Understanding the Self-monitoring Practices of People Living with Gestational Diabetes: A Qualitative Study with Implications for the Design of Self-monitoring Technologies

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Gestational Diabetes (GD) is a common perinatal condition that can strongly impact the health of both the mother and the foetus. To avoid complications, people living with GD need to quickly learn to monitor their blood glucose levels and implement relevant changes to their diet and physical activity. Despite the importance of self-monitoring in GD, there is limited understanding of how people living with GD monitor their blood glucose in everyday life. This paper describes the self-monitoring practices of people living with GD in Portugal, drawing on 25 interviews with women who had GD, complemented by observations of glucose monitoring training sessions and interviews with five nurses. Our findings show that people living with GD learned complex practices within weeks of diagnosis, including measuring on the move, measuring while task-switching, and performing repeated measurements. We reflect on the impact of practices in everyday life and outline three implications for the design of self-monitoring technologies for GD.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; • **Applied computing → Consumer health**.

Additional Key Words and Phrases: Gestational Diabetes, Self-monitoring, Self-monitoring technology, Maternal Health, Digital maternal health

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1 Introduction

Gestational Diabetes (GD) is a common pregnancy complication [101] that elevates the glucose level in the blood, putting the mother and the foetus at risk of birth complications and long-term issues [73]. Upon diagnosis, people living with GD[1] need to adapt their lifestyle by changing their eating practices, learning what foods and quantities they can eat (and which to avoid), and (self-) monitoring blood glucose levels (BGLs) [23, 56], all of which can be very challenging [6, 117]. In particular, measuring blood glucose plays an important role in managing GD, as people living with the condition measure their BGLs up to four times a day, according to medical guidelines [6, 104]. Understanding the connections between everyday events and BGLs is crucial for assessing how an individual's diet and physical activity influence these values and how to manage the condition [24, 74].

The self-monitoring practices in GD, defined here as the practices that support or frame blood sugar measurement, remain underinvestigated. While self-monitoring practices have been previously described in the context of Type I and Type II Diabetes (T1D and T2D)[2] [2, 106, 123], there is no detailed study describing the self-monitoring practices of people living with GD. Understanding these practices is crucial for developing potential technical or nontechnical interventions [28] that support people living with GD in learning and adapting self-monitoring regimes in their evolving pregnancy journey. Related work tells us that people living with GD: (i) use the smartphone to remember measurements [24], (ii) document their measurements in paper logs or mobile apps [56], (iii) or that they measure to learn impact of certain foods or the reason behind elevated glucose values [23, 64], but there is no in-depth description of how people living with GD practically achieve blood glucose monitoring in everyday life. We do find a wealth of studies investigating different aspects of the self-care of GD, including barriers to self-care [12, 50, 57, 61, 122, 124], exercise practices [23, 60, 62, 132], changes in eating and cooking practices [23, 61, 62, 122], or even the emotional toll and burden of the condition [24, 59, 61, 108]. Considering the central role of self-monitoring in GD, we believe it is essential to study these practices to better tailor digital health interventions for this audience.

This study investigated the self-monitoring practices of people living with GD to inform the design of self-monitoring technologies. We conducted semi-structured interviews with 25 people living with GD and people who had GD in the past (current and former patients) to better understand condition challenges, self-care and self-monitoring practices, and how people learned these. In addition, we observed blood glucose measurement training sessions to understand how nurses taught blood glucose measurement, and conducted five interviews with nurses to understand their perspective on the practices we identified among our participants. The most salient theme in the analysis was how people living with GD developed complex self-monitoring practices in a short period of time. Learning to engage in new self-care and/or self-monitoring practices is a common experience for many people living with chronic conditions [10, 123], but people living with GD must often adopt these practices few weeks after diagnosis. The expedited learnings and adaptations were motivated by the belief that the behavioural changes were temporary and that mothers were doing what was best for their child. People living with GD measured their blood glucose in creative ways, such as using the kitchen counter and a standing position to multitask and while carrying out other activities and responsibilities. They used smartphone alarms and measured while walking or in hard-to-measure settings to ensure they did not skip measurements. Participants performed additional measurements to understand the impact of certain events, and repeated measurements to

[1]The term "people living with GD" is used throughout this paper to refer to individuals diagnosed with GD, acknowledging that not all identify as women. However, since all participants we interviewed identified as women, we also use the term "women with GD" in some instances, specifically referring to our participants.

[2]GD differs from T1D and T2D. T1D and T2D are chronic conditions that individuals typically live with before, during and after pregnancy. GD develops during pregnancy and it can be resolved after childbirth. Moreover, pregnant people living with T1D or T2D often manage their diabetes with established treatment plans, whereas those with GD may need different approaches tailored to the temporary nature of their condition and the unique challenges of pregnancy.

discard errors in the glucometer. Finally, we also uncovered the lack of self-monitoring practices, with participants choosing not to measure after eating food that was outside of their meal plan.

Our study has three contributions. The first is empirical and relates to the detailed description of the self-monitoring practices of people living with GD, which complements prior work on the self-monitoring practices in T1D and T2D [3, 11, 86, 87, 102, 105, 106, 121, 123] and existing knowledge about self-care in GD [12, 23, 24, 57, 59, 61, 62, 108, 124]. The second contribution is more conceptual and relates to the understanding of self-monitoring in GD and its impact on the design of self-monitoring technologies. We believe the speed at which people living with GD learn to self-monitor, and the flexibility and integration of measurements in everyday activities, encourage reflection on how we as a community conceptualise self-monitoring and technologies that support it. The third contribution consists of three design implications to inform the design of self-monitoring technologies, acknowledging the practices mentioned above.

2 Background

2.1 Gestational Diabetes, self-care, and self-monitoring

Gestational Diabetes (GD) is a form of Diabetes Mellitus that develops during pregnancy due to hormonal changes, which cause a greater resistance to insulin [5, 111]. GD has a global prevalence of 14.7% of all pregnancies [114], a percentage which increases with maternal age [117]. Unlike T1D and T2D, which tend to persist throughout patients' lives, GD often resolves after giving birth. Nevertheless, GD poses significant risks to the mother and to the unborn child, including preterm birth [73], child obesity [20, 73] or the possibility of developing T2D later in life (more than half of the individuals who have had GD later develop T2D [91]). Diet changes are used as the frontline intervention for treating GD [117], and to manage it, people living with GD should measure blood glucose and engage in self-care[3] [15, 75].

The main practice most people living with GD follow is learning which foods and quantities make their BGLs rise [23, 136]. In their day-to-day, people living with GD adopt practices, such as cooking the meals they eat [23] and measuring portion sizes [122], to better understand food-related fluctuations in their BGLs. They tend to distribute their carbohydrate intake across main meals and snacks and add protein-rich foods to late-night snacks [89]. However, it is not always easy to adhere to a new/changed diet and, as a result, people living with GD develop personal strategies to implement the new dietary recommendations. For example, food cravings are hard to control, so, people living with GD, may avoid having unhealthy food at home or strongly reduce the intake of the foods they are asked to avoid [129, 136]. The self-care practices related to physical activity include taking walks after the main meals [23, 89] and practising extra physical activity after consuming more carbohydrates or unrecommended meals [129]. For some individuals, physical activity sometimes includes scheduling house chores after meals to keep the body moving when going out for a walk is not possible [129].

To support people living with GD, nurses or other healthcare professionals organise a session to teach how to measure blood glucose with a glucometer[4] [35]. International guidelines recommend that the BGLs should be <95mg/dl while fasting and <140mg/dl one hour after meals [4, 15], which differ from the guidelines for T1D and T2D [74]. The interpretation of BGL allows the adjustment of carbohydrate intake, exercise, and medication [35], but, as literature on T1D and T2D refers, it can be hard to engage in self-monitoring during the first weeks [85]. As mentioned in the introduction, there is scarce information regarding how people living with GD engage in self-monitoring, nevertheless, we are able to get insights from prior work on the self-care of GD. We learn, for

[3]The concept of self-care is usually employed in the context of chronic conditions to refer to the practices of observing the body, managing treatment, changing lifestyle, coping with the disability [13], as well as the practical mundane work of living with a chronic condition [99]. We view the challenges and practices of people living with GD as similar to those of people living with chronic conditions and thus refer to self-care in reference to GD.

[4]The glucometer is a portable medical device that people living with diabetes use to measure their blood sugar.

example, that people living with GD use paper logs or mobile apps for keeping track of their values [56], that they measure more often after getting elevated glucose values [23] or eating specific foods [64], that smartphone alarms are used as reminders to measure [24], or that people who work outside the home during pregnancy struggle more to make the required measurements [69].

The self-monitoring practices in GD, T1D and T2D are not necessarily the same. The core principles of self-monitoring are similar, as people living with diabetes who measure their blood glucose need to interpret the data and adjust their behaviour to maintain control over their condition [15, 74]. However, managing T1D includes additional practices, less common in GD, such as advanced carbohydrate counting and insulin administration [30]. People living with GD or T1D tend to measure very regularly, but in T2D it is relatively common to find people who do not measure or measure only once a day [41]. When people living with T2D start taking insulin, then their measurements become as regular as T1D or GD [85]. For non-pregnant people living with T2D, the risks of missing a measurement or not knowing their BGLs are less immediate and predictable, leading people living with diabetes to measure less frequently or only when they suspect a change in their BGLs [92]. In contrast, for people living with GD, failing to maintain regular self-monitoring can result in severe short-term consequences [73]. Another important difference is the duration of the self-monitoring practices, which tend to be long-lasting for T1D and T2D, but mostly temporary for GD.

