Received: 29 March 2022 | Accepted: 16 November 2022

DOI: 10.1111/dme.15008

DIABETIC Medicine

RESEARCH ARTICLE

Pre-pregnancy health of women with pre-existing diabetes or previous gestational diabetes: Analysis of pregnancy risk factors and behavioural data from a digital tool

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Funding information
Public Health England, Tommy's and the Royal College of Obstetricians and Gynaecologists

Abstract

Aims: To examine health behaviours and risk factors in women with pre-existing diabetes or previous gestational diabetes mellitus who are planning pregnancy.

Methods: Health behaviour, risk factor and demographic data obtained from a digital pregnancy planning advisory tool (Tommy's charity UK) were analysed. Descriptive statistical analysis was performed, stratified by diabetes type.

Results: Data from 84,359 women, including 668 with type 1 diabetes, 707 with type 2 diabetes and 1785 with previous gestational diabetes obtained over a 12-month period (September 2019–September 2020) were analysed. 65%, 95%CI (61,68%) of women with type 2 diabetes and 46%, 95%CI (43,48%) with previous gestational diabetes were obese (BMI ≥30 kg/m^2), compared with 26%, 95%CI (26,26%) without diabetes. Use of folic acid supplements was low; 41%, 95%CI (40,41%) of women without diabetes and 42%, 95%CI (40,45%) with previous gestational diabetes reported taking folic acid (any dose) while 47%, 95%CI (43.50%) women with type 1 diabetes and 44%, 95%CI (40,47%) women with type 2 diabetes respectively reported taking the recommended dose (5 mg). More women with type 1 diabetes and type 2 diabetes reported smoking (20%, 95%CI [17,23%] and 23%, 95%CI [20,26%] respectively) and taking illicit/recreational drugs (7%, 95%CI [6,10%] and 9%, 95% CI [7,11%]) compared to women without diabetes (smoking 17%, 95% CI [16,17%], drug use 5%, 95%CI [5,5%]). Alcohol consumption, low levels of physical activity and of fruit and vegetable intake were also evident.

Conclusions: This study highlights the potential of online pregnancy planning advisory tools to reach high-risk women and emphasises the need to improve pre-pregnancy care for women with pre-existing diabetes and previous gestational diabetes, many of whom are actively seeking advice. It is also the first to describe pre-pregnancy health behaviours in women with previous gestational diabetes.

KEYWORDS
gestational diabetes mellitus, planning for pregnancy, pre-pregnancy, type 1 diabetes, type 2 diabetes

1 | INTRODUCTION

In line with the rising global prevalence of diabetes, the number of pregnancies complicated by pre-existing type 1 diabetes or type 2 diabetes and by gestational diabetes mellitus is increasing in the United Kingdom and elsewhere.[1,2]

Women with diabetes in pregnancy are at greater risk of maternal and neonatal complications compared to those without diabetes. A recent population-based cohort study of 17,375 pregnancies between 2014 and 2018 among women with type 1 diabetes or type 2 diabetes in England and Wales reported high rates of preterm birth, and of infants born large for gestational age. Higher than average perinatal deaths, particularly in women with type 2 diabetes, who now account for more than 50% of pregnancies complicated by pre-existing diabetes, were also reported.[3,4] The obstetric and neonatal complications associated with gestational diabetes[5] include large for gestational age infants, complications in labour and delivery and neonatal hypoglycaemia, as well as long-term implications for both mother and child.[6]

The importance of pre-pregnancy care is underpinned by the potential to improve already established suboptimal health behaviours and risk factors for pregnancy complications before a woman conceives.[7] We previously reported that UK women in general are not adequately prepared for pregnancy, with suboptimal health behaviours including smoking, lack of folic acid supplementation, alcohol consumption, low levels of physical activity and inadequate fruit and vegetable intake.[8]

Planning for pregnancy through tailored pre-pregnancy care, as recommended by the National Institute for Health and Care Excellence in the United Kingdom,[9] is particularly important for women who have pre-existing diabetes, to minimise risk before conception. Optimising glycaemic management and appropriate medication use, for example, stopping potentially teratogenic medication and commencing higher dose (e.g. 5 mg) folic acid,[9] among other preparatory actions, is known to improve pregnancy outcomes in this high-risk group. In contrast, for women who have experienced a previous pregnancy affected by gestational diabetes, there are no preconception-specific guidelines, only postpartum recommendations for diagnostic testing for diabetes and type 2 diabetes risk reduction.[9–11] This is despite the well-recognised risk of gestational diabetes recurring in a subsequent pregnancy.

What's new?

- There is limited knowledge of health behaviours in women who are planning pregnancy and have pre-existing diabetes or who developed gestational diabetes in a previous pregnancy.
- Our study highlights the reach of a digital tool designed to improve preparation for pregnancy by high-risk women with pre-existing diabetes or previous gestational diabetes.
- Sub-optimal health behaviours including a lack of folic acid supplementation, smoking, alcohol intake, low levels of physical activity and of fruit and vegetable intake are described. Over half of women were overweight or obese.
- This study emphasises the need to improve pre-pregnancy care for women with pre-existing diabetes and previous gestational diabetes.

