-person sessions, brief digital practices, self-guided audio exercises, and app-based meditation tools, have further enhanced accessibility and expanded support for diverse populations.

Evidence suggests that MBIs may reduce stress, anxiety, rumination, and emotional reactivity while improving emotional regulation, self-compassion, and coping capacity, outcomes highly relevant to the psychological burden experienced by individuals with GDM.^{14–17} Preliminary evidence also suggests potential benefits for glycaemic control through reduced stress-related reactivity and improved behavioural adherence.¹⁸ However, most MBIs used in perinatal care are generalised, not tailored specifically to the unique behavioural and emotional demands faced by individuals managing glucose levels during pregnancy.^{19,20} Moreover, traditional mindfulness programmes, such as MBSR, require in-person attendance, extended sessions, and group participation, which can be challenging to integrate into already demanding GDM care schedules.

Digital delivery has emerged as a promising strategy for overcoming these barriers while extending access to tailored psychosocial support. Nevertheless, existing GDM apps predominantly focus on glucose monitoring, dietary tracking, and education, often overlooking emotional well-being.^{21,22} On the other hand, at present, no widely available digital intervention integrates structured mindfulness training tailored to the stressors faced by individuals with GDM.^{23,24} Technology-enabled approaches provide an opportunity to scale mindfulness interventions by facilitating home-based practice, personalisation, and integration within broader mHealth ecosystems.^{25,26} Such approaches may be particularly valuable for individuals with GDM, who often receive their diagnosis late in pregnancy and require flexible, accessible support during a limited intervention window.

Collectively, these gaps highlight a compelling need for a tailored digital mindfulness programme that extends beyond generic stress-reduction approaches and directly addresses the psychological demands of living with GDM.²⁷ This is supported by recent advances in mindfulness adaptation, in particular, the model proposed by Loucks et al. underscores the importance of preserving the core “active ingredients” of mindfulness, such as attentional control, interoception, and compassion, while allowing contextual modification of delivery mode, language, and session structure.²⁸ Meanwhile, theoretical models like the Obesity-Related Behavioural Intervention Trials (ORBIT) framework for behavioural intervention development emphasise the necessity of structured, iterative, and stakeholder-engaged design to ensure interventions are both clinically relevant and feasible in real-world settings.²⁹

Building on identified needs, this study aimed to develop a digital mindfulness programme tailored specifically for GDM through a multi-phase, user-centred approach. This includes: (1) a qualitative needs assessment to understand the psychological experiences, stressors, and unmet well-being needs of individuals with GDM; (2) exploration of attitudes towards a tailored, app-based mindfulness programme designed to address these needs; and (3) iterative refinement of programme content, structure, and delivery through co-design workshops with individuals with GDM and the healthcare professionals (HCPs) involved in their care.

The programme was created for integration within a holistic GDM self-management app. While the broader app encompasses monitoring and educational components, the present paper focuses exclusively on the development of the mindfulness programme, its theoretical foundations, adaptation, content creation, and digital implementation. By leveraging advanced multimedia production and app-based delivery, the developed programme aims to maximise accessibility, personalisation, and engagement. This helps address the persistent gap in holistic, contextually relevant psychosocial support in GDM. Overall, this study contributes to advancing digital maternal health and strengthens the emerging evidence base for tailored behavioural and contemplative interventions for GDM in pregnancy.

2. Methods

2.1. Study design overview

This study was a qualitative, multi-phase digital mindfulness intervention development for stress management in GDM conducted between July 2024 and December 2025, encompassing initial needs assessment, participatory co-design, iterative programme refinement, and multimedia content production and delivery. The development process was guided by two complementary theoretical models: (1) Loucks et al.’s²⁸ evidence-based adaptation framework for Mindfulness-Based Programmes (MBPs) and (2) the ORBIT²⁹ model for behavioural intervention development. Loucks et al.’s²⁸ framework recommends (a) establishing the need for adaptation, (b) preserving the core mechanisms of mindfulness (attentional control, interoception, emotion regulation, compassion), (c) evaluating feasibility, and (d) tailoring content to contextual domains such as delivery setting, duration, existing interventions, and cultural/communication needs.

The ORBIT model complements this by providing a structured framework for the iterative development and early-phase evaluation of behavioural interventions.²⁹ The model advocates for a staged approach in which intervention components are systematically developed, refined, and tested with stakeholder input before proceeding to formal efficacy evaluation. In the context of the present study, the ORBIT framework guided the sequential progression from needs identification and programme conceptualisation, through participatory co-design and iterative content refinement, to multimedia production and preparation for pilot evaluation. This staged approach ensured that the mindfulness programme was both theoretically grounded and contextually validated before integration into the broader GDM self-management application.

Inclusion criteria for individuals with GDM included a confirmed diagnosis, age ≥ 18 years, gestational age 28–40 weeks, and proficiency in English. Participants with a history of mental health conditions or individuals with pre-existing diabetes diagnosed prior to pregnancy were excluded. In the Irish antenatal care setting, individuals considered at increased risk of GDM may undergo glucose screening at the initial booking appointment (approximately 8–12 weeks gestation) to facilitate early identification of hyperglycaemia.³⁰ Participants diagnosed before the routine GDM screening period (24–28 weeks gestation) in this study were identified through these early screening pathways and subsequently managed within standard GDM care services. The HCPs were representatives from Endocrinology, Obstetrics, Midwifery, and Dietetics teams, each with more than 3 years of experience in GDM care. All participants were recruited through the antenatal diabetes clinic at Our Lady of Lourdes Hospital, Drogheda. Participants were recruited through posters and verbal information provided by clinic staff, while written participant information leaflets were distributed to eligible individuals.