The barriers to self-care and self-monitoring are multiple. Changing one's diet can be a significant barrier to self-managing GD [59], particularly for people with dietary habits that are misaligned with their meal plan [23, 24, 132] or with low income [61, 68]. Culture and religion can also be significant barriers, particularly for migrants, since healthcare professionals are not necessarily familiar with their dietary practices and prescribe diet plans without considering their sociocultural practices and eating habits [12, 68, 124]. To worsen the situation, healthcare institutions often fail to provide enough educational materials [24, 60, 122, 133] and their content can be hard to understand, particularly for people with different sociocultural backgrounds [89]. Regarding the barriers to self-monitoring, people living with GD usually report a lack of time [24, 60, 68, 122] and motivation [122] to measure, which can have negative effects on their health.

The literature is scant on descriptions of self-monitoring practices of people living with GD. While prior work describes barriers, reference values, and some aspects of operationalising measurements, such as drawing on smartphone alarms as a reminder to measure, there is little information on how people living with GD engage in self-monitoring in practical terms.

2.2 Technologies to support the self-care and self-monitoring of Gestational Diabetes

The most used technology in GD is the glucometer, a device that measures the BGL in a drop of blood. People living with GD can also use the continuous glucose monitor, a device with a needle attached to the arm or abdomen that measures blood glucose at very regular intervals [36, 43]. Nevertheless, continuous glucose monitors can be expensive and are not supported by the Portuguese healthcare system for people living with GD, which may explain why none of the participants of our study used them.

Other technologies typically used to monitor GD include smartphones, computers, and tablets, with greater use of smartphones due to the existence of mobile apps for people living with GD [16]. To better understand the mobile apps available for people living with GD, we conducted a review of apps in January 2025 focusing on their self-monitoring and self-care features (see the overview of apps on Table 1). A total of 53 mobile apps were initially identified through searches in the Google Play Store and Apple App Store using the keywords *"Gestational Diabetes"* and *"Diabetes Gestacional"*, which is the name of the condition in Portuguese. Of the 53 apps, 14 were duplicates because the app was available for both Android and iOS. Four apps were excluded because they were available in languages other than English or Portuguese. Two apps were deemed out of scope because they were unrelated to GD, and another four focused solely on presenting the risks of GD rather than supporting

its self-monitoring. Table 1 includes 33 mobile apps, 29 from the review and four which were identified in the literature and were not available in the app stores. We analysed the features of the apps, taking into consideration the app websites, app store descriptions, screenshots, and their description in research papers.

Mobile apps for GD included four main features to support self-monitoring of blood glucose values. The most prevalent feature is the ability to log blood glucose values, included in 25 out of 33 of the mobile apps from Table 1 including it (e.g., GDM-DH [34]). Logging blood glucose values allowed users to record and monitor their BGLs over time [82]. Complementing this feature was the visualisation of BGLs through plots, found in 22 of 33 mobile apps (e.g., Happy Bob [54]), which visually represent trends and patterns to improve users' comprehension and foster learning [49, 78, 135]. Some apps used colour coding to highlight values outside the target range, making it easier to interpret the BGLs [84]. Additionally, many apps (11/33) enabled users to annotate their logged values with contextual information such as recent meals, physical activity, stress, sleep patterns, or other incidents, such as Pregnant+ [66]. The fourth most common feature was reminders of measurements (found in 16 out of 33 apps), a feature that helped users stay consistent with their measurements. These alarms may take the form of countdowns triggered an hour after eating, like the example of Malama [84] or pre-defined alarms scheduled according to the user's measurement plan found in Diabetes Care Insulclock [65].

Mobile apps also provided features for supporting the self-care of GD. Educational content about GD was found in 10 out of the 33 identified mobile apps, offering insights into the condition, its risks, and practical management tips [49, 72]. Educational content was presented in various formats, including articles in the app Malama [84], or lesson modules in the app Habits GDM [125, 135]. Another feature to support self-care is access to appropriate meal recipes, present in five apps which offer healthy options aligned with the user's prescribed diet plans (Beeaab HealtH [14], DiabTrend [37], Malama [84], My Diabetes Diet & Meal Plan [51] and SweetMama [134]). More widely available is the ability to log meals, with 17 mobile apps offering this feature, often integrated with the feature of blood glucose annotations, like in the app Diabetes: M - Blood Sugar Diary [119], helping users recognise patterns and understand how specific foods impact their levels [27]. Similarly, physical activity tracking, found in 12 mobile apps (e.g. forDiabetes [126]) allows users to log physical activity and assess their influence on blood glucose levels [14, 22].

Prior work discussing mobile app use and its potential for people living with GD identified some advantages of these technologies. An interview study from Edwards et al. [42] argued that using mobile apps to keep track of blood glucose values: (a) increased patient awareness about the impact of certain foods on their blood sugar; (b) improved trust, comfort, and confidence in their self-monitoring practice due to sharing their data with healthcare professionals; and (c) reduced hospital visits due to remote communication and value sharing with healthcare professionals. The interviews from Safiee et al. [115] highlighted the importance of educational content for people living with GD and their healthcare professionals. Moreover, emotional and motivational content support was also requested by patients [42, 115].

Despite the potential of technology to support self-monitoring and improve blood glucose management, several barriers hindered its efficacy. A critical challenge was the lack of personalisation and cultural diversity in many apps [77]. Addressing this gap requires not only adapting diet plans to be more multicultural but also clarifying myths that might arise from cultural misunderstandings [133]. Another limitation was the lack of real-time feedback on BGLs, a feature many users with GD expressed a strong desire for [77]. Additionally, while healthcare professionals could access self-monitoring data, users lacked direct communication channels to ask questions or seek clarification through these systems [16]. Adding to these challenges were security and privacy concerns surrounding sensitive health data [116]. While most apps adopted encryption and privacy measures [31], patients still missed value explanations of how the data is collected, transmitted, stored and used [25, 49].

Mobile apps for GD offered features to track BGLs, meals, and physical activity, helping users understand the impact of their lifestyle choices. They also offered features with educational content on the condition and its management. However, we need a deeper understanding of self-monitoring practices to determine what features

Table 1. Characteristics of mobile apps for people living with GD. The list of apps was obtained by reviewing mobile apps from the literature and all apps in the iOS App Store and Google Play Store for GD available in Portugal.

	App store			Self-monitoring				Other features			
Name [Reference]	App Store	Launch year	Price (€)	Log blood glucose values	Annotate blood glucose values	Remind to measure	See blood glucose plots	Educational content	Log meals	Log exercise/activity	Access meal recipes
BeeaaB HealtH [14]	g	2023	0						x	x	x
Blood Glucose Sugar Tracker [94]	i	2024	0*	x		x	x				
Blood Sugar Diabetes Tracker [9]	b	2024	0*	x	x	x	x				
Blood Sugar Tracking Glucobyte [44]	i	2020	0*	x	x	x	x				
Carbs & Cals [27]	g	2012	0*						x		
Diabetes & Diet Tracker [95]	g	2015	10	x			x		x	x	
Diabetes Care Insulclock [65]	g	2019	0	x		x	x		x	x	
Diabetes controle - Glicose [90]	g	2017	0*	x		x	x				
Diabetes Forum [32]	i	2013	0								
Diabetes: M - Blood Sugar Diary [119]	g	2013	0*	x	x	x	x		x		
Diabetic Tracker App [113]	g	2023	0*	x		x		x	x		
DiabTrend: Gestão da Diabetes [37]	g	2021	0*	x	x	x	x	x	x	x	x
forDiabetes: app de diabetes [126]	g	2018	0	x		x	x		x	x	
GDM-DH [34]	g	2021	0	x	x	x	x	x	x	x	
Gestational Diabetes Tracker [88]	g	2021	0*	x	x	x			x		
Glucomate: Monitor de Diabetes [55]	i	2023	0*	x		x	x				
Glucose tracker++ [1]	i	2019	0*	x			x				
gluQUO: Control your Diabetes [82]	i	2017	0*	x	x	x	x		x		
Habits GDM [125]	NA	2021	NA	x	x	x	x	x	x	x	
Habits: Gestational Diabetes [22]	i	2017	0	x			x		x	x	
Happy Bob [54]	g	2020	0*				x				
Hola Bebé, Adios Diabetes [118]	NA	2020	NA					x		x	
Malama - Gestational Diabetes [84]	b	2023	0*	x	x	x	x	x	x		x
MOMMY CARE [47]	i	2024	0	x			x				
My Diabetes Diet & Meal Plan [51]	i	2021	0*	x					x	x	x
myFetalLife [45]	i	2018	0*	x			x				
myGestationalDiabetes [46]	i	2021	0*	x			x				
mySugr – Diário da Diabetes [96]	g	2015	0*	x		x	x		x		
New To Type 2 [127]	i	2022	0					x			
Pregnant with diabetes [66]	b	2014	0					x			
Pregnant+ [66]	NA	2015	NA	x	x			x	x	x	
Rastreador de Açúcar no Sangue [8]	i	2016	0	x	x		x				
SweetMama [134]	NA	2021	NA					x		x	x

Store: g - Google Play Store, i - iOS App store, b - both Google Play Store and iOS App store, NA - Not applicable.