Data on health behaviours in women with pre-existing diabetes are limited and to the best of our knowledge, there are no such data in women with previous gestational diabetes. The aim of this study was to examine pre-pregnancy health behaviours and pregnancy risk factors in women with pre-existing diabetes or previous gestational diabetes, who completed a questionnaire incorporated into a digital pregnancy planning advisory tool. An additional aim was to document the reach of such a digital tool among high-risk women.

2 | METHODS

Data were provided by a UK charity (Tommy's) which hosts a free digital pregnancy planning tool (https://www.tommys.org/pregnancy-information/planning-pregnancy/planning-for-pregnancy-tool). Information submitted between 1 September 2019 and 1 September 2020 was analysed. This online tool,[8] includes a questionnaire on pre-pregnancy health and lifestyle behaviours to identify women at higher risk of developing pregnancy complications. Following completion of the questionnaire, tailored advice for women with diabetes such as use of high dose folic acid and accessing specialist care is provided.

Demographic data included age (18–24, 25–34, 35–40 and 40+ years) and geographical location which was identified via the anonymised IP address and recorded by country. Women were asked to specify if they or their partner had ancestors from Africa, the Caribbean, the Mediterranean, India, Pakistan, South or Southeast Asia or the Middle East (yes/no/do not know).

Weight and height were reported and body mass index (BMI kg/m^2) calculated and recorded as a continuous variable, and according to World Health Organization categories (underweight <18.5 kg/m^2, recommended weight 18.5–24.9, overweight 25–29 and obese 30+).[12]

Data on health behaviours included smoking, folic acid supplementation of 400 μg or 5 mg daily, caffeine consumption, alcohol intake and use of recreational or illicit drugs (all yes/no). Dietary intake of five portions of fruit and vegetables at least 4 days a week was recorded (yes/no/do not know), and weekly physical activity reported as <150 min, at least 150 min of moderate activity or >150 min of vigorous physical activity (recorded as <150, ~150 and >150 min).

Women were asked if they had diabetes (type 1 diabetes, type 2 diabetes or another diabetes type), or if they had experienced gestational diabetes in a previous pregnancy. Women with diabetes or previous gestational diabetes were asked if they had spoken to their GP or diabetes specialist about their plans for pregnancy.

2.1 | Data and statistical analysis

Duplicate entries were removed (identified by time, date and IP address). To account for user error in the self-reported entries of height and weight, implausible entries were removed,[8] identified as being outside the range of 140–190 cm for height and 30–190 kg for weight. Not all questions were answered by every woman, and the maximal number of observations available for analysis was used for each question.

Descriptive statistics were calculated, stratified by all diabetes types; no diabetes, previous gestational diabetes, type 1 diabetes, type 2 diabetes, other diabetes types and no answer (respondents who did not specify if they had diabetes or not). Median and interquartile range were calculated for the continuous variables weight and BMI, and frequencies and percentages and 95% confidence intervals (CIs) were calculated for discrete variables.

Further analysis was performed by sub-dividing women into three subgroups; type 1 diabetes, type 2 diabetes and those with previous gestational diabetes. Within each of these subgroups, descriptive statistics were calculated, stratified by respondents located inside or outside the United Kingdom. Statistical analysis was performed using RStudio.

3 | RESULTS

3.1 | Study population

The Tommy's planning for pregnancy tool database recorded a total of 121,064 entries between 1 September 2019 and 1 September 2020. Following removal of duplicate entries, of the 120,919 observations, 95,551 women who were actively planning a pregnancy (having stopped