Purposive sampling was employed to recruit participants with direct experience of GDM management and clinical expertise in GDM care. Participant recruitment involved eligibility screening and voluntary participation, with final sample sizes for the needs assessment ($n = 15$) and co-design workshops ($n = 10$) determined by the principles of information power rather than statistical power, which is appropriate for qualitative and participatory design research. Sample sizes were

considered sufficient when the information obtained was rich, specific to the study aim, and theory-driven, consistent with guidance for qualitative research by Malterud et al.³¹ Formal sample size calculation and power analysis were not conducted, as this study was not designed to detect statistical effects.

Reporting of the study followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines to enhance transparency and completeness in reporting the qualitative components of the study³² (See [Supplementary Material 1](#)).

2.2. Phase 1: Needs assessment

A qualitative needs assessment was conducted to explore the psychosocial experiences, stressors, and digital literacy of individuals with GDM, as well as to assess the perceived usefulness and expected acceptability of a mindfulness-based digital intervention. Data were collected through three focus group discussions (FGDs) two with GDM participants ($n = 11$) and one with HCPs ($n = 4$) involved in their care. The lead researcher (P.G.) is a medical doctor and doctoral researcher with clinical and research experience relevant to GDM and digital health interventions. This background informed the development of topic guides and the facilitation of the FGDs, which were conducted in the antenatal diabetes clinic. Semi-structured guides probed emotional responses to GDM diagnosis, practical and psychological self-management burdens, existing coping strategies, familiarity with mindfulness, and confidence with technology. FGDs were audio-recorded, transcribed verbatim, and thematically analysed to identify core needs and inform the design of the mindfulness programme. The transcripts were not returned to participants for member checking; however, key findings and design decisions were shared and validated during the subsequent co-design workshops.

2.3. Phase 2: Participatory co-design of MBP for GDM

Findings from the needs assessment and Loucks et al.'s²⁸ evidence-based MBP framework directly informed the initial conception and structure of the mindfulness programme. Six submodules were designed around four core content domains: foundations of mindfulness, cognitive/emotional awareness, body-focused practices, and positive emotion cultivation (compassion and gratitude), with an emphasis on integration and long-term self-management.

2.3.1. Script development and content creation (initial drafts)

Sample mindfulness scripts, audio recordings, and videos were developed under each module, reflecting user-identified stressors, emotional experiences, and daily GDM management challenges. To ensure alignment with established digital MBPs, publicly available mindfulness applications (Headspace, Calm, Mindfulness Coach) were reviewed to observe common patterns in session structure, voice characteristics, pacing, and delivery style. No copyrighted or proprietary content was reproduced; rather, insights from this review provided a strong foundation for these sample scripts before co-design refinement.

Two participatory design workshops were conducted with GDM participants ($n=5$) and HCPs ($n=5$) to gather feedback to iteratively refine the content and delivery. The lead researcher (P.G.) facilitated these two workshops. Workshop activities included real-time feedback on script language, session length, voice preferences (gender, pitch, pace), format (audio vs. video), session frequency, and integration into daily routines.

2.3.2. Design outline: Tailored MBP for individuals with GDM

The finalised programme comprised a one-month course of 20 guided mindfulness exercises, logically grouped into six progressive modules: Foundations of Mindfulness for GDM, Understanding and Managing Thoughts & Emotions, Deepening Body Awareness and Stress Regulation, Cultivating Loving-Kindness and Compassion, Gratitude, Reflection and Integration. Each session targeted GDM-specific challenges, such as anxiety over blood glucose readings, dietary pressures, and balancing self-care with family responsibilities.

Traditionally, gold-standard MBIs such as MBSR are delivered over eight weeks, with weekly sessions (2–2.5-hour group sessions) and daily home practice (45 minutes).^{33,34} However, a review of publicly available mindfulness apps reveals a range of programme lengths, with many offering courses from days to several weeks, beginning at 10–20 minutes daily and gradually increasing use. In the context of GDM, the interval between diagnosis (typically at 24–28 weeks of gestation) and delivery is relatively short. Therefore, a one-month duration was selected to maximise feasibility.³⁵ Additionally, the programme was intentionally structured to build habitual mindfulness practice towards the end of the month, supporting participants in developing skills and routines that could be sustained beyond the initial intervention period. Furthermore, based on the identified practical and emotional burdens from our needs assessment, the programme was structured to include five sessions per week (20 exercises per month), rather than daily practice, to ensure the intervention functioned as a daily routine support rather than an additional burden.

2.4. Phase 3: MBP scripts and multimedia content production and delivery

Following the co-design refinements, the final mindfulness exercises were developed in three stages: script development, audio generation, and video creation. This process was guided by user needs assessment and participatory workshops, while also preserving the core guided principles recommended in MBP adaptation guidance.