* The app is available for free, but additional features and content require an upgrade to a paid version

meet the needs of people living with GD, support their management, and if there is a need to invest more on patient education or on condition management.

Despite the central role of self-monitoring in GD, there is limited research on how people living with GD perform glucose measurements in daily life. Existing literature and mobile apps focused on barriers and basic tracking, but did not fully address the real-world practices or needs of people living with GD. This gap makes it unclear whether current digital interventions adequately support users' actual needs or their educational requirements for managing the condition. The need to understand these behaviours and inform the development of effective support for people living with GD motivates our work.

3 Methods

3.1 Interviews with people living with GD and people who experienced GD in the past

To better understand self-care practices, condition challenges, and how people learned to engage in self-care, we conducted interviews with people living with GD and people who had the condition in the past [5]. The interviews were qualitative, semi-structured, and focused [81]. In addition to people living with GD, we decided to also interview people who had GD in the past to discuss with people who had the complete GD experience, and investigate different care paths[6]. The interview script included questions about daily routines in managing GD, diet changes, self-care and self-monitoring practices, the impact of GD, how participants learned to live with the condition, their experience engaging in self-monitoring with mobile apps and other technologies, as well as any feature suggestions to include in a mobile app to support the self-care of people living with GD. The interview script was developed by the research team drawing on their expertise in chronic care and self-monitoring practices. The script was iteratively changed throughout data collection to ensure analysis was driven by data collection [26]. The main changes in the script occurred from participant P6 to P7, as we removed questions about diagnosis and GD surveillance which were the same for all participants from ULSSA/CMIN or ULSPVVC, and then again from P16 to P17 to narrow the focus to self-monitoring practices and the practicalities of measuring their blood glucose measurements (e.g. body position, contextual factors). In the Supplementary Materials, the reader will find the latest version of the interview script.

We interviewed 25 participants (see Table 2) – 19 people living with GD and 6 people who had GD in the past. The interviews lasted on average 27 minutes each (SD = 13), totalling 11 hours of audio recordings. People living with GD were recruited at the outpatient dietitian appointment of ULSPVVC[7] and ULSSA/CMIN[8] during the 2^{nd} or 3^{rd} trimester of their pregnancy. Most participants were interviewed in a dedicated room following their dietitian appointment. Participants who could not be interviewed at that time due to schedule constraints were interviewed over the phone. In both cases, one or two researchers from the team sat in on the interview, taking brief notes. Regarding the characteristics of the participants with GD, the youngest was 23 and the oldest 41, with an average age of 32 (SD = 5). The level of education ranged from basic education to MSc. The occupations of participants were varied, yet most participants were on sick leave from work due to the risk of GD

[5]This study is part of the NUTRIA project, which is developing a mobile app for people living with GD, integrated with a web app for dietitians. The research team includes user researchers and designers, developers, recommender system specialists, and nutritionists from multiple hospitals.

[6]We wanted to understand the perspective of women at different stages of GD, which is temporary. Having a retrospective mapping of experiences from women who had experienced GD in a previous pregnancy, a few months before, would be relevant, as these participants could provide an overview of the GD period of their lives. By recruiting people who had GD from the community, we were also able to learn about different care pathways to complement the experiences gathered from participants from ULSPVVC and ULSSA/CMIN.

[7]Unidade Local de Saúde da Póvoa de Varzim/Vila do Conde EPE. ULSPVVC is a hospital that serves a region in northern Portugal that covers peri-urban and rural areas.

[8]Unidade Local de Sáude de Santo António EPE / Centro Materno Infantil Norte. ULSSA is the reference centre for pregnant people in the urban area of Porto and CMIN is the reference maternity hospital. Recruiting from these two institutions allowed us to have a diverse sample of participants, of different ages, from rural to urban areas, and with different education levels.

for their pregnancy and/or the challenges of engaging in self-care while working. All participants with GD used glucometers provided by their healthcare institutions. Interviews with people living with GD were conducted between May 2023 and March 2024.

Participants who had GD in the past were recruited through convenience sampling. The interviews were conducted online through Microsoft Teams by two or three researchers and used the same interview script. Regarding the characteristics of the participants, people who had GD in the past were in their thirties or forties. The level of education varied from MSc to PhD, and occupations consisted mostly of knowledge workers (e.g., researcher, UX designer, physician)[9]. All former patients had GD in the three years prior, with half (3 participants) having had GD within the last twelve months. During their pregnancy, these participants also used glucometers provided by their healthcare institutions. Interviews with prior patients were conducted from March to May 2023.

3.2 Interviews with nurses and observations of blood glucose measurement training sessions

To provide additional context and complement the insights from interviews with people living with GD, we conducted interviews with nurses who led blood glucose measurement training at their institutions. The interviews with nurses were qualitative, semi-structured, and focused [81]. We inquired participants about the training process, challenges in learning to engage in self-monitoring, strategies used by nurses to support learning, and nurses' perspectives on our latest findings. In the Supplementary Materials, the reader will find the latest version of our interview script.

In total, we interviewed five nurses. Each interview took on average 27 minutes (SD = 15), resulting in 2 hours of audio recordings (see Table 3). Interviews were conducted in person or over the telephone, according to what was more convenient for the participants. Recruitment followed convenience sampling, making an effort to involve nurses from the hospital/maternity hospital and primary care, as people living with GD are trained to measure their blood glucose in both of these settings. The ages of participants varied from 32 to 53 (average 44), with most having more than 20 years of experience as a nurse. Nurse participants were from three different institutions. These interviews took place between September and November 2024.

In addition to the interviews, we also observed two blood glucose training sessions for women with GD at ULSSA/CMIN and ULSSJ/MAC[10]. Having gathered authorisation to conduct the observation, the researcher sat in a corner of the room, refraining from interacting. Each session lasted approximately 20 minutes, during which the researcher took notes without interfering in the training.

3.3 Analysis

Our analysis process was guided by Reflexive Thematic Analysis [19, 29]. This approach recognises that the researcher is deeply involved in the research work and that their focus, positioning, and lens impact the identified results. Half the authors have extensive experience investigating self-care [98] and self-monitoring practices in chronic care [53], and it is clear that this lens has motivated us to reflect on the daily lives of people living with GD and the work to achieve self-monitoring practices. Having been trained in the ethnographic tradition of studying practices [76] before introducing technologies probably encouraged the team to understand in-depth self-monitoring and to reflect on ways to support technology design. Moreover, studies recognising the role of the body in managing a chronic condition [93] and overall in understanding women's health and body tracking [21] helped us stay alert to the influence of the role of the body in self-monitoring practices.

The characteristics of the research team members also influenced our perspective. Having dietitians in the research team enabled us to contrast the experiences from our participants with others that they remembered

[9]The higher level of education of people who had GD in the past is likely a consequence of the recruitment method used, as sampling through the researchers' networks may have biased the sample towards individuals with above-average education levels.
[10]Unidade Local de Saúde de São José EPE/Maternidade Alfredo da Costa.

Table 2. Characteristics of the participants from this study with current or past GD experiences. The table displays demographic information, condition information, details whether participants log their values in an app, and details which participants engage in specific self-monitoring practices or habits described in this paper.

	Participant characterisation									SM practices						
Participant ID	**Age**	**Gestational age (weeks)**	**Diagnosis trimester**	**Nationality**	**Level of education**	**Occupation**	**Sick leave**	**Taking medication**	**Logs glucose on app**	**Measures in the kitchen**	**Measures standing**	**Uses reminders to measure**	**Measures walking**	**Measures outside routine**	**Repeats measures**	**Skips measures**
P1	40	NA	2nd	PT	PhD	Researcher	NA	x	x	x	x	✓	x	x	x	✓
P2	39	NA	1st	PT	MSc	Physician	NA	x	✓	✓	✓	✓	x	✓	✓	x
P3	34	NA	1st	PT	PhD	Researcher	NA	✓	x	x	✓	✓	x			
P4	32	NA	1st	PT	MSc	PhD Student	NA	✓				✓	✓			
P5	33	NA	1st	PT	MSc	UX Designer	NA	x	m			✓		✓		
P6	40	NA	2nd	PT	MSc	Entrepreneur	NA	✓	m			✓				
P7	37	19	1st	PT	MSc	School teacher	✓	✓	x	✓	x			✓	✓	x
P8	30	26	1st	PT	Basic	Factory worker	✓	✓	x	x	✓	✓				
P9	37	20	1st	BR	PG	Personal trainer	✓	x	x	✓	✓	✓		✓	✓	x
P10	23	26		PT	Basic	Manicure	x	x	x	✓						
P11	37	27	1st	PT	H. School	Social animator	✓	x	x	✓		✓		✓		✓
P12	34	29	1st	PT	H. School	Sterilizing technician	✓	✓	x	✓	✓			✓		
P13	31	29	1st	PT	H. School	Customer service	✓	✓	x	x	✓	✓	✓	x	✓	✓
P14	27	27	1st	PT	H. School	Truck driver	✓	x	o	✓	✓	✓	✓			✓
P15	27	25	1st	PT	MSc	Factory worker	✓	x	x	✓	✓	x	✓	✓		
P16	35	23	1st	PT	H. School	Domestic worker	✓	x	x	✓	✓		x	✓		
P17	41	36		PT	H. School	Administrative	✓	✓	x	✓	✓	✓	✓	✓		
P18	36	36		UA	PG	Tourist Guide	✓	x	✓	✓	✓		x	✓		
P19	34	28		PT	PG	Human resources	✓	x	o	x	x	✓	x	✓	✓	✓
P20	32	32	2nd	PT	MSc	Trial admin	✓	x	x	✓	✓	x	x	✓	✓	
P21	21	36		PT	Basic	Esthetician	x	x	x	x	x		x	x	x	
P22	27	38	2nd	PT	Basic	Hotel maid	✓	x	x	✓	✓	✓	✓		✓	
P23		33	2nd	PT	Basic	Customer service	✓	x	x	x	x	✓	x	x		
P24	40	20	1st	PT	Basic	Geriatric assistant	✓	x	x	✓	✓	✓	✓	x	x	
P25	37	35	2nd	FR	BA	Stylist	x	x	x	✓	✓	✓	x	✓	✓	✓