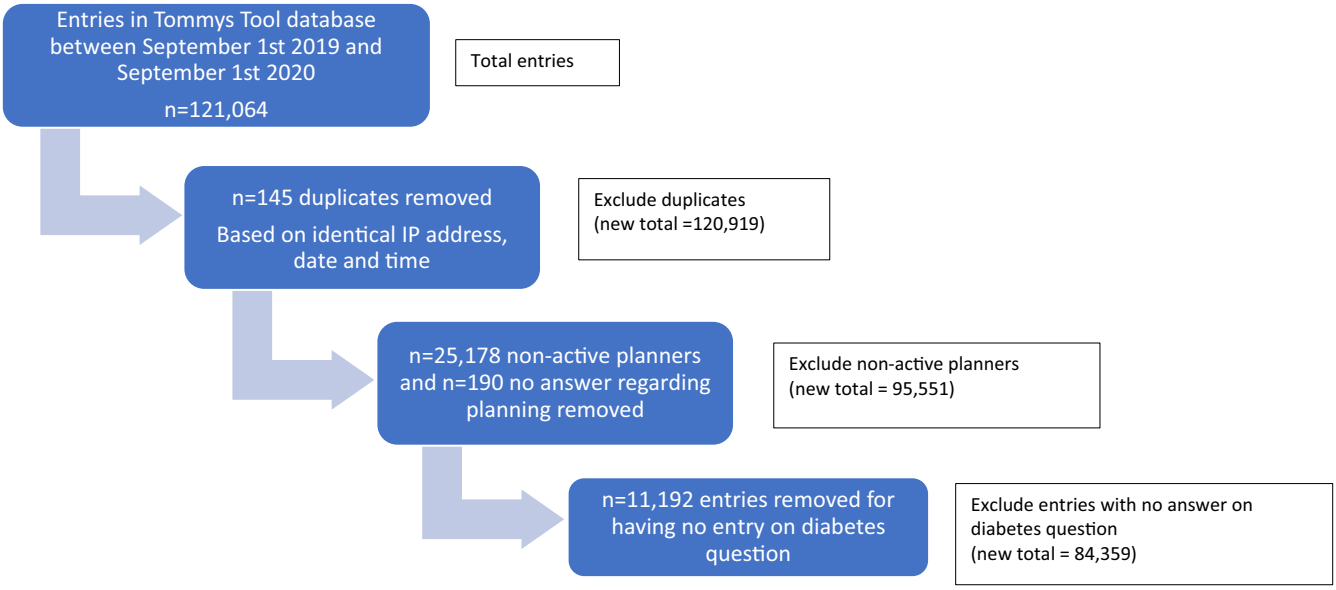

FIGURE 1 Flow chart of included women

TABLE 1 Demographics and preconception health behaviours of women with pre-existing diabetes, previous gestational diabetes or other types of diabetes

		No Diabetes (n = 81,042)			Type 1 diabetes (n = 668)		
Question	**Response**	**Number**	**%**	**95% CI**	**Number**	**%**	**95% CI**
Age (years)	18–24	18,133	22	(22,23)	157	24	(20,27)
	25–34	46,152	57	(57,57)	376	56	(53,60)
	35–40	11,795	15	(14,15)	96	14	(12,17)
	41+	2406	3	(3)	21	3	(2,5)
	No answer	2556	3	(3)	18	3	(2,4)
Higher risk ethnic group	No	55,755	69	(69,69)	490	73	(70,77)
	Yes	18,338	23	(22,23)	89	13	(11,16)
	Do not know	3790	5	(5)	29	4	(3,6)
	No answer	3159	4	(4)	60	9	(7,11)
Folic acid 400 μg*	No	41,006	51	(50,51)	3	0	(0,1)
	Yes	29,724	37	(36,37)	2	0	(0,1)
	No answer	10,312	13	(13)	663	99	(98,100)
Folic acid 5 mg	No	6410	8	(8)	337	50	(47,54)
	Yes	3345	4	(4)	311	47	(43,50)
	No answer	71,287	88	(88,88)	20	3	(2,5)
Folic acid any	No	47,399	59	(58,59)	337	50	(47,54)
	Yes	33,045	41	(40,41)	311	47	(43,50)
	No answer	598	1	(1)	20	3	(2,5)
Caffeine intake	No	19,380	24	(24,24)	159	24	(21,27)
	Yes	59,863	74	(74,74)	495	74	(71,77)
	No answer	1799	2	(2)	14	2	(1,4)
Five portions of fruit and vegetables	No	23,775	29	(29,30)	186	28	(25,31)
	Yes	42,719	53	(52,53)	361	54	(50,58)
	Do not know	12,606	16	(15,16)	94	14	(12,17)
	No answer	1942	2	(2,3)	27	4	(3,6)
Weekly exercise	>150 minutes	11,560	14	(14,15)	102	15	(13,18)
	~150 minutes	34,911	43	(43,43)	253	38	(34,42)
	<150 minutes	34,300	42	(42,43)	310	46	(43,50)
	No answer	271	0	(0,0)	3	0	(0,1)
Alcohol consumption	No	43,215	53	(53,54)	391	59	(55,62)
	Yes	36,098	45	(44,45)	262	39	(36,43)
	No answer	1729	2	(2)	15	2	(1,4)
Recreational/illicit drug use	No	75,340	93	(93,93)	600	90	(87,92)
	Yes	3834	5	(5)	49	7	(6,10)
	No answer	1868	2	(2)	19	3	(2,4)
Smoking status	No	66,320	82	(82,82)	521	78	(75,81)
	Yes	13,353	17	(16,17)	134	20	(17,23)
	No answer	1369	2	(2)	13	2	(1,3)