2.4.1. Script development (final scripts)

A total of 20 mindfulness scripts were drafted across six thematic domains. Scripts drew directly on user-identified stressors, emotional experiences, and daily GDM management challenges, such as anxiety around glucose readings, fear of insulin use, diet-related guilt, fatigue, and concerns about foetal well-being. Each script incorporated pregnancy-safe guidance, gentle pacing, simple language, and relatable GDM-specific examples (See [Supplementary Material 2](#)). Refinements were made iteratively in response to feedback from individuals with GDM and HCPs, ensuring the content remained contextually relevant while maintaining the core therapeutic mechanisms of mindfulness (attentional control, interoception, emotion regulation, and compassion).

2.4.2. Audio production

To create a flexible and accessible audio library, all scripts were converted into guided audio sessions using advanced text-to-speech (TTS) technology.³⁶ TTS is an artificial intelligence-driven tool that synthesises spoken language from written text, enabling the production of high-quality audio without the need for live voice recordings. TTS settings, including voice gender, tone, cadence, and pitch, were selected based on co-design findings. Natural pauses were inserted throughout the recordings to facilitate reflection and reduce cognitive load. Final audio files were exported in a mobile-optimised format (MP3).

2.4.3. Video creation

Complementary video materials were developed using Canva Pro to support users who preferred visual engagement.³⁷ Videos incorporated slow, soothing nature imagery, warm colour palettes, smooth transitions, and minimal text to support ease of use on mobile devices. Visuals were carefully matched to the tone of each script; for example, grounding exercises were paired with still natural scenes, while gratitude practices used soft sunrise or landscape imagery. All videos were rendered in lightweight formats suitable for mobile devices.

2.5. Data analysis

Qualitative data from the FGDs and co-design workshops were analysed thematically using NVivo 12. Following Braun and Clarke's principles of reflexive thematic analysis, transcripts were coded inductively.³⁸ To enhance the rigour and trustworthiness of the analysis, coding and theme development involved discussion among three researchers. Emerging codes and interpretations were reviewed collaboratively, with discrepancies in interpretation resolved through iterative discussion until consensus was achieved. This process supported reflexivity, consistency in interpretation, and refinement of the final themes. A coding framework was developed to guide refinement of categories and support consistency across the dataset. Themes were identified relating to emotional responses to GDM, practical management challenges, existing coping strategies, attitudes towards mindfulness, and patterns of digital engagement. Feedback from the co-design workshops was summarised and directly mapped onto programme modifications to ensure alignment between user needs and intervention design.

2.6. Ethical considerations

The study was reviewed and approved by Dundalk Institute of Technology School of Health and Science Research Ethics Committee (Approval Reference: REC/24/019). All participants provided written informed consent prior to participation. Confidentiality and anonymity were maintained throughout data collection and reporting.

3. Results

3.1. Participant characteristics

A total of 15 participants took part in the needs assessment phase, comprising 11 individuals with GDM (in two FGDs) and four HCPs (one endocrinologist, one obstetrician, and two midwives) in one FGD. In the subsequent co-design phase, 10 individuals participated in the two co-design workshops: five GDM individuals (newly recruited as the first group had

completed their pregnancies by this stage) and five HCPs (one endocrinologist, one obstetrician, one midwife, and two dietitians). Participant recruitment and flow across the two study phases are presented in Figure 1.

Table 1 summarises participant characteristics across the needs assessment and co-design phases. Variables including age, ethnicity, gestational timing of GDM diagnosis, employment status, and current treatment approach were selected because