Pregnancy trimester: NA - Not applicable. **Nationality:** BR - Brazilian, FR - French, PT - Portuguese, UA - Ukranian. **Level of education:** Basic - basic education cycle completed, H. School - High school education cycle completed, BA - Bachelor of arts completed, PG - Postgraduate program or certificate completed, MSc - Master of Science completed, PhD - Doctorate completed. **Logs glucose on app:** m - MySugr mobile app, o - OneTouch mobile app. Blank fields mean missing data.

Table 3. Characteristics of the nurse participants from this study. The table displays demographic information, years of experience as a nurse, and work location.

P	Age	Years of experience	Workplace
N1	53	30	ULSSA/CMIN
N2	46	20	Family Health Unit from (centre region)
N3	46	20	ULSSA/CMIN
N4	32	9	Family Health Unit from (northern region)
N5	43	25	ULSSA/CMIN

from their clinical practice, and encouraged reflecting on the potential impacts for clinical care. Moreover, one author had their partner's risk pregnancy monitored in one maternity hospital studied, which might have helped understand risk pregnancy surveillance at that hospital. Two more authors were pregnant and delivered their babies during the project, which might have helped empathise with participants.

Data analysis drove the data collection, meaning the interview scripts were regularly updated to reflect the focus of the codes and categories identified in the analysis. People living with GD were interviewed only once due to anonymity, but we sent follow-up questions by email to people who had GD in the past and to nurses, asking them about codes we later identified in the data. The collected material was fully transcribed and coded in Portuguese to avoid losing meaning in translation [130]. Constant comparison [26] was used to compare quotes, participants, and settings.

We systematically coded all collected material using a bottom-up approach. We performed iterative open coding [26] up to participant P17 and engaged in more focused coding [26] thereafter, as the theme of self-monitoring practices became prevalent in our dataset. Coding was performed using Mural[11] boards, which enabled the labelling of quotes and organisation of the material into codes, categories, and themes, as well as supporting team discussions. The coding itself was performed by the first author in regular discussion with the last author, as these authors conducted most interviews. The remaining authors provided feedback on the main categories and representative quotes, in Portuguese and English, following PowerPoint presentations of the analysis, or iterative versions of the manuscript. The translation of the quotes was performed by the first author, fluent in the source language and independently verified by a second bilingual author to ensure accuracy and fidelity to the original meaning. The remaining non-Portuguese authors reflected on whether the quotes were clear and comprehensive.

The main theme identified in the analysis involved self-monitoring practices of women with GD (See Figure 1), which are described in this paper. Other themes identified include *"Practices employed for diet changes"*, *"Impacting the family and social life of people living with GD"* and *"Getting support from their spouse"*.

3.4 Ethics

We followed ethical guidelines and principles to protect participants' rights and welfare. All interviewed participants provided written informed consent prior to the interviews, after being informed about the project, data collection, and data management. Verbal consent was obtained before the observations after hearing a brief summary of the project and observation objectives. People living with GD who took part in observations also received a flyer with additional information and contacts to reach out to the research team. The study was

[11]The MURAL platform is a digital workspace for visual collaboration that draws on post-its and other multimedia material, which proved to be useful in coding and organising quotes. MURAL is available at: https://www.mural.co/.

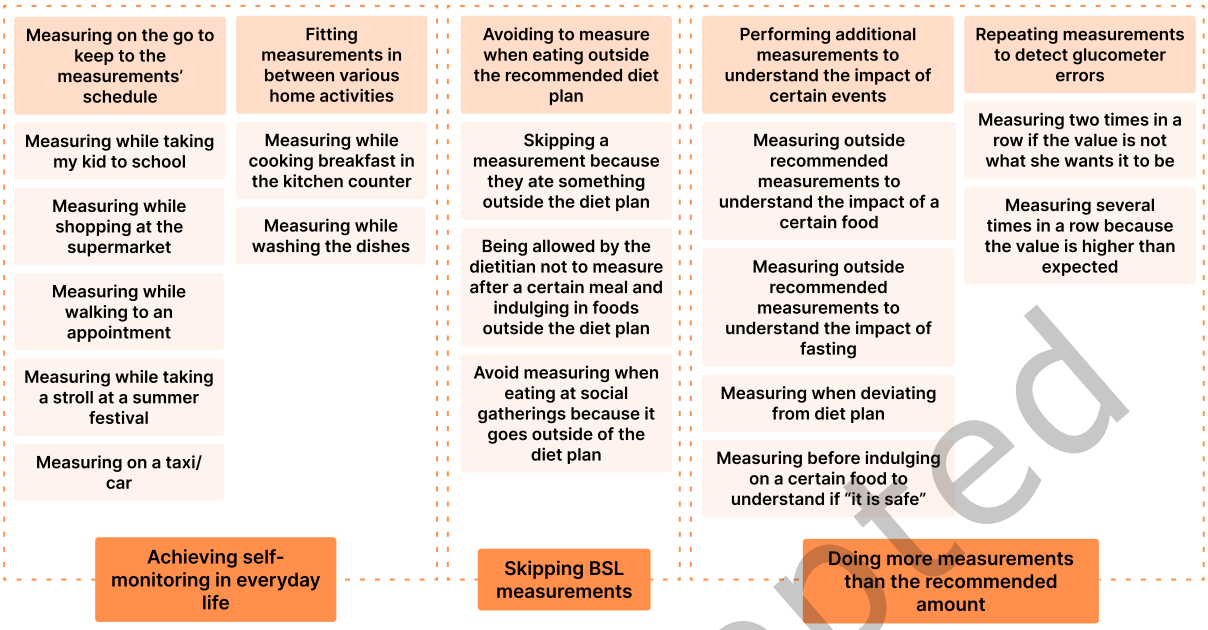

Fig. 1. Thematic Map.

approved by the ethics boards of ULSSA/CMIN and ULSPVVC. The observations in ULSSJ/MAC were conducted as part of the third author's master study in clinical nutrition and were considered exempt from ethics clearance[12].

4 Self-monitoring practices in GD

Engaging in self-monitoring was an important part of the lives of the participants in our study. While participants could not change their condition following diagnosis, engaging in self-monitoring was their chance to know the impact of their eating and exercise practices, and if they were risking future consequences for them and the baby. Thus, our participants quickly learned to monitor their blood glucose and integrated complex self-monitoring practices into their everyday lives. In this paper, we discuss these self-monitoring practices, focusing on how people living with GD: (i) ensured they made the measurements at the correct time, (ii) used measurements to learn about the impact of certain events, (iii) repeated measurements to learn more, and/or (iv) avoided taking measurements so as not to be confronted with the obtained values (see Figure 1). Before describing these practices, we will contextualise the care follow-up and environment of our participants, based on insights from observations or interviews.

Participants in our study were regularly monitored at the hospital or maternity hospital because, in Portugal, GD is considered a high-risk pregnancy. Following diagnosis in the first or second trimester tests, people living with GD were referred to the hospital or maternity hospital where they consulted an endocrinologist and nutritionist every two or four weeks, to monitor the condition status, receive diet advice, or adjust the meal plan. Most people living with GD were able to control the condition using diet changes and exercise, but when

[12]Master theses based on observation are considered exempt from ethics clearance at ULSSJ/MAC. We consulted with the president of the ethics board of the institution to know if we should apply for ethics review at the hospital, to be able to use the results of the master thesis in the context of the larger project. We were told that the project was considered exempt as the focus of the master thesis was strongly aligned with that of the larger project.

Fig. 2. Setup used by nurse N1 to teach people living with GD to perform blood glucose measurements at ULSSA/CMIN. From top left, we find needles inside a plastic bag, a gauze strip, and test strips inside a silver package. In the row below, we find the glucometer and the lancet.

this first line of treatment was unsuccessful, they were prescribed Metformin or insulin. Between appointments, people living with GD were asked to measure their blood glucose three or four times a day – with measurements during fasting, and before or after breakfast, lunch, and dinner – and to perform additional blood tests or exams that led to care adjustments.