Type 2 diabetes (n = 707)			Gestational diabetes (n = 1785)			Other types of diabetes (n = 157)		
Number	%	95% CI	Number	%	95% CI	Number	%	95% CI
86	12	(10,15)	197	11	(10,13)	28	18	(13,25)
304	43	(39,47)	965	54	(52,56)	86	55	(47,62)
182	26	(23,29)	453	25	(23,27)	27	17	(12,24)
108	15	(13,18)	106	6	(5,7)	9	6	(3,11)
27	4	(3,6)	64	4	(3,5)	7	5	(2,9)
406	57	(54,61)	1166	65	(63,68)	78	50	(42,57)
217	31	(27,34)	444	25	(23,27)	43	27	(21,34)
36	5	(4,7)	66	4	(3,5)	12	8	(4,13)
48	7	(5,9)	109	6	(5,7)	24	15	(11,22)
0	0	(0,1)	655	37	(35,39)	1	1	(0,4)
2	0	(0,1)	485	27	(25,29)	1	1	(0,4)
705	100	(99,100)	645	36	(34,38)	155	99	(96,100)
387	55	(51,58)	345	19	(18,21)	88	56	(48,64)
309	44	(40,47)	272	15	(14,17)	56	36	(29,43)
11	2	(1,3)	1168	65	(63,68)	13	8	(5,14)
385	55	(51,58)	1000	56	(54,58)	87	55	(48,63)
311	44	(40,48)	757	42	(40,45)	57	36	(29,44)
11	2	(1,3)	28	2	(1,2)	13	8	(5,14)
199	28	(25,32)	410	23	(21,25)	36	23	(17,30)
495	70	(67,73)	1336	75	(73,77)	116	74	(67,80)
13	2	(1,3)	39	2	(2,3)	5	3	(1,7)
231	33	(29,36)	547	31	(29,33)	52	33	(26,41)
348	49	(46,53)	923	52	(49,54)	67	43	(35,51)
112	16	(13,19)	274	15	(14,17)	32	20	(15,27)
16	2	(1,4)	41	2	(2,3)	6	4	(2,8)
93	13	(11,16)	221	12	(11,14)	18	12	(7,17)
253	36	(32,39)	690	39	(36,41)	65	41	(34,49)
357	51	(47,54)	867	49	(46,51)	72	46	(38,54)
4	1	(0,1)	7	0	(0,1)	2	1	(0,5)
498	70	(67,74)	1143	64	(62,66)	89	57	(49,64)
196	28	(25,31)	606	34	(32,36)	62	40	(32,47)
13	2	(1,3)	36	2	(2,3)	6	4	(2,8)
630	89	(87,91)	1673	94	(93,95)	142	90	(85,94)
64	9	(7,11)	70	4	(3,5)	9	6	(3,11)
13	2	(1,3)	42	2	(2,3)	6	4	(2,8)
532	75	(72,78)	1456	82	(80,83)	129	82	(75,87)
163	23	(20,26)	298	17	(15,19)	26	17	(12,23)
12	2	(1,3)	31	2	(1,3)	2	1	(0,5)

(Continues)

TABLE 1 (Continued)

Question	Response	No Diabetes (n = 81,042)			Type 1 diabetes (n = 668)		
		Number	%	95% CI	Number	%	95% CI
BMI category[†]	Underweight (<18.5)	2426	3	(3,4)	15	3	(2,4)
	Normal weight (18.5–24.9)	31,140	43	(42,43)	213	38	(34,42)
	Overweight (25–29)	18,678	26	(25,26)	172	30	(27,34)
	Obese (30[+])	18,973	26	(26,26)	152	27	(23,31)
	No Answer	1694	2	(2)	14	3	(2,4)
Weight (kg)[†,‡]			69	59–82		70	62–82
BMI (kg/m^2)[†,‡]			25.5	22.3–30.3		26.0	22.8–30.5

Note: Demographics and preconception health behaviours of women stratified by those with and without diabetes. For each question with a categorical response the number, relative % and 95% confidence interval (CI) giving each response are presented.

*Note that for women with type 1 and type 2 diabetes, they were not asked about use of 400 μg folic acid as UK guidance recommends taking 5 mg.

[†]Note that for BMI, weight and BMI category any values deemed biologically implausible were excluded. For these questions, 8484 values are excluded reducing the data points used for the calculations to n = 75,875. This is split as n = 72,911 without diabetes, n = 566 with type 1 diabetes, n = 620 with type 2 diabetes, n = 1644 with previous gestational diabetes and n = 134 other.

[‡]For questions with a numeric response the median and interquartile range are presented.

contraception) were included. Of the 95,551 women, 11,192 did not answer the diabetes question and therefore were not included in the final analysis (n = 84,359), see Figure 1. Of the 84,359 women who initiated using the tool, 69% completed all core questions, and a further 25% completed all but one. The degree of missingness for each question is reported in Table 1. Women were predominantly based in the United Kingdom (54%), but respondents also included those living in the United States (17%), South Africa (7%) and India (5%). Four per cent of women reported some type of diabetes; 668 had type 1 diabetes, 707 type 2 diabetes, 1785 previous gestational diabetes and 157 reported having another type of diabetes. Women with type 2 diabetes and gestational diabetes were older; over 25% being 35–40 years of age, while 15% of women with type 2 diabetes were over 40 years. Compared to women without diabetes (23%, 95%CI [22,23%]), a higher proportion of women with type 2 diabetes (31% 95%CI [27,34%]) reported that they or their partner were from an ethnic group at higher risk of developing diabetes (Table 1).

Compared to women without diabetes, women with pre-existing type 2 diabetes or previous gestational diabetes had a higher BMI (median BMI 33.4 kg/m^2, IQR 28.2–40.0 and median BMI 29.3 kg/m^2, IQR 24.5–35.6 respectively). Approximately two thirds (65%, 95%CI [61,68%]) of women with type 2 diabetes and 46%, 95%CI (43,48%) of women with previous gestational diabetes were classified as obese, compared with 26%, 95%CI (26,26%) of women without diabetes.