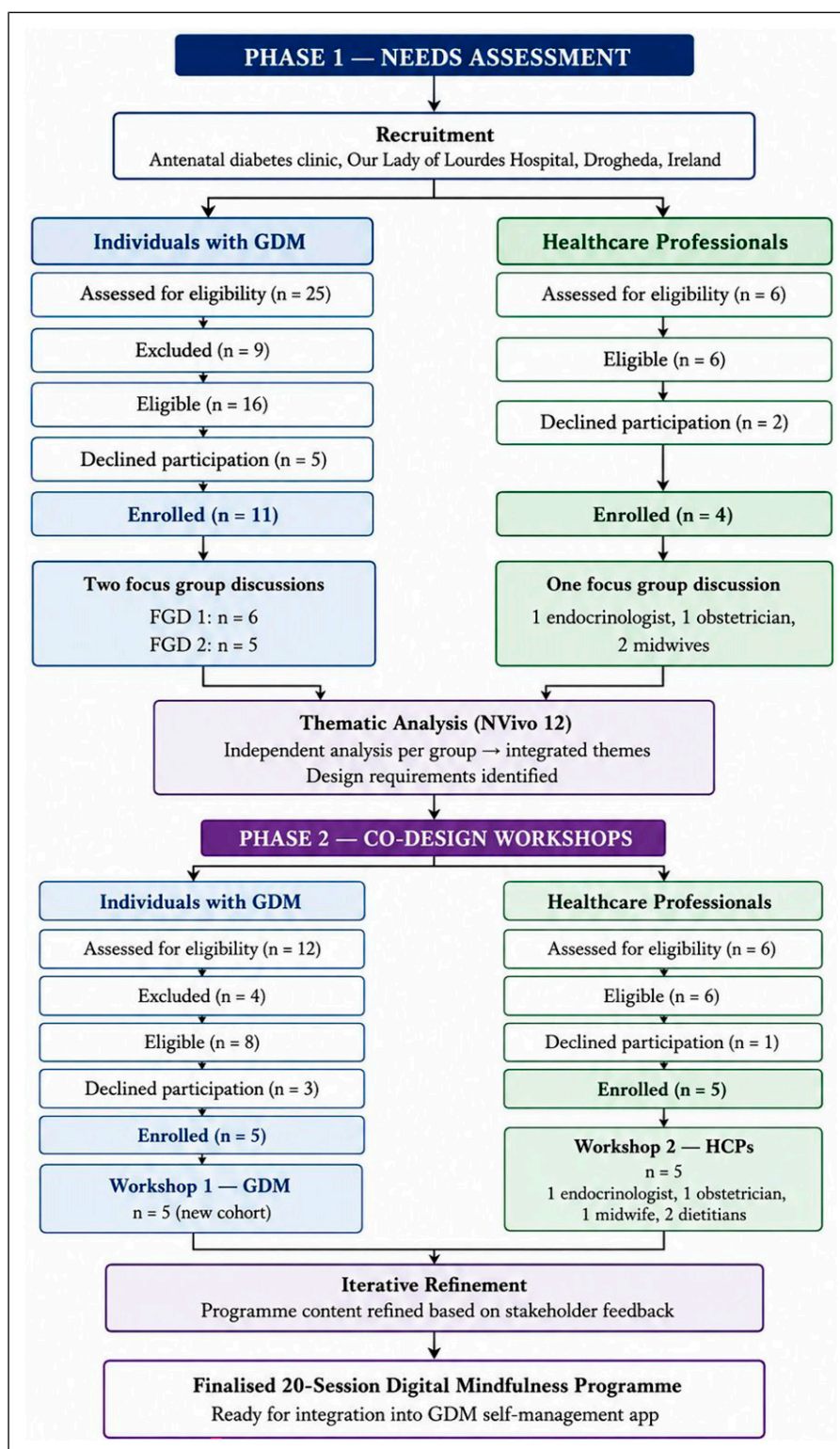


Figure 1. Participant flow diagram across phase 1 (needs assessment) and phase 2 (co-design workshops).

Table 1. Participant characteristics of individuals with GDM included in the needs assessment and co-design workshops.

Variable	Value	Needs assessment (n=11)	Co-design workshop (n=5)
Age (years)	24–30	2 (18.2%)	2 (40.0%)
	31–35	5 (45.5%)	2 (40.0%)
	36–40	4 (36.4%)	1 (20.0%)
Ethnicity	White	5 (45.5%)	3 (60.0%)
	South Asian	4 (36.4%)	1 (20.0%)
	African	2 (18.2%)	1 (20.0%)
Week of GDM diagnosis	<15 weeks	3 (27.3%)	2 (40.0%)
	16–26 weeks	8 (72.7%)	3 (60.0%)
Employment Status	Employed	4 (36.4%)	4 (80.0%)
	Unemployed	7 (63.6%)	1 (20.0%)
Current GDM treatment	Insulin	8 (72.7%)	2 (40.0%)
	Diet only	0 (0.0%)	2 (40.0%)
	Metformin only	2 (18.2%)	0 (0.0%)
	Insulin & metformin	1 (9.1%)	1 (20.0%)

they may influence experiences of GDM self-management, perceived stress, digital health needs, and engagement with mHealth interventions. For example, treatment modality and timing of diagnosis may reflect differing management burden, while ethnicity and employment status may shape access, cultural preferences, and practical challenges associated with GDM management. Reporting these characteristics, therefore, provides contextual understanding of the diversity of experiences represented within the sample.

3.2. Needs assessment findings

The detailed findings from the qualitative needs assessment have been published in the proceedings of the EAI International Conference on Pervasive Computing Technologies for Healthcare.³⁹ Below is a concise summary of the themes most relevant to the development of the mindfulness programme.

3.2.1. Emotional and psychological responses to GDM

Individuals with GDM and HCPs reported that a GDM diagnosis was often met with shock, fear, and anxiety, especially regarding insulin use and foetal health. Persistent worry about glycaemic control and the demands of self-management were prevalent. HCPs also confirmed the emotional burden and noted frequent distress among those with a first-time diagnosis.

3.2.2. Practical and emotional burdens in GDM self-management

Participants described confusion and frustration over unpredictable glucose readings despite dietary adherence, difficulty with portion sizes, and emotional fatigue from frequent monitoring and medication regimens. Balancing GDM management with family, work, and household responsibilities was a significant stressor. Misinformation from social media and fear of medical interventions (e.g., insulin, caesarean) compounded these burdens.

3.2.3. Coping strategies and gaps in psychosocial support

Most GDM participants relied on informal coping mechanisms, such as physical activity, yoga, maintaining routines, and peer or family support. While some found value in group education or supportive midwives, formal, GDM-specific mental health resources were lacking. HCPs acknowledged that psychological support was generalist, very limited, and not tailored to GDM.

3.2.4. Perceptions and acceptability of mindfulness

Awareness of mindfulness varied. Some participants were familiar and receptive, while others were unfamiliar but open to learning. Both groups recognised mindfulness as potentially beneficial for emotional regulation and stress reduction in GDM, though HCPs cited barriers to clinical implementation, including time, training, and resource constraints.

3.2.5. Digital literacy and preferences

Most GDM participants expressed confidence in using mobile apps and digital health tools, though some reported lower digital literacy, but a willingness to engage if the app was guided and user-friendly. Clear instructions and intuitive interfaces were cited as essential for adoption.