To learn how to measure blood glucose, people living with GD had one or two appointments with a nurse at the hospital or primary care. During this appointment, the nurse provided people living with GD with the tools they would use (See Figure 2), namely (i) the glucometer – a machine that shows the blood glucose value, (ii) the lancet – used to prick the finger, and (iii) the test strips – where they will drop the blood and insert into the glucose device monitor. The nurse provided patients with a booklet or sheet for writing down the measurements and informed they could install a mobile app, for patients who were proficient with the smartphone and who had been prescribed a device that featured a dedicated app. Patients were advised multiple times to wash their hands with soapy water and dry them before handling the testing equipment. The nurse taught how to prick the sides of the fingers and alternate fingers to prevent soreness, following international guidelines [74]. After showing patients how to measure their blood glucose, the nurse asked them to repeat the process to ensure they understood it. During the appointment, the nurse emphasised the importance of following the diet plan, explaining that, like a prescription, it should be followed precisely in terms of portion sizes and timing to ensure effectiveness. The nurse also explained that the only way to ensure the diet is working is for patients to engage in self-monitoring.

4.1 Fitting measurements in between various home activities

One common insight from the interviews was that measuring blood glucose occurred in between a myriad of activities. A GD diagnosis leads to a big change in lifestyle – a set of activities added to paid work, care work, housework, errands, and pregnancy – or GD-related appointments. When asked about blood glucose measurements, participants often shared cases in which they were carrying out an activity, quickly paused to perform the measurement, only to return to the initial activity.

> *'I'm washing dishes, in the meantime [the alarm] is ringing to measure, I wash my hands, I measure, it becomes a.... it is when it has to be.'* – **P17**, 10 weeks since diagnosis[13]

Most participants we interviewed frequently measured their blood glucose in the kitchen. The measurement schedule in GD is strongly related to meals, because participants need to measure before eating and/or one hour after eating. Placing the glucometer and measurement setup on the kitchen counter was the most common experience because, as participants confided, it can be quite practical to measure in the same place where they prepare, eat, or clean up after meals. Additionally, being at the kitchen counter while performing the measurement enables participants to wash their hands, operate the lancet and strips easily, and write down the value obtained in the dedicated booklet or sheet. In this particular case, P17 needed to measure her blood glucose 1h after the meal, and as she was cleaning up in the kitchen, she could quickly operate the glucometer and setup and return to her activity, without significantly impacting her everyday activities.

Another way participants found to make measurements quicker and less time-consuming was to take them while standing, as the following example from P9 shows.

> *'[in the morning, when measuring] fasting, I'm always standing, because I have to prick [my finger] and cook breakfast'* – **P9**, 12 weeks since diagnosis

The majority of participants in our study measured their blood glucose while standing, often at the kitchen counter. The surface of the kitchen counter made the measurement easy, as mentioned above, but it also enabled participants like P9 to multitask. Instead of sitting and taking the blood glucose measurement steps one at a time, P9 interweaved them while preparing breakfast, making use of the wait times of cooking to use the glucometer, as a way to accomplish both her family and health commitments. Measuring while standing was thus a choice made for practical reasons and flexibility.

Being able to perform measurements quickly and practicably was important to participants as they tried to adapt the practice to their daily life, and not have it interfere with their routine. Reflecting on why people living with GD measured their blood glucose while standing and in the kitchen, nurse N5 shared:

> *'And this [glucose measurement] is something that in the midst of a life with lots of things to do, in the middle of a kitchen, and we're preparing our meal, and sometimes there are children, and sometimes there are more things to do, and we're like, this has to be quick, doesn't it? (...) And maybe I'd often do it [glucose measurements] standing up and at the kitchen sink. If nobody told me it was important to sit down.'* – **N5**, nurse

Measuring blood glucose can be challenging, considering the busy pace of life and the multiple responsibilities that people living with GD already have. Taking measurements between activities, while standing or even multitasking, was the way our participants used to control their tasks. To nurse N5, these adaptations were not only understandable but also an efficient way to deal with the challenges that the participants faced.

[13]We present the number of weeks since diagnosis to highlight how quickly it was for participants to come up with these practices, and how fast they were able to learn to control the condition.

4.2 Measuring on the go to keep to the measurements' schedule

The need to take blood glucose measurements outside the home also accompanied people living with GD. Participants were advised to follow the recommended measuring schedule as much as possible, so they acted to ensure they remembered to take the measurements and all the needed materials. Measuring outside the home also meant that people living with GD had to adapt to performing measurements in less-than-ideal conditions.

One way our participants ensured they measured their blood glucose at the right time was to set up smartphone alarms. Instead of relying on their memory or regularly looking at the clock, participants would set up alarms on their smartphones – a practice which was previously identified among people living with T1D, T2D [85] and GD [24]. When the alarm sounded, participants took action to measure their blood glucose, wherever they were, including at work, at a restaurant, at a café, at a party, at a festival, in the car, the taxi, walking their kids to school, or even while maneuvering a supermarket shopping cart. P17 shared an interesting example in which she used alarms to remember to measure.

> *'Just now at lunchtime. I had an appointment at half past three (...) I had to measure myself at three twenty, because I had a late lunch today, so I parked here by the barbecue restaurant. In the meantime, the alarm started to ring, and so I was walking and measuring myself.'* – **P17**, 10 weeks since diagnosis

P17 was going to the nutritionist appointment at the hospital, and since she needed to measure her blood glucose soon, she had set up an alarm on the smartphone. The participant had a glucometer pouch with her, which carried the glucometer device, the lancet, test strips, and the notebook to write down glucose values. When the alarm rang, P17 measured the blood glucose while she continued to walk. She could have stopped at a café, for example, but P17 did not want to arrive late to the nutrition appointment, so she opted to measure while she was walking to the hospital. Measuring while walking (quickly) was harder than measuring while sitting or standing, but the glucometer had a plastic piece that held the glucometer together with the lancet and strips (see Figure 3), making it easier to take the measurements. Taking the measurement according to the plan was crucial for P17, but she would rather be flexible about the conditions to measure and arrive to the appointment on time, than to look for a calm place with all the conditions to perform measurements and arrive late to her appointment. P14 also shared an instance when she decided to perform the measurement while walking.

> *'And then I set the alarm on my mobile phone for an hour later and we're, I don't know, walking somewhere and I'm like, «Look, the alarm's ringing» I take the thing [glucometer] out of my bag and prick while walking, that's it. The other day, in the middle of Senhor de Matosinhos [popular festival in the North of Portugal], I had a little piece [strip] in my hand and my friends, who I was with, said: "Do you want me to stop". It's not worth it, it's almost done. I just put it in, I take a photo and it's recorded on the phone'* – **P14**, 19 weeks since diagnosis

Before leaving home, P14 set up an alarm clock for 1h after the meal, and packed her glucometer, lancet, and strips in her purse. After setting up the alarm, P14 could engage in other activities without needing to keep close control of the time to measure. However, when the alarm rang, she remembered and started to prepare things to measure her blood glucose. Feeling that she could measure while walking, P14 chose not to stop the stroll. After the measurement, P14 took a picture of the glucometer's screen so she could register the value in the notebook at a later point. Despite being at a festival, P14 prioritised her blood glucose measurement routine, taking the measurement as necessary. Other participants reported that measuring was their priority, and that meant stopping their day-to-day activities to take their measurements, even if they had to ask the person with them to hold some of the materials or to lean on the supermarket shopping cart. As in the previous section, people living with GD often managed the condition trying to minimise the impact it had on their lives, but still prioritising the measurements. Measuring while standing was one way to achieve this goal.

Fig. 3. Participant P17's glucometer. In this figure, you can see all the material that is used to do the self-monitoring. The pen to the left had the lancet to prick the finger. The bottle below holds in the strips. You can also observe on the top of the machine the slit to insert the strip. This particular device has a holder that connects all the necessary pieces, allowing this particular participant to measure while walking.

Participants also mentioned other situations where they measured their blood glucose in less-than-ideal conditions.

> *'I did it once in a taxi, you know? You're in a taxi and the driver is driving so he doesn't look, and I do my thing quickly (...).'* – **P25**, 9 weeks since diagnosis

P25 described how she took a measurement during a taxi car ride. In this situation, P25 did not have a table, a stable environment, or conditions to wash her hands, but she prioritised sticking to her planned schedule and decided to proceed to measure anyway. Being adaptable was key to living well with gestational diabetes. According to our participants, being willing to accept the responsibility of taking the glucometer pouch and the flexibility of measuring anywhere, the impact on their daily life was greatly reduced.

When discussing these insights with the nurses, N1 told us that the plastic piece of P17's glucometer is part of its packaging. While the plastic piece comes with the device, users are, according to N1, expected to remove it before using. N1 explained that when demonstrating the use of the glucometer, she always took all pieces out of the packaging and placed them on the table before asking patients to perform a measurement (See Figure 3). It had never occurred to her that patients might use the packaging as a holder or even use it to measure blood glucose while walking. Nurse N3 was also surprised by this creative use of the plastic piece of the glucometer

package and questioned the possible risks this practice might have on the accuracy of the BGL: *"Now, if it has repercussions, if it changes the value, then I have my doubts, don't I?"*, showing that she could acknowledge the technique while still reflecting on whether it might affect the accuracy of blood glucose measurement results.

Even with limited time to learn and practice, participants quickly adapted and incorporated self-monitoring into their daily routines, even repurposing a piece of packaging as a holder to assist with measurements while walking. Although the participants had been diagnosed only a few weeks earlier, they had already adopted practices typically associated with relevant experience and reflection.