Less than half of all women reported taking folic acid; 42%, 95%CI (40,45%) of women with previous gestational diabetes reported taking any folic acid, while 47%, 95%CI (43,50%) women with type 1 diabetes and 44%, 95%CI (40,47%) women with type 2 diabetes reported taking the higher recommended dose of 5 mg folic acid respectively.

Approximately half of women reported consuming five portions of fruit and vegetables at least 4 days a week which was lowest in women with type 2 diabetes (49%). Compared to women without diabetes, women with pre-existing diabetes or previous gestational diabetes had lower physical activity levels. Women with type 2 diabetes reported the lowest levels of physical activity with 51% reporting <150 min of activity a week followed by women with previous gestational diabetes (49%). Compared to women with no diabetes (17%, 95%CI [16,17%]), a higher proportion of women with type 1 diabetes and type 2 diabetes reported smoking; 20%, 95%CI (17,23%) and 23%, 95%CI (20,26%) respectively and taking recreational drugs; 7%, 95%CI (6,10%) and 9%, 95%CI (7,11%) respectively versus 5%, 95%CI (5,5%). Alcohol intake was highest in women without diabetes (45%, 95%CI [44,45%]), and lowest in women with type 2 diabetes (28%, 95%CI [25,31%]) while over 70% of all women consumed caffeine (Table 1).

When comparing UK versus non-UK women (Table 2), women with type 1 diabetes from the United Kingdom were less likely to be obese (27%, 95%CI [23,32%] vs. 43%, 95% CI [37,49%]) and more likely to take 5 mg folic acid (54%, 95%CI [50,59%] vs. 34%, 95% CI [29,40%]) compared to women living outside the United Kingdom. The question related to consulting with a GP or specialist prior to pregnancy was commonly unanswered (58% to 70% missing across all diabetes groups). In those who responded, United Kingdom-based women with type 1 diabetes were more likely to speak to a GP or specialist regarding their plans for pregnancy than non-UK women. In contrast,

Type 2 diabetes ($n = 707$)			Gestational diabetes ($n = 1785$)			Other types of diabetes ($n = 157$)		
Number	**%**	**95% CI**	**Number**	**%**	**95% CI**	**Number**	**%**	**95% CI**
6	1	(0,2)	34	2	(2,3)	3	2	(1,6)
72	12	(9,14)	416	25	(23,28)	33	25	(18,33)
129	21	(18,24)	406	25	(23,27)	36	27	(20,35)
401	65	(61,68)	752	46	(43,48)	57	43	(35,51)
12	2	(1,3)	36	2	(2,3)	5	4	(2,8)
	89	74–108		77	64–95		79	64–96
	33.4	28.2–40.0		29.3	24.5–35.6		29.0	22.3–30.4

non-UK women with previous gestational diabetes appear more likely to have spoken to a GP or specialist about planning for pregnancy although the 95% CIs for the proportion answering yes overlap.

4 | DISCUSSION

This investigation includes a large cohort of high-risk women with pre-existing diabetes or previous gestational diabetes who have utilised a digital tool for pregnancy preparation. The personalised practical advice provided by the digital pregnancy planning tool (e.g. regarding folic acid use, consulting a specialist) would have been appropriately targeted. However, many pre-pregnancy health behaviours were suboptimal in this higher risk group of women.

To our knowledge, this is the first study to describe health behaviours and pre-pregnancy risk factors in women with previous gestational diabetes. Our findings show that these women are not adequately prepared for subsequent pregnancies, especially through poor adherence to folic acid recommendations and a high prevalence of obesity. This emphasises the need for improved weight management strategies and tailored interconception guidelines for women at high risk of developing gestational diabetes in a subsequent pregnancy.

There was also a high prevalence of obesity in women with pre-existing diabetes which was independent of country of origin. Over two thirds of women with type 2 diabetes were obese, which concurs with the UK National Pregnancy in Diabetes audit that included 8685 women with type 2 diabetes, of which 65% were obese. Approximately, one in four women with type 1 diabetes were obese, also consistent with the audit which reported a prevalence of 22.8%.[3] Maternal obesity is an independent risk factor for stillbirth and other adverse pregnancy outcomes.[13,14,15] As obesity per se is a risk factor for type 2 diabetes and a mediator for poorer glycaemic control in pregnancy, strategies to optimise pre-pregnancy weight in women with pre-existing diabetes are strongly indicated.

Less than half the women with type 1 diabetes actively planning pregnancy reported taking 5 mg folic acid, also consistent with the National Pregnancy in Diabetes audit.[3] More women with type 2 diabetes in this study (43.7%) reported taking high dose folic acid compared to the audit which reported 22%. The recommendation that all women planning pregnancy should take folic acid clearly remains unheeded.[8] These data together with the National Pregnancy in Diabetes audit, support public health measures including mandatory folic acid fortification of white wheat flour, awaiting implementation across the United Kingdom.