3.3. Preliminary MBP framework for iterative design improvement

After identifying the needs of mental health support and unique stressors associated with GDM management, the preliminary structure of the MBP was mapped to address key psychosocial and behavioural challenges. Six core modules were developed, each targeting specific objectives and psychoeducational themes aligned with participant priorities.

For each module, an initial sample script was drafted and subsequently produced as both an audio recording and a video presentation with variations in duration, voice type, and voice speed. These prototypes reflected real-world stressors and scenarios relevant to GDM self-management. This approach ensured that the content was grounded in user experiences and ready for iterative refinement during participatory co-design workshops. [Table 2](#) below presents the initial six-module framework, illustrating how each module was directly mapped to specific psychosocial needs identified during the needs

Table 2. Initial six-module structure developed from needs assessment to support GDM-specific mindfulness programme.

Module	Participant-identified needs	Module learning objectives	Psychoeducational content delivered
Module 1: Foundations of Mindfulness for GDM	High emotional distress at diagnosis; lack of coping tools; low prior exposure to mindfulness	• Introduce mindfulness concepts • Build basic attention stability • Reduce acute stress	• What mindfulness is • How breath anchors the mind • The role of grounding during stressful moments
Module 2: Understanding and Managing Thoughts & Emotions	Worry spirals related to glucose readings; fear of harming the baby; rumination	• Build awareness of stress-related thoughts • Introduce labelling techniques • Reduce reactivity to thoughts • Help individuals understand the “thinking mind.”	• Automatic thoughts and emotional spirals • Habit loops (worry → stress → avoidance → worry) • Early cognitive techniques adapted from MBCT
Module 3: Deepening Body Awareness and Stress Regulation	Somatic stress symptoms: pregnancy-related discomfort, increasing stress	• Strengthen mind–body connection • Reduce reactivity to unpleasant sensations • Promote acceptance and patience with pregnancy changes • Cultivate compassion	• Interoception and emotional regulation • Body scanning as grounding • Allowing vs resisting sensations
Module 4: Loving-Kindness, Compassion, and Emotional Softening	Self-blame following “out-of-range” glucose values; guilt and perceived failure	• Build warmth and emotional resilience • Strengthen feelings of connection to self and baby	• How compassion counteracts shame • Common humanity (“others experience this too”) • Softening the inner critic
Module 5: Gratitude, Positive Emotion Building, and Cognitive Shift	Emotional exhaustion; need for positive emotional resources	• Strengthen gratitude as an emotional resource • Promote positive affect and emotional balance • Support cognitive reframing towards appreciation	• Gratitude as an emotional regulation strategy • How gratitude broadens attention and reduces rumination • Using positive emotions to buffer stress
Module 6: Reflection, Integration & Sustaining Practice	Need for flexible, sustainable practices as pregnancy progresses	• Consolidate mindfulness skills • Build confidence in continued practice • Support emotional preparation for late pregnancy and childbirth	• How to maintain mindfulness beyond the programme • Mindfulness in everyday stressors • Adapting practice to fluctuating pregnancy energy levels

assessment. The 'Participant-identified needs' column describes the participant-identified challenges that each module was designed to address, ensuring that the programme content remained grounded in lived experience.

3.4. Co-design workshop feedback and mindful programme content refinement

The co-design workshops generated detailed, user-informed insights that directly shaped the refinement of the mindfulness programme. During these workshops, individuals with GDM and HCPs provided real-time feedback on the clarity, relevance, and acceptability of the sample scripts, as well as their preferences for delivery mode, session length, voice characteristics, and integration into daily routines. This collaborative process allowed for the progressive adaptation of both the content and format in response to user needs. Table 3 below summarises the key themes and representative quotes that emerged, highlighting the specific design considerations that informed the final structure and delivery of the mindfulness programme.

3.5. Final mindfulness programme structure

The final version of the mindfulness programme comprised 20 structured practices organised across the initially identified six thematic modules. Each module corresponded to a core area of emotional, cognitive, or physiological need identified during the needs assessment and refined through participatory co-design. The one-month programme was designed for flexible digital delivery, with users encouraged to engage in practice five days per week, allowing rest days to accommodate fluctuating pregnancy demands.

Each daily practice incorporated a specific mindfulness anchor, such as breath awareness, thought labelling, body scanning, compassion, or gratitude, to ensure conceptual clarity and a coherent progression across the programme. Script length was intentionally calibrated to be neither too long nor too brief, enabling smooth audio and video production while

Table 3. Key insights from participatory co-design workshops and their implications for programme refinement.