4.3 Performing additional measurements to understand the impact of certain events

Our participants reported measuring their BGLs more frequently than recommended to understand the impact of specific foods, such as those outside their typical diet plan. By evaluating multiple measurements throughout the day, they tried to understand how their values were impacted by certain actions.

As mentioned before, healthcare professionals typically recommend monitoring blood glucose 3 to 4 times a day, at specific times and, during their appointments, the nurse emphasised the importance of adhering to these schedules – *"The guidance we give here is to keep to the schedule."* – **N5** (from observations). Regular monitoring, N5 explained, enables both patients and healthcare professionals to evaluate the effectiveness of the diet plan and determine if any adjustments are necessary. When providing the training, nurses advised people living with GD to write down what they ate to determine if a particular food or its quantity caused the change in blood glucose values.

One of our participants, P9, shared a situation where she felt the need to measure blood glucose beyond the recommended measures. Curious about the impact of eating ice cream on her blood glucose values, she decided to take an additional measurement afterwards.

> *'I've already had ice cream and I measured it... it was within the normal range and I felt calm. If it had been high, I would never have eaten it again. (...) I measured it just to make sure it wasn't doing any harm, but I didn't take ice cream again. It was really like, I'm going to go off the diet, so I'm going to measure [more]. I hardly ever have ice-cream. It was really sporadic, I really felt like it '* – **P9**, 12 weeks since diagnosis

The ice cream was not part of the prescribed diet plan, so P9 decided to take an extra measurement to make sure the ice cream did not raise her blood sugar values above the recommended limit. Even though the values did not rise, P9 still decided not to indulge again and stick to the diet plan prescribed by the dietitian, as that would be safer for her baby. Other participants shared that they would take extra measurements when they decided to try out a different food, that might or not be on the diet plan, but that they were not sure what impact it would have on their BGLs.

Participant P16 found herself in a similar situation when she was at a birthday party and wanted to have some cake. Before eating the piece of cake, P16 decided to measure to make sure her values were not so high that they could surpass the blood glucose level limit. This was particularly useful when people living with GD were already aware of what were "normal" values for them, meaning they knew the range of values they usually oscillate between meals. Some participants even mentioned using a tighter threshold than the referenced values recommended by their healthcare professionals to reduce the risk of potential consequences. Getting to know their usual BGLs and their metabolism allowed our participants to measure before eating something they were not recommended and evaluate whether it would have an impact on the measurement after the meal.

Also noteworthy were participants who exercised or went for long walks after the main meals. These participants were informed by their healthcare professionals that if they took a walk between their meal and the measurement,

their values would decrease[14]. To better understand the impact that physical activity had on their BGLs and assess its potential to decrease BGLs, people living with GD would measure blood glucose after the walks and compare d them to days or meals when they did not practise physical activity. For some participants, this approach allowed them to occasionally eat more or choose different types of foods that would normally raise their BGLs, compensating with additional physical activity to reduce its impact.

Participants also learned from the recommended measures. For example, participant P11 shared how it took her a while until she found the number of hours she could spend fasting at night.

> *'So if I'm struggling with 7h [of fasting time] (...) let's try it tomorrow with 8 and then 9...'* – **P11**, 17 weeks since diagnosis

The number of hours a person living with GD spends fasting is also part of the meal plan provided by the dietitian. The interval between dinner (or supper) and breakfast can strongly impact the blood glucose value measured before breakfast, but also the blood glucose values measured throughout the day – the greater the number of hours spent fasting, the higher the risk of elevated BGLs on the next day. These fluctuations in values pose numerous risks, the most immediate being risks to the foetus, so it was important for P11 to understand how many hours she could be fasting while keeping her values under control.

Participants recognised the importance of monitoring their BGLs to control GD. They also understood that certain factors, like a poor night's sleep or increased anxiety, could cause changes in their BGLs beyond their control. Performing additional measurements helped people living with GD feel more in control by allowing them to assess the impact of certain foods and physical activity in their diet. This knowledge also proved useful during appointments, where they could discuss with their dietitian potential alternatives to certain foods or meals.

4.4 Repeating measurements to detect glucometer errors

As participants learned about the impact of different meals on their body, they started predicting the range of values that would result from their measurements. When the measured values differed from what they were expecting, people living with GD tended to repeat the measurement, sometimes on the same finger, sometimes on a different finger, because they did not believe their values could be what the machine showed. During glucose measurement training, nurses explained to the patients – *" You have to wash your hands beforehand so that you don't get your hands dirty [when measuring] from a piece of fruit that might drop sugar and then the value is biased. You have to wash your hands beforehand and dry them well."* – **N2**. Errors could also happen due to an error on the glucose device monitor. However, in the case of participant P13, she shared that she measured her values several times in a short amount of time.

> *'I measured about 10 times [in a row]! The values vary every 5 minutes'* – **P13**, 19 weeks since diagnosis

When P13 noticed her BGLs rising without understanding the cause, she became anxious which, according to her dietitian, probably led to further spikes in her blood glucose values. As she entered the third trimester of her pregnancy – a time when the diet plan often requires adjustments due to fetal growth – her endocrinologist determined it was important to introduce medication, as it was no longer possible to control the condition with diet and exercise alone.

The most common reason, among our participants, to repeat measurements involved encountering BGLs higher than anticipated, prompting people living with GD to repeat the measurement more than once to discern whether it was a device error or their actual BGL (see Figure 4). This practice highlights the importance of people tracking their own data and associating BGL with specific events. By becoming familiar with these patterns, people living with GD readily identified anomalies, reflected on them, and discussed them with their dietitian

[14]Walking after meals enhances insulin sensitivity and stimulates muscle contractions, leading to increased uptake and utilisation of glucose by the body, consequently lowering blood glucose values [128].

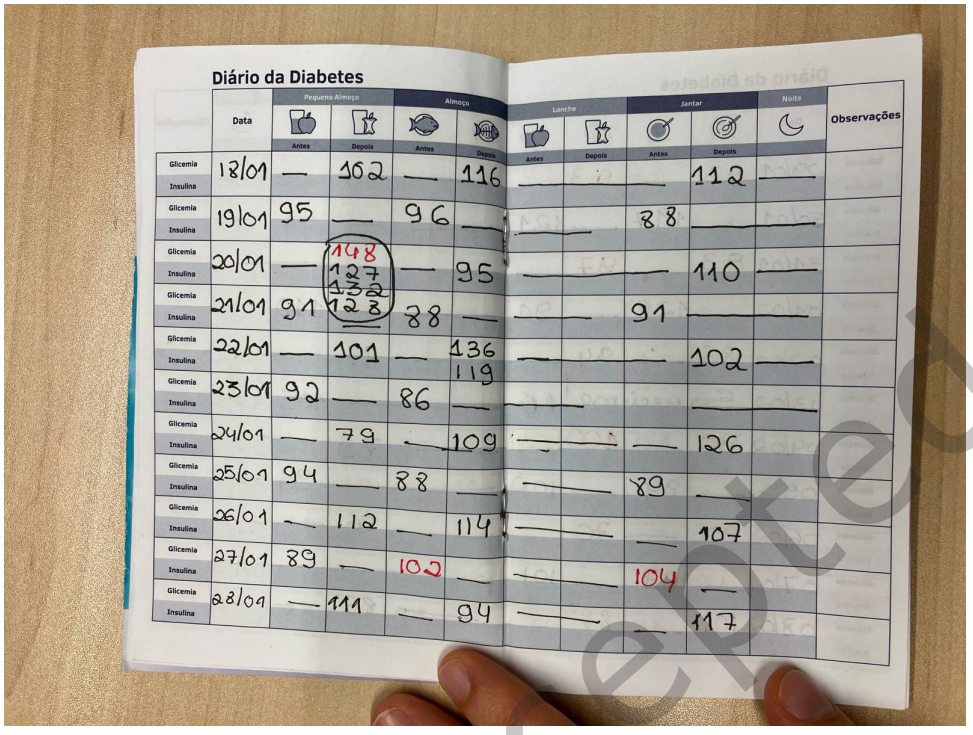

Fig. 4. Pages from the blood glucose log book. This particular log book enabled people living with GD to input BGL before and after four meals (breakfast, lunch, afternoon snack, dinner) and at night. This particular participant always measured before or after breakfast, lunch, and dinner. When the BGLs were above the recommended values she annotated them in red ink, in order to stand out from the others. On the left page, she annotated three different values in one meal (after breakfast on 20/01) showing that the participant measured several times in a row, obtaining different values.

or endocrinologist enabling adaptations to their diet (or medication) as needed. However, to prevent anxious reactions like the one experienced by P13, nurse N1 mentioned that she avoided sharing the reference values with more anxious patients, at least during the first appointment. She believed that knowing the reference values may cause patients to become overly fixated on the numbers rather than focusing on following the dietary advice.

4.5 Avoiding measuring when eating outside the recommended diet plan

The treatment of GD was quite hard for some of our participants. Having to change one's diet while experiencing more appetite, whims, and an emotional rollercoaster, was anything but easy. Social activities made it even harder because while people living with GD were limited to their diet, those around them could eat things that were forbidden to them. Even if most participants persevered in keeping to the meal plan, we understood that it was common for people living with GD to eat outside of the meal plan or indulge every few weeks. When eating more or outside the meal plan, participants would usually experience higher blood glucose values. Knowing that BGLs would be higher, some participants chose not to measure their blood glucose value, even calling it cheating[15].