We found that approximately one in five women with pre-existing diabetes reported smoking. Smoking is a risk factor for stillbirth in the general maternity population[16,17]; women with diabetes are at greater risk of stillbirth[15] as well as cardiovascular disease, therefore, support for smoking cessation is a particularly important component of pre-pregnancy care. Other suboptimal health behaviours included a low intake of fruit and vegetables, low levels of physical activity and alcohol and caffeine consumption consistent with previous reports in women planning pregnancy.[8] Our study indicates that such behaviours are already established before conception among these higher risk women, for whom diet and physical

TABLE 2 Demographics and preconception health behaviours of women with pre-existing diabetes or previous GDM by respondent location

		Type 1 Diabetes ($n = 668$)					
		UK ($n = 412$)			Non-UK ($n = 256$)		
Question		***n***	**%**	**95% CI**	***n***	**%**	**95% CI**
Age (years)	18–24	81	20	(16,24)	76	30	(24,36)
	25–34	250	61	(56,65)	126	49	(43,55)
	35–40	67	16	(13,20)	29	11	(8,16)
	41+	12	3	(2,5)	9	4	(2,7)
	No answer	2	1	(0,2)	16	6	(4,10)
Higher risk ethnic group	No	333	81	(77,84)	157	61	(55,67)
	Yes	48	12	(9,15)	41	16	(12,21)
	Do not know	9	2	(1,4)	20	8	(5,12)
	No answer	22	5	(4,8)	38	15	(11,20)
Folic acid 400 μg*	No	3	1	(0,2)	0	0	(0,2)
	Yes	1	0	(0,1)	1	0	(0,2)
	No answer	408	99	(98,100)	255	100	(98,100)
Folic acid 5 mg	No	182	44	(40,49)	155	61	(54,66)
	Yes	224	54	(50,59)	87	34	(29,40)
	No answer	6	2	(1,3)	14	6	(3,9)
Folic acid any	No	182	44	(40,49)	155	61	(54,66)
	Yes	224	54	(50,59)	87	34	(29,40)
	No answer	6	2	(1,3)	14	6	(3,9)
Caffeine intake	No	81	20	(16,24)	78	31	(25,36)
	Yes	329	80	(76,83)	166	65	(59,70)
	No answer	2	1	(0,2)	12	5	(3,8)
Five portions of fruit and vegetables	No	110	27	(23,31)	76	30	(24,36)
	Yes	248	60	(55,65)	113	44	(38,50)
	Do not know	48	12	(9,15)	46	18	(14,23)
	No answer	6	2	(1,3)	21	8	(5,12)
Weekly exercise	>150 m	49	12	(9,15)	53	21	(16,26)
	~150 m	169	41	(36,46)	84	33	(27,39)
	<150 m	192	47	(42,51)	118	46	(40,52)
	No answer	2	1	(0,2)	1	0	(0,2)
Alcohol consumption	No	223	54	(49,59)	168	66	(60,71)
	Yes	187	45	(41,50)	75	29	(24,35)
	No answer	2	1	(0,2)	13	5	(3,9)
Recreational/illicit drug use	No	387	94	(91,96)	213	83	(78,87)
	Yes	24	6	(4,9)	25	10	(7,14)
	No answer	1	0	(0,1)	18	7	(5,11)
Smoking status	No	335	81	(77,85)	186	73	(67,78)
	Yes	77	19	(15,23)	57	22	(18,28)
	No answer	0	0	(0,1)	13	5	(3,9)
Spoken to GP/specialist	No	15	4	(2,6)	26	10	(7,15)
	Yes	112	27	(23,32)	52	20	(16,26)
	No answer	285	69	(65,73)	178	70	(64,75)