Theme	Description	Representative quotes (GDM participants)	Representative quotes (HCPs)
Content Relevance & Utility	Mindfulness content is perceived as helpful, calming, and directly relevant to GDM stressors.	"I love practising it. It's really helpful for relieving stress." (P2) "Oh, no. That's lovely. I love it. It's very nice." (P5)	"Most of the women I work with already feel overwhelmed. So, this would be really helpful for them." (HCP3)
Format Preference: Audio vs. Video	Audio strongly preferred for ease of engagement and ability to close eyes; video optional as supplementary visual support.	"Audio is better... to concentrate, we have to close our eyes." (P1) "I like the audio more, but the videos are nice too, especially if they've got pictures." (P3)	"If you ask them to close their eyes, then you can't really give them a video." (HCP1) "People might be more interested if there are videos and audios." (HCP2)
Session Frequency & Duration	Short, flexible sessions (5–10 min) preferred; longer options (15–20 min) valued for deeper relaxation or high-stress moments.	"Five or ten minutes is perfect... four or five times a week is good." (P3) "Having a 10-minute and a 20-minute option would be great." (P5)	"Keep it short and repeatable... five minutes is enough." (HCP1) "Aim for three to four times a week, but keep it flexible." (HCP3)
Voice Preferences & Pacing	General preference for a soft, slow female voice; tone more important than gender.	"I prefer a female voice... it's softer and more soothing." (P2) "A soft, calming voice makes it easier to relax." (P3)	"Voice preference is subjective... tone must be gentle and non-clinical." (HCP2) "Slower is usually better; a rushed tone defeats the purpose." (HCP3)
Integration Into Daily Routine	Users valued practices that fit naturally into existing routines, e.g., before sleep or during breaks.	"Sometimes, like, you're anxious in bed, it would be great — you just put on an audio and fall asleep." (P5) "I could do it while my baby was taking his bottle." (P1)	"Short practices before glucose monitoring could reduce stress." (HCP2) "Mindfulness should feel like support, not another task on their checklist." (HCP5)

fitting within the preferred time frame (5–10 minutes for short practices; optional 15–20 minutes for longer practices) identified by participants during co-design.

These anchors also supported user comprehension and facilitated habit-building, particularly important for individuals newly introduced to mindfulness during a period of elevated emotional load. A summary of the finalised programme structure is presented in [Table 4](#).

3.6. Final audio development

Guided audio recordings were produced for all 20 mindfulness practices using a female text-to-speech (TTS) voice, selected based on co-design feedback favouring a soft, calm, and reassuring tone. The final voice (Michelle; English-US) was configured with adjusted pacing and tone (voice speed 24%, pitch 0%).³⁶ These settings were chosen to maximise relaxation, support slow breathing, and reduce cognitive load during practice.

Each audio session was designed to fall within the 5–10 minute range, reflecting participants' preferences for short, manageable practices that could be integrated into daily routines. To support deeper engagement for users who wish to practise for longer, intentional pause points were embedded within the recordings. At these moments, the narrator gently prompts: "If you wish to continue, you may pause the audio here." All audio files were exported in mobile-optimised MP3 format to ensure smooth in-app playback.

3.7. Final video development

The final video materials were created in Canva Pro by integrating the completed TTS-generated audio files directly into a sequence of natural, calming visual elements. Each video corresponded precisely to one of the 20 mindfulness sessions, ensuring visual–audio alignment across the programme.

To support a soothing and immersive experience, videos incorporated slow-moving nature imagery, such as rivers, flowing water, soft light patterns, sunrise silhouettes, and gentle meditation-themed scenes ([Figure 2](#)). These visuals were selected to match the tone and thematic focus of each script (e.g., grounding practices paired with river scenes; loving-kindness paired with warm light and silhouettes).

Table 4. Finalised 20-day mindfulness curriculum.

Module	Scripts titles	Mindfulness anchor
Module 1: Foundations of Mindfulness for GDM	Day 1: Beginning with the Breath Day 2: Setting Your Intention Day 3: Returning to the Present Day 4: Noticing Thoughts & Letting Go	Breath awareness Intention-setting Present-moment focus Letting go
Module 2: Understanding and Managing Thoughts & Emotions	Day 5: Building a Daily Habit Day 6: Introduction to Labelling Day 7: Labelling Past & Future Day 8: Helpful or Unhelpful Thoughts Day 9: Labelling Body Sensations	Habit-building Thought labelling Temporal awareness Cognitive reframing Interoceptive awareness
Module 3: Deepening Body Awareness and Stress Regulation	Day 10: Beginning the Body Scan Day 11: Deepening the Body Scan Day 12: Observing Sensations with Curiosity	Body scanning Expanded body awareness Curiosity
Module 4: Loving-Kindness, Compassion, and Emotional Softening	Day 13: Beginning Loving-Kindness Day 14: Expanding Loving-Kindness Day 15: Universal Loving-Kindness	Loving-kindness phrases Compassion Connection
Module 5: Gratitude, Positive Emotion Building, and Cognitive Shift	Day 16: Gratitude Meditation Day 17: Gratitude + Negative Visualisation Day 18: Gratitude for Nature	Gratitude Reframing Sensory grounding
Module 6: Reflection, Integration & Sustaining Practice	Day 19: Reflection & Inner Growth Day 20: Continuing Mindfulness Daily	Reflection Integration