'so I ate cake and then I didn't even measure it [BGL].' – **P1**, former patient

[15]Prior work on GD and T1D also referred to skipping measurements as cheating [63, 106, 120].

Participant P1 was very careful about her diet. She followed the diet plan by the book and noted down everything she ate next to her blood glucose value logs. However, as the quote shows, she was finding it hard to be so restrictive all the time – possibly due to more appetite, whims, group pressure or even family pampering. While attending a birthday party, P1 felt compelled to eat a piece of cake, even if it was outside the meal plan. Knowing that her blood glucose value would probably elevate beyond the recommended threshold, she decided not to measure. Avoiding measuring was a way for participants not to confront themselves with the impact of unrecommended meals on their blood glucose values. Though the value itself was there even if not measured, by not seeing how much it elevated, people living with GD felt less responsible for the impact of the food on their foetus and their health. Reflecting on these practices, nurse N5 shared:

> *'[putting herself in the patients' shoes, justifying why they do not measure] I made a mistake, and now I don't want to know the impact it had, well, maybe that's it. And what I think is that sometimes I can't understand why they missed, because sometimes, when they miss, when they don't do it, they don't say why'* – **N5**

Appointments with healthcare professionals can be quite daunting for people living with GD. Blood glucose levels are compared with thresholds, counted, and even discussed to better understand their possible causes. Even if the person living with GD is not completely responsible for their body's response, each value above the threshold can feel like a personal failure and a testament that they were not good mothers during that time. Healthcare professionals know about these feelings, but even if they reassure patients and ask for honest answers, it is very common to be confronted with missing values that professionals are unable to understand. The nurses explained that this practice is not common among people who take insulin, as they rely on knowing their BGLs to calculate the correct dosage to inject, but among people living with diabetes who do not take insulin, the situation is different. Choosing not to measure might reflect a miscommunication or misunderstanding of the role of measurement. Instead of serving as a tool to adjust diet plans and treatment to patients' physiological needs and appetite, measurement is sometimes perceived as a way to evaluate patients' competence, commitment, and motivation to deal with the condition.

5 Discussion

Our study uncovered the self-monitoring practices people living with GD adopt to better control the condition. After receiving a GD diagnosis, participants began to follow a diet plan and measure their blood glucose. What is most interesting is that only a few weeks after the diagnosis, participants already displayed self-monitoring practices that were creative, highly adapted, and effective. Our results suggest that learning to engage in self-monitoring and self-care can happen quite quickly, which contrasts with the literature on the self-care of chronic conditions that describes learning as slow, iterative, and dependent on many patient-clinician interactions [7, 17, 80, 98, 99].

Our paper makes a significant contribution to describing the self-monitoring practices of people living with GD. While prior work on the self-care of GD has touched on some aspects of self-monitoring, no study has described the practices of BGL measuring in depth. In this section, we discuss the quick learning of these practices and their adoption in the participants' day-to-day activities. Finally, we present three implications for informing the design of self-monitoring technologies for GD.

5.1 Quick learning of self-monitoring practices

A key insight of this study is related to the speed with which participants learned to engage in self-monitoring. Within weeks of their diagnosis, participants were adapting routines to measure on time, performing blood glucose measurement effectively, interpreting BGLs, repeating measurements to know the consequences of foods, and overall adjusting behaviours based on different factors, such as food, sleep, or stress. Seeing participants

perform the complex task of measuring while walking, like P17, less than ten weeks after the diagnosis, is a symbol of how efficiently people living with GD learned and how well they integrated this practice in their everyday life. Moreover, it is important to consider that patients' first appointment with endocrinologists, dietitians, and nurses conducting measurement training, could be four to six weeks after the diagnosis; meaning people living with GD had even less time to learn self-monitoring practices.

The learning speed of our participants contrasts with the typical learning experiences of people living with T2D and other chronic conditions, which was usually understood to be slow and repetitive [7, 17, 80, 98, 99]. The knowledge of our participants was also deeply tied to their experiences and measuring experiments, as with other people living with chronic conditions [7, 18], yet people living with GD did not get a grace period where the symptoms were more reduced and where they could slowly change their lifestyle and integrate treatment [109]. Unlike people living with chronic conditions, such as T2D and Chronic Obstructive Pulmonary Disease (COPD), where a serious complication (e.g., amputation, need to use oxygen) can be years or decades away, people living with GD may suffer complications of the condition within weeks or months [73], thus our participants were pressured to quickly learn and adapt their everyday life, as shown in prior work [63, 64]. People living with T1D are also pressured to learn quickly about their condition [33] because uncontrolled BGLs can have strong and immediate consequences on their lives. However, learning to control T1D typically takes more time because people need to master more complex measurement practices, such as carbohydrate counting [30]. In essence, people living with GD were able to quickly learn about their condition and change their lifestyle, because (a) they sensed the urgency of change due to the imminent possibility of complications, specifically for the baby, and (b) because self-monitoring practices they needed to acquire could be grasped quickly (unlike those needed for T1D).

The regular contact with healthcare professionals could also impact the speed of learning. Considering people living with GD are meeting clinicians every two to four weeks they would have more chances for receiving feedback. However, the self-monitoring practices described by participants seem to be the result of strong self-experimentation. For example, while healthcare professionals provided the thresholds for measurements, women with GD were the ones actively interpreting the reasons for their high BGLs after meals, and taking additional measurements to understand in-depth the impact of certain foods. We even mentioned in the results one participant (P11) who mentioned that she iteratively tried different fasting periods for achieving appropriate fasting BGLs. In this sense, the experiential learning of people living with GD also resembles that of people living with chronic conditions, who, through trial and error, learn to understand their body and disease [18, 112].

The motivation to do the best for the unborn baby also appears to accelerate engagement in self-monitoring and self-care, reinforcing the learning speed. Similar to prior work, participants in our study often mentioned that they were not practising self-care for themselves, but for the baby to have the best possible conditions and not be born with health issues [23, 24]. Not being able to control GD with only diet and exercise caused some participants to feel guilty of being a bad mother to their child, and thus, they felt pressured to achieve appropriate condition outcomes. The temporary nature of the GD also meant that the sacrifices people living with GD were making during pregnancy would be alleviated afterwards, which was another motivation to follow advice and engage closely in self-monitoring during pregnancy.

5.2 Adaptable and practical day-to-day practices

Participants in our study were very adaptable and practical with their measurements. At home, people living with GD would leave the glucometer on the kitchen counter, weaving measurements in between activities. Outside the home, they would take the glucometer in their purse, ensuring they could take the measurements on the go. These results suggest that self-monitoring is tightly integrated into the everyday lives of these women through multitasking or task switching. Aarhus and Ballegaard [2] previously mentioned patient flexibility in diabetes in a study describing how two patients stored and carried their glucometers. However, prior work has usually

provided little detail about how measuring blood glucose is carried out in practice, in different contexts. Even in studies such as the eDiary [3], which focuses on pregnant women with T1D, the results focus more on the practicality of having a tool that can be carried than on the practice of measuring in different places and situations. Similarly, O'Kane [106] notes various locations where participants measured (e.g., by the pool, at their office desk or on their bikes) and presents situations where participants are clearly multitasking (e.g. measuring while straightening the hair) but does not dive deep into how people living with T1D achieve this flexibility.

Prior work focusing on older adults living with T2D has not described practices such as multitasking in the monitoring of their BGLs [110]. While older adults are a diverse group, it is common for the average older adult to have a less active lifestyle or less mobility than younger adults which make multitasking during monitoring less common [2]. Our findings show a need to integrate self-monitoring in the daily lives or people living with GD, which aligns more closely with the experiences of people living with T1D [106]. O'Kane et al. [102] describes how people living with T1D negotiate when and where to measure based on personal preferences, social situations and past experience. A similar negotiation was present among our participants, justified by the immediacy of measurements, their motivation to protect their baby's health and the added burden of the condition on top of housework and childcare demands. Rather than adapting self-monitoring to fit their lives, our participants adapted their lives around self-monitoring, integrating it into ongoing activities through multitasking and task switching.

5.3 Impact and consequences of the self-monitoring practices on Gestational Diabetes

Measuring while standing or walking demonstrated high proficiency in taking measurements and a deep integration of these activities in participants' daily life, but there could be inconveniences in measuring under these circumstances. We know that the healthcare professionals from the centres we worked with, including nurses, dietitians, obstetricians and endocrinologists, did not advise participants on the position to measure blood glucose. Moreover, we found no guidelines [4, 97] or recommendations in the literature [15, 40, 74, 104] about which position should be adopted, as opposed to e.g., the monitoring of blood pressure which has specific guidelines to measure while sitting [131]. That said, performing blood glucose measurements while walking has the potential to result in different values. We understood, from the clinical partners in the project, that if people living with GD are not washing their hands they are more likely to have grease or sugar in them, affecting their BGLs. If people living with GD are measuring while walking, or in places where hand washing is not possible, they are most likely to skip it before taking the measurement. Every glucometer and every recommendation for BGL measurements mentions the importance of having clean and dried hands and that not doing so might have impacts on the BGLs and reduce measurement accuracy [15].