Type 2 Diabetes ($n = 707$)						Gestational Diabetes ($n = 1785$)					
UK ($n = 347$)			Non-UK ($n = 360$)			UK ($n = 953$)			Non-UK ($n = 832$)		
n	%	95% CI	*n*	%	95% CI	*n*	%	95% CI	*n*	%	95% CI
35	10	(7,14)	51	14	(11,18)	86	9	(7,11)	111	13	(11,16)
151	44	(38,49)	153	43	(38,48)	501	53	(49,56)	464	56	(52,59)
97	28	(24,33)	85	24	(20,28)	292	31	(28,34)	161	19	(17,22)
60	17	(14,22)	48	13	(10,17)	64	7	(5,9)	42	5	(4,7)
4	1	(0,3)	23	6	(4,9)	10	1	(1,2)	54	7	(5,8)
203	59	(53,64)	203	56	(51,61)	679	71	(68,74)	487	59	(55,62)
115	33	(28,38)	102	28	(24,33)	219	23	(20,26)	225	27	(24,30)
6	2	(1,4)	30	8	(6,12)	13	1	(1,2)	53	6	(5,8)
23	7	(5,10)	25	7	(5,10)	42	4	(3,6)	67	8	(6,10)
0	0	(0,1)	0	0	(0,1)	342	36	(33,39)	313	38	(34,41)
2	1	(0,2)	0	0	(0,1)	300	32	(29,35)	185	22	(20,25)
345	99	(98,100)	360	100	(99,100)	311	33	(30,36)	334	40	(37,44)
178	51	(46,57)	209	58	(53,63)	168	18	(15,20)	177	21	(19,24)
163	47	(42,52)	146	41	(36,46)	135	14	(12,17)	137	17	(14,19)
6	2	(1,4)	5	1	(1,3)	650	68	(65,71)	518	62	(59,66)
176	51	(46,56)	209	58	(53,63)	510	54	(50,57)	490	59	(56,62)
165	48	(42,53)	146	41	(36,46)	435	46	(43,49)	322	39	(36,42)
6	2	(1,4)	5	1	(1,3)	8	1	(0,2)	20	2	(2,4)
90	26	(22,31)	109	30	(26,35)	222	23	(21,26)	188	23	(20,26)
256	74	(69,78)	239	66	(61,71)	725	76	(73,79)	611	73	(70,76)
1	0	(0,2)	12	3	(2,6)	6	1	(0,1)	33	4	(3,6)
126	36	(31,42)	105	29	(25,34)	275	29	(26,32)	272	33	(30,36)
177	51	(46,56)	171	48	(42,53)	528	55	(52,59)	395	48	(44,51)
40	12	(9,15)	72	20	(16,24)	145	15	(13,18)	129	16	(13,18)
4	1	(0,3)	12	3	(2,6)	5	1	(0,1)	36	4	(3,6)
40	12	(9,15)	53	15	(11,19)	100	11	(9,13)	121	15	(12,17)
131	38	(33,43)	122	34	(29,39)	380	40	(37,43)	310	37	(34,41)
175	50	(45,56)	182	51	(45,56)	469	49	(46,52)	398	48	(45,51)
1	0	(0,2)	3	1	(0,2)	4	0	(0,1)	3	0	(0,1)
242	70	(65,74)	256	71	(66,76)	591	62	(59,65)	552	66	(63,70)
105	30	(26,35)	91	25	(21,30)	357	38	(34,41)	249	30	(27,33)
0	0	(0,1)	13	4	(2,6)	5	1	(0,1)	31	4	(3,5)
321	93	(89,95)	309	86	(82,89)	929	98	(96,98)	744	89	(87,91)
26	8	(5,11)	38	11	(8,14)	17	2	(1,3)	53	6	(5,8)
0	0	(0,1)	13	4	(2,6)	7	1	(0,2)	35	4	(3,6)
259	75	(70,79)	273	76	(71,80)	810	85	(83,87)	646	78	(75,80)
87	25	(21,30)	76	21	(17,26)	139	15	(13,17)	159	19	(17,22)
1	0	(0,2)	11	3	(2,5)	4	0	(0,1)	27	3	(2,5)
15	4	(3,7)	20	6	(4,8)	203	21	(19,24)	172	21	(18,24)
87	25	(21,30)	130	36	(31,41)	100	11	(9,13)	143	17	(15,20)
245	71	(66,75)	210	58	(53,63)	650	68	(65,71)	517	62	(59,65)

(Continues)

TABLE 2 (Continued)

Question		Type 1 Diabetes ($n = 668$)					
		UK ($n = 412$)			Non-UK ($n = 256$)		
		n	%	95% CI	*n*	%	95% CI
BMI category[†]	Underweight (<18.5)	22	5	(4,8)	22	9	(6,13)
	Normal weight (18.5–24.9)	163	40	(35,44)	51	20	(16,25)
	Overweight (25–29)	113	27	(23,32)	60	23	(19,29)
	Obese (30+)	113	27	(23,32)	110	43	(37,49)
	No Answer	1	0	(0,1)	13	5	(3,9)
Weight (kg)[†,‡]			70	61–81		70	62–84
BMI (kg/m^2)[†,‡]			25.6	22.7–30.1		27.3	23.8–30.9

Note: Demographics and preconception health behaviours of women stratified by diabetes type and whether the respondent had a United Kingdom-based IP address or not. For each question with a categorical response the number, relative % and 95% confidence interval (CI) giving each response are presented.

*Note that for women with type 1 and type 2 diabetes, they were not asked about use of 400 μg folic acid as UK guidance recommends taking 5 mg.

[†]Note that for BMI, weight and BMI category any values deemed biologically implausible were excluded. This leads to reduced denominators used in these questions split as, $n = 566$ with type 1 diabetes, $n = 620$ with type 2 diabetes and $n = 1644$ with previous gestational diabetes.

[‡]For questions with a numeric response the median and interquartile range are presented.

activity are fundamental to management, and should be targeted during pre-pregnancy care.

Uptake of pre-pregnancy care is particularly poor in women with type 2 diabetes, considering their higher risk of pregnancy and birth complications.[18,19] There is a general lack of awareness about pre-pregnancy care needs of women with type 2 diabetes among not only the women themselves, but also healthcare professionals.[20] Pre-pregnancy care is not adequately integrated into the routine care of women with type 2 diabetes. In contrast, women with type 1 diabetes are more likely to be cared for by specialist teams.[21] While previous studies have attempted to improve pre-pregnancy care uptake in women with pre-existing type 1 diabetes and type 2 diabetes,[18,19,22,23] improvements in outcomes are mostly among women with type 1 diabetes, with limited impact of pre-pregnancy care in those living with type 2 diabetes from minority ethnic groups and/or lower socio-economic status.[18,19,23] Only 6% of women with diabetes from minority ethnic groups were adequately prepared for pregnancy in the National Pregnancy in Diabetes,[3] and in the present study, over 30% of women with type 2 diabetes belonged to an ethnic group considered high risk for diabetes. This implies that online support could be used to enhance pre-pregnancy care uptake in multi-ethnic groups of women with diabetes.