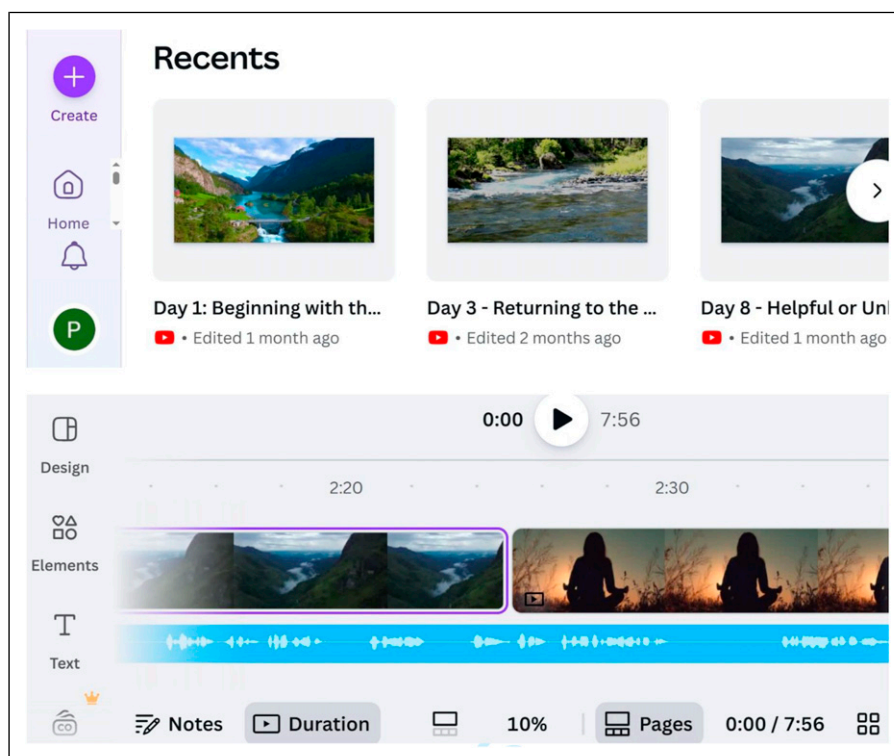


Figure 2. Development of mindfulness videos for the digital programme (a) examples of completed mindfulness videos incorporating calming nature imagery. (b) Canva pro interface showing integration of TTS-generated audio with visual content during video production.

All videos were rendered in mobile-optimised formats suitable for use within the GDM app prototype. The final library consisted of 20 visually consistent, minimalist videos designed to enhance relaxation, reduce distraction, and complement the guided audio practices.

4. Discussion

This study presents the process of development of a digitally delivered, MBP tailored specifically for individuals with GDM, addressing the critical gap in psychosocial support within standard GDM care. The resulting one-month programme comprises six modules targeting stress regulation, cognitive awareness, body sensing, compassion, gratitude, and long-term integration, ensuring that content is both contextually relevant and practically feasible for individuals in late pregnancy.

4.1. Key findings and contributions

The needs assessment findings highlight the acute emotional burden associated with GDM diagnosis and management, aligning with prior research that identifies shock, anxiety, and fear as prevalent psychological responses.^{5,40} Participants also reported significant stress related to glucose monitoring, dietary restrictions, and balancing self-care with other life responsibilities, challenges that are often inadequately addressed by standard GDM care, which primarily focuses on biomedical outcomes.⁴¹ These findings reinforce the importance of integrating psychosocial support within antenatal diabetes care, particularly given the short time window between diagnosis and delivery. Both GDM individuals and HCPs support it by expressing a strong desire for structured emotional support. Although their prior experience with mindfulness varied, they consistently viewed mindfulness as a helpful strategy for managing stress. This confirms that psychosocial care is both needed and welcomed within this population.⁴²

The co-design process yielded critical insights into user preferences for mindfulness delivery.⁴³ In line with recent digital health literature, participants favoured brief, flexible audio-guided practices that could be easily integrated into existing routines.^{44,45} The strong preference for short, accessible mindfulness practices aligns with evidence demonstrating limited uptake of traditional, lengthy MBSR/MBCT formats among pregnant individuals due to scheduling barriers and fatigue.⁴⁶

Additionally, the preference for a soft, slow-paced female voice and calming, minimalist visuals underscores the importance of sensory comfort and personalisation in digital mindfulness interventions.²⁷ The decision to offer both audio and video formats, optimised for mobile delivery, addresses barriers related to digital literacy and personal preference, supporting inclusivity and sustained use. These design choices are supported by evidence showing that user-tailored digital interventions increase engagement, adherence, and psychological benefit.^{28,47}

Importantly, both GDM participants and HCPs emphasised that mindfulness practices should serve as supportive tools rather than additional burdens, a crucial consideration for intervention feasibility and acceptability. The integration of customisable session duration and flexible practice schedules into the final programme structure responds directly to this concern, reinforcing the value of participatory, stakeholder-engaged design.⁴⁸ Collectively, these findings informed the development of a digital MBP that is both evidence-based and highly relevant to individuals with GDM.

4.2. Implications for intervention design

The present study demonstrates the critical value of integrating behavioural intervention frameworks when adapting MBP for specific clinical populations. By employing the ORBIT model,²⁹ which emphasises early-phase, iterative, and user-engaged development, this project ensured that the intervention was both feasible and contextually relevant prior to formal evaluation.

In parallel, Loucks et al.'s²⁸ mindfulness adaptation framework provided essential guidance for maintaining the therapeutic integrity of core mechanisms while allowing contextual flexibility in tone, session length, examples, and pacing. The resulting GDM-specific mindfulness programme exemplifies this approach, preserving the core “active ingredients” of mindfulness, with a modified delivery to accommodate the unique demands of late pregnancy, self-management burden, and diverse user preferences.

Given the well-established relationship between psychological stress and glycaemic instability in GDM, the integration of mindfulness into digital care platforms may offer dual benefits for emotional and glycaemic outcomes. This brief, tailored, app-based programme is particularly well-suited to those overwhelmed by new self-management responsibilities, users with limited access to psychological care, and culturally diverse populations, reflecting the ethnically diverse participant sample included in this study (White, South Asian, and African backgrounds). However, further evaluation in broader populations is needed to establish wider cultural applicability.