Measuring blood glucose more frequently than recommended can help pregnant women better understand their metabolism, allowing them to adjust their meals and physical activity accordingly [85]. However, some nurses worried that over-measuring could also have negative consequences. If P9 had based the decision of eating ice cream solely on the positive measurement that followed it, she could have decided to eat ice cream regularly, ignoring the impact it would have in later measurements (or in the long-term). Similarly, if people living with GD obtained alarming values from the glucometer, and instinctively decide to cut on carbohydrates, their values could be even less controlled [83]. For this reason, some nurses we interviewed chose not to disclose the target BGLs to patients to prevent such behaviours.

Not measuring blood glucose had conflicting consequences. On one hand, avoiding to measure could hide very high values and hinder clinicians from adjusting patients' treatment. On the other, avoiding to measure shielded mothers from confronting themselves with high BGLs following eating a meal outside of the meal plan. In our perspective, not measuring reflects a negotiation between the desire to enjoy foods outside the recommended meal plan and the remorse of not adhering to it. This tension was also identified by Gorm and Shklovski [52],

who described how self-tracking can create feelings of disappointment and guilt when people do not live up to the expectations their devices, or in this case, the recommended care, impose. Moreover, not measuring, for our participants, was a way to avoid judgment from healthcare professionals for not following the diet plan. We believe our insights encourage reflection about clinical guidelines and patient education to not only focus on ensuring people living with GD comply with their meal plan and measurements [35, 36], but also to learn the strategies to avoid high values when deviating from the diet plan (e.g., going for a walk after eating).

5.4 Implications for design

The self-monitoring practices of people living with GD made us reflect on how self-monitoring technologies could assist these individuals and what implications this would have for future technology design. In this section, we present three design implications for self-monitoring technologies derived from our findings.

5.4.1 Acknowledge and support the flexible use of the glucometer. Participants in our study were very flexible in how they measured to ensure they could take measurements at the right time. Being flexible meant participants were able to measure in hard-to-measure settings, such as at the back of a taxi, but what was more interesting was the appropriation[16], by the participants, of the glucometer[17] packaging. Multiple participants repurposed a plastic packaging (see Figure 3) piece that held together the glucometer, needle, and test strips, to measure while walking or using a single hand. We argue that glucometer manufacturers should acknowledge this creative use of packaging and reflect on how to support it because, as prior work argues [99], supporting appropriation has the potential to better fit the self-care technologies to the practices of people living with GD. We presume the manual or quick guide of the glucometer could mention this potential use of the plastic piece, encouraging more people living with GD to use it in their everyday life. Moreover, the colour of the plastic piece, glucometer or needle could also be adjusted to further give the idea that they make a single object or piece, which would signal to users they carry them together. By adopting these ideas, glucometer manufacturers would recognise that appropriation is inevitable, as mentioned in prior work [38, 102], promoting the flexible use of their device for people living with GD, and, perhaps, other people living with diabetes.

5.4.2 Explore the design of mobile app educational programs for GD. Our interviews showed that people living with GD learned many aspects about their condition and self-monitoring, within weeks of their diagnosis. The knowledge enabled women to learn about their body, understand the impact of certain foods, and ensure they measured at the right time, all of which while limiting the impact of self-monitoring practices in their everyday life. Having said this, there were some recommendations provided in nutrition and nurse appointments that were not being fully implemented by some participants, including handwashing before taking measurements or measuring the blood glucose after eating foods outside of the plan. We argue mobile app educational programs could support patient education and help implement more appropriate self-monitoring practices, because, as studies explain, better informed patients achieve better practices and outcomes [24, 62, 103, 129]. Most apps for GD do not present an educational program, and those that do are usually limited to presenting information about the condition, its symptoms, and/or very high-level advice [48]. To avoid these issues, educational programs could, for example, teach about the risks of GD, offer information on the importance of measuring, remind how to take a measurement, provide tips to implement self-monitoring, and how to deal with high values (e.g., going for a walk after main meals). Behavioural change techniques or gaming elements might be especially appropriate to support

[16]Appropriation is an anthropological concept that means making something one's own. In the context of HCI, appropriation is used for the phenomenon by which users adapt technology to their particular characteristics and the circumstances they encounter [39].
[17]Our participants received their glucometers from the healthcare institutions. Their device was chosen by their healthcare professionals, usually their endocrinologist. None of our participants was using a continuous glucose monitor, despite its potential for simplifying blood glucose monitoring [36], as they are not reimbursed by the healthcare system for people living with GD (only for people living with T1D).

education programme effectiveness [100]. Moreover, just-in-time interventions, which have been used in T1D and T2D, might also be useful to support the adoption of appropriate behaviour when certain context conditions are met [58, 79]. In essence, educational programs provide the opportunity to complement the education in the nutrition appointment, highlighting and reminding appropriate behaviour, and contributing to healthy practices and positive outcomes.

5.4.3 Explore the design of features to experiment and learn from additional measurements. Participants in our study often took additional measurements to learn about their body's reaction to specific foods or quantities. Motivated by high glucose values, unrecommended food intake or curiosity about the impact of going for a walk after meals, participants repeated measurements to track their glucose value evolution and make sense of it. While people living with GD take repeated measurements with their glucometer, the apps and paper logs alone did not actively help them reflect and learn from their measurements, as there were no dedicated features to annotate and visualise measurements performed as part of an experiment. We argue that mobile apps for GD could integrate an experimental mode, in line with self-experimentation literature [70, 71], to allow users to organise and categorise measurements around specific behaviours or contexts. If, for example, users could create a category for *"ice cream"* or *"after meal walks"*, people living with GD would be able to aggregate and interpret measurements over time to identify patterns and distinguish consistent effects from isolated events. This approach builds on existing annotation and extra-logging features (see Table 1), but advances them by enabling a longitudinal, user-defined analysis of personal data. The recorded values could, in the future, enable intra-individual forecasting to support personalised feedback, building on the work from Paymal and Homewood [107] who argue that technology should adapt to the user's current and prior input. Prior studies also highlight that real-time, context-specific feedback can enhance understanding and improve self-management outcomes for GD [77] and for other chronic conditions [53].

In addition, we propose that the experimental mode be complemented with tailored visualisation tools, complementing the work of Kanstrup et al. [67] and Smith et al. [121]. Despite different clinical implications, current self-monitoring apps often rely on simplified timelines that do not differentiate between fasting and post-prandial BGLs. These uniform visualisations limit users' ability to interpret their data effectively. We argue that visualisations should integrate the contextual data captured through the experimental mode – such as food intake, activity, or sleep – to enhance users' ability to reflect on trends and identify meaningful patterns in their BGLs [64, 77]. Interactive visualisations could support better comprehension of the data, more informed decision-making, and discussions during clinical appointments, which can be a challenge, as shown by prior research from Storni [123] among people living with diabetes and hypertension.

5.5 Limitations

This study has several limitations. First, the retrospective approach of interviews to explore self-monitoring practices might have limited the amount of detail we could capture from, for example, observations. Additionally, because interviews require participants to rely on memory when describing their practices, this method provides valuable insights into their perspectives, but it may not always accurately reflect what actually occurred. Second, we included people who had GD in the past as participants. While the data from their interviews complemented and closely aligned with the data of people living with GD, we acknowledge the potential for additional recall bias in these interviews. Third, the limited number of observations and interviews with nurses may not fully capture the broader range of practices and perspectives among healthcare professionals managing GD. Fourth, the design implications presented have not been systematically tested or validated by healthcare professionals or people living with GD, limiting their practical applicability. Lastly, the results of this study are situated in the Portuguese context, which offers patients obstetrics, endocrinology, and dietitian appointments, which might

not be common everywhere. We were reminded by reviewers that countries like the UK have a national app for supporting GD and that there might be particularities of self-monitoring in such a context, which could differ.

6 Conclusions and Future Work

This study described the self-monitoring practices of people living with GD. After only a few weeks with the condition, people living with GD exhibited complex self-monitoring practices that were highly creative and adapted to their activities. Participants mentioned taking measurements in the kitchen, in between activities, outside the home, while standing, or even on the move, while walking to other commitments. They used smartphone alarms and were tolerant to measuring in hard-to-measure settings to ensure they did not miss any measurements. Participants measured, in addition to the recommended measurements, to understand the impact of certain events, with repeated measurements being used to detect error values in glucometer devices. Finally, we also understood some participants chose not to measure when they indulged in food that was out of their meal plan to avoid confronting themselves with the high measurement values.

Our results help reflect on self-monitoring and the role of self-monitoring technologies. The speed with which participants learned to engage in self-monitoring questions the idea from the self-care literature that learning to engage in self-care and self-monitoring is slow and iterative. The willingness to do what is best for the baby and the temporary nature of the condition motivated participants to quickly learn and put into practice self-monitoring practices. Our implications for design suggest acknowledging and supporting the flexible use of the glucometer, exploring the design of education programs and of features to support self-experimentation.

Future research could focus on validating and expanding upon these findings across diverse cultural contexts, recognising the impact of sociocultural aspects on self-monitoring practices. There is also an opportunity to explore how self-monitoring is performed with continuous glucose monitoring devices, increasingly common among people living with T1D, which automate the measurement process and may change the times in which people living with GD visualise and reflect on their measurements. There is an opportunity to improve the support of mobile apps for self-monitoring practices of people living with GD, drawing on implications, and we encourage researchers to follow a participatory design approach with people living with GD and healthcare professionals to achieve this. In our project, NUTRIA, we are incorporating reflections from the implications presented in this study and will engage in field trials with a mobile app for people living with GD.

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