This study highlights the potential of digital tools to reach high-risk women planning pregnancy. The Tommy's tool provides personalised advice to women with pre-existing diabetes or previous gestational diabetes to improve health before pregnancy. With the growing recognition that interventions in pregnancy are often too little, too late, a digital tool to identify high-risk women planning pregnancy and targeted health advice may reduce pregnancy complications. Future studies should assess whether this approach is successful in reducing health inequalities and improving pregnancy preparation and outcomes in this high-risk group of women.

This study has several strengths. It examined health behaviours prior to pregnancy among women with pre-existing diabetes or previous gestational diabetes in whom there is a paucity of data. The very large sample size and wide geographical distribution provides insight into pre-pregnancy health which may influence policy on an international level. A digital tool was used to collect data in a large number of women, reflecting user friendliness of an online platform. In addition, online data collection reduces the possibility of interviewer bias.

Limitations of the study included the lack of data on socio-economic status, and data on parity, however, tools such as this are likely to play an additional and useful role in widening access to pre-pregnancy care. Questions on health behaviours such as alcohol and caffeine intake did not include frequency of consumption and all data including height and weight were self-reported, potentially impacting data quality. Diverse international guidelines may influence practice, particularly for folic acid dosing, and this may have affected reporting. It is possible that women who engaged with the Tommy's tool were more orientated to their need for specific care before pregnancy and this may represent selection bias, nevertheless we have reached a large sample of women with diverse experiences. Although we document large numbers of women

Type 2 Diabetes ($n = 707$)						Gestational Diabetes ($n = 1785$)					
UK ($n = 347$)			Non-UK ($n = 360$)			UK ($n = 953$)			Non-UK ($n = 832$)		
n	%	95% CI	*n*	%	95% CI	*n*	%	95% CI	*n*	%	95% CI
20	6	(4,9)	10	3	(2,5)	42	4	(3,6)	42	5	(4,7)
35	10	(7,14)	39	11	(8,15)	238	25	(22,28)	182	22	(19,25)
63	18	(15,23)	66	18	(15,23)	211	22	(20,25)	196	24	(21,27)
228	66	(61,71)	234	65	(60,70)	455	48	(45,51)	382	46	(43,49)
1	0	(0,2)	11	3	(2,5)	7	1	(0,2)	30	4	(3,5)
	94	76–109		91	73–105		79	65–95		76	64–92
	34.4	28.5–39.3		32.8	27.6–38.7		29.6	24.5–36.0		28.9	24.6–35.0

using the tool, we have no data to assess the impact on change of behaviour as a result of its use. Finally, the data were collected during the COVID-19 pandemic which may have had an impact on health behaviours.

5 | CONCLUSION

This study provides novel insight into health behaviours among higher risk women with diabetes or previous gestational diabetes trying to conceive. The findings clearly show that women at higher risk of pregnancy complications are not adequately prepared for pregnancy, as evidenced by a high proportion of obesity, low folic acid use, a high prevalence of smoking, inadequate intake of fruit and vegetables, low physical activity levels, alcohol and caffeine consumption as well as lack of consultation with a GP or specialist. However, it also highlights that a digital tool that is easily accessible online might successfully influence behaviour. Together, these findings highlight the importance of finding novel ways of targeting pre-pregnancy care for such women planning pregnancy.

ACKNOWLEDGEMENTS

We gratefully acknowledge the contribution of all women planning pregnancy who completed the questionnaire.

FUNDING INFORMATION

The Tommy's Planning for Pregnancy tool and accompanying social media campaign was funded by Public Health England, Tommy's and the Royal College of Obstetricians and Gynaecologists. Neither Public Health England, Tommy's nor the Royal College of Obstetricians and Gynaecologists had any role in data analysis or interpretation, nor in the writing of the report or the decision to submit the paper for publication. At the end of August 2019, questions on diabetes were added to the existing tool. The study period was chosen after these questions went live. A social media campaign was launched in September 2019 and lasted 4 weeks.

CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

I confirm that my Data Availability Statement (pasted below) complies with the Expects Data Policy. The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Agreement for anonymous utilisation of health data collected via the Tommy's Preparing for Pregnancy Tool was included in the terms and conditions available on the Tommy's website.

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How to cite this article: Flynn AC, Robertson M, Kavanagh K, et al. Pre-pregnancy health of women with pre-existing diabetes or previous gestational diabetes: Analysis of pregnancy risk factors and behavioural data from a digital tool. *Diabet Med*. 2022;00:e15008. doi:10.1111/dme.15008