Furthermore, embedding mindfulness training within a comprehensive GDM self-management app, alongside blood glucose monitoring, educational resources, and lifestyle tracking, creates an opportunity for synergistic benefits, supporting emotional regulation in tandem with practical self-management tasks.

4.3. Research contribution

This study makes important methodological and practical contributions to the field of digital maternal health. Methodologically, it presents a rigorous and transparent MBP development process, which is rarely documented in full within the development of digital interventions for pregnancy or chronic disease.^{49,50} By detailing each phase of the MBP design and refinement, this study offers a replicable framework for tailoring to other pregnancy-related or chronic health contexts.

Practically, unlike many MBP development papers that produce only conceptual frameworks, this study yielded a full 20-day library of scripts, audio guides, and videos ready for integration into a mobile app, offering immediate utility for practice and research.^{51,52} The inclusion of TTS configuration and Canva-based video development provides practical guidance for future digital intervention designers. In addition, it provides actionable insights regarding optimal session length, tone, multimedia preferences, and strategies for integrating mindfulness practices into daily routines.

4.4. Strengths and limitations

A key strength of this study is its rigorous, multi-phase, user-centred methodology, which integrated qualitative needs assessment, participatory co-design, and iterative refinement with real-time feedback. Engaging end users and clinicians in every phase ensured that the intervention design was grounded in the lived experiences and clinical realities of its target users. High-quality multimedia production allowed for the creation of engaging, accessible content tailored to user preferences. Furthermore, the programme was developed with strong theoretical grounding, drawing on established behavioural science and mindfulness adaptation frameworks^{28,29} to ensure both therapeutic integrity and contextual relevance. Scripts drew directly from user narratives, capturing anxieties around glucose monitoring, dietary pressures, fear of insulin, physical discomfort, and emotional overload, ensuring high emotional resonance and applicability in late pregnancy.

However, several limitations should be acknowledged. The co-design workshops involved a relatively small sample size, which, while appropriate for design research, may limit the generalisability of findings. Additionally, a formal sample size

calculation was not conducted, as this study employed purposive sampling appropriate to its qualitative design. Future pilot and feasibility studies should prospectively calculate sample sizes based on the preliminary effect-size estimates generated by this work. The materials were developed in English only, potentially restricting accessibility for non-English-speaking users, a recognised risk population for optimal GDM management.⁵³ In addition, the study was conducted within a single geographical and clinical context (Ireland), and findings may not fully reflect the needs of more diverse or international populations. Although digital delivery expands reach, digital literacy barriers may still hinder uptake among certain user groups. Additionally, while the programme was developed for mobile integration, real-world uptake and engagement remain to be evaluated.

4.5. Future works

The immediate next step will be the full integration of the mindfulness programme into the holistic GDM self-management app, ensuring seamless user access alongside monitoring, educational, and lifestyle support features. Following this integration, a pilot feasibility study will be conducted to evaluate the acceptability, usability, and engagement of the embedded mindfulness programme among individuals with GDM. This pilot will also assess preliminary psychological outcomes, such as stress, anxiety, and mindfulness skills, as well as explore trends in secondary glycaemic indicators.

In parallel, future work will focus on adaptation and tailoring for multilingual and culturally diverse populations to maximise reach and relevance. Additionally, exploring adaptive or personalised delivery approaches, such as dynamic session recommendations, AI-driven pacing adjustments, and adaptive scheduling based on user behaviour or stress indicators, will be prioritised to optimise individual engagement and benefit.

5. Conclusion

This study demonstrates the feasibility and value of a structurally developed, digitally delivered mindfulness programme tailored to the unique psychosocial and behavioural needs of individuals with GDM. By integrating qualitative needs assessment, participatory co-design, and iterative multimedia production, the intervention was designed to be accessible, easy to use, and responsive to user preferences and clinical realities. Early user experiences highlight the importance of personalisation, sensory comfort, and integration into daily routines, supporting the potential for broader impact. The resulting programme, comprising short and contextually relevant mindfulness practices, is intended to be embedded within a holistic GDM self-management app, addresses a critical gap in antenatal care by providing structured psychosocial support alongside practical disease management.

Future research will focus on piloting the MBP within the integrated app, assessing its feasibility, psychological impact, and glycaemic outcomes. The methodological approach offers a replicable model for adapting MBPs to other pregnancy-related or chronic conditions. Ultimately, this work advances the evidence base for digital contemplative interventions in maternal psychological health and paves the way for more holistic, user-centred approaches to GDM management.

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Ethical considerations

The study was reviewed and approved by Dundalk Institute of Technology School of Health and Science Research Ethics Committee (Approval Reference: REC/24/019).

Consent to Participate

Written informed consent was obtained from all subjects involved in the study.

Author contributions

Conceptualization, P.G. and O.G.; methodology, P.G.; software, P.G.; validation, P.G., O.G., J.D., and A.B.; formal analysis, P.G.; investigation, P.G.; resources, P.G.; data curation, P.G.; writing—original draft preparation, P.G.; writing—review and editing, O.G., J.D.,

and A.B.; visualization, P.G.; supervision, O.G., J.D. and A.B.; project administration, O.G.; funding acquisition for project, O.G. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

Data supporting these findings are available within the article or upon request.

Supplemental material

Supplemental material for this article is available online.

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