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Participation in structured diabetes self-management education programs and its associations with self-management behaviour – a nationwide population-based study

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ABSTRACT

Objective: To evaluate the relationship between participation in structured diabetes self-management education programs (DSME) and self-management behaviour (SMB) in routine care.
Methods: The study included 864 ever- and 515 never-DSME participants from the population-based survey German Health Update (GEDA) 2014/2015. SMB and clinical care variables were: Following a diet plan, keeping a diabetes diary, holding a diabetes pass, self-monitoring of blood glucose (SMBG), foot self-examination (FSE), retinopathy screening, haemoglobin A1c (HbA1c) measurement and examination of the feet by clinicians (FEC). We conducted logistic regression analyses for association of DSME-participation with SMB, adjusting for various variables.
Results: DSME-participation was significantly associated with SMB including following a diet plan (OR 1.88 [95% CI 1.21–2.92]), keeping a diabetes journal (OR 3.83 [2.74–5.36]), holding a diabetes health passport (OR 6.11 [4.40–8.48]), SMBG (OR 2.96 [2.20–3.98]) and FSE (OR 2.64 [2.01–3.47]) as well as retinopathy screening (OR 3.30 [2.31–4.70]), HbA1c measurement (OR 2.58 [1.88–3.52]), and FEC (OR 3.68 [2.76–4.89]) after adjusting for confounders.
Conclusion: DSME-participation is associated with higher frequencies of various SMB and clinical care variables in routine care. Never-DSME attenders are more likely not to receive retinopathy screening, FEC and HbA1c measurements as recommended.
Practice implications: Clinicians should refer diabetes patients to a DSME and ensure a regular follow up for never-DSME attenders.

1. Introduction

Diabetes is a global public health issue, affecting approximately 463 million people worldwide with a global prevalence of 9.3% [1]. Diabetes is associated with severe macrovascular and microvascular complications [2], premature mortality, higher comorbidity, lower quality of life and increased health care costs [3].

In diabetes treatment, achieving a near-normal blood glucose is important for the prevention of long-term complications. Adequate self-management behaviour (SMB) can help to achieve this [4] and is therefore a crucial cornerstone in the therapy of diabetes. Regardless of diabetes type, key areas of SMB include life style modifications, such as meal planning, self-examination of the feet and if necessary, self-monitoring of the blood or urine glucose and appropriate medication intake [5,6]. As patients with type 2 diabetes are often overweight or obese, life style changes are particularly important [7]. Furthermore, persons with type 2 diabetes and type 1 diabetes require regular measurement of haemoglobin A1c (HbA1c), retinopathy screenings and foot examinations by a clinician [5,8].

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In Germany, an estimated 7 million people suffer from diabetes [9]. All patients with diabetes receive a diabetes health passport to ensure the compact documentation of HbA1c measurements, blood pressure and retinopathy screening status [10]. All patients with type 1 diabetes [8], and also around 25% of patients with type 2 diabetes in Germany, require insulin [11]. For patients requiring insulin treatment, self-monitoring of blood glucose (SMBG) and documentation in a diabetes diary is of essence [5]. However, data relating to SMB adherence in real life settings in Germany are limited.

Structured diabetes self-management education programmes (DSME) provide participants with knowledge about health-promoting behaviour, enabling them to implement these aspects of SMB in their everyday lives [12,13]. DSME thus aim to empower patients to actively manage their disease in everyday life [14,15]. National and international guidelines recommend participation in a DSME at least once for each patient with diabetes [5,13,16,17]. In Germany, DSME is provided predominantly in outpatient settings as group education for four to six patients [18]. Persons with type 2 diabetes not requiring insulin therapy receive at least eight tutorials, held in four weekly sessions of 90 min each [19]. Persons with type 2 diabetes with insulin therapy receive at least twelve tutorials [20]. Persons with type 1 diabetes receive more extensive DSME distributed over several days [18]. DSME is predominantly provided by DSME-trained nurses, although a physician usually presents one session or provides several minutes of support in each session. In Germany, referral for DSME from a physician is mandatory for participation in DSME. Usually, patients receive a recommendation shortly after diabetes diagnosis or in case their metabolic control becomes worse or they require insulin treatment, as these indications for DSME are covered by the German national health insurances [18].

Clinical trials, such as RCTs [21–23] as well as systematic reviews [24–27] have shown that DSME was effective to achieve better SMB in persons with diabetes. Furthermore, DSME was shown to positively influence clinical exam adherence [27,28], relevant parameters such as blood sugar and HbA1c, [26,27,29–31], disease-related problem solving [32,33] and to reduce the cost of patient care [34]. However, data based on population-based samples are limited. Therefore, the objective of the present study is to investigate the relationship between DSME-participation and SMB in a nationwide population-based sample that covers the entire adult age range.

2. Methods

2.1. Study population

The study analysed cross-sectional data deriving from the population-based nationwide GEDA (German Health Update) 2014/2015-EHIS (European Health Interview Survey) wave 2. This study was designed by the Robert Koch Institute and conducted between November 2014 and July 2015. Sample selection was based on a two-stage cluster design. A random selection of 301 German municipalities was followed by randomly drawn samples based on the local population registers of these municipalities [35,36]. Sampling probabilities were in proportion to the populations of the communities [36]. After participants gave their informed consent, they were asked to complete a self-administered questionnaire, offered either online or as a paper-based version. The response rate was 26.9% [35]. This study was approved by the "Federal Commissioner for Data Protection and Freedom of Information in Germany".

2.2. Assessment of diabetes and DSME

Participants were asked "During the past 12 months, have you had any of the following diseases or conditions?" and provided a list of conditions including "diabetes (not including gestational diabetes)". Those, who answered with "yes" for this question were classified as having diabetes. Afterwards, in a diabetes care module, participants with diabetes were asked whether they had ever participated in a DSME (DSME-ever participants / DSME-never participants).

2.3. Assessment of SMB and clinical exam adherence

Using the diabetes care module, the SMB of participants with diabetes was assessed based on the following questions: "Do you currently follow a diet plan due to your diabetes?" (yes/no), "Do you currently keep a diabetes diary?" (yes/no), "Have you ever kept a personal diabetes health passport?" (yes/no), "Do you - or your relatives for you - perform self-measurement of blood glucose?" (yes/no), "How often do you perform self-examination of your feet for ulcers or pressure marks?" (daily/times per week/times per month/never, categorized for analysis as 'at least occasionally'/ 'never').

SMB related to clinical exam adherence was assessed as follows: "How often was your haemoglobin A1c measured in the last 12 months?" (times in the last 12 months; analysed as 'at least 4 times' / 'less than 4 times in the last 12 months'), "How often did you have a retinopathy screening in the last 12 months?" (times in the last 12 months; analysed as 'at least once' / 'none in the last 12 months'), "How often have you had your feet examined by a doctor / medical professional in the last 12 months?" (times in the last 12 months; analysed as 'at least once' / 'none in the last 12 months'). The diabetes health passport is a patient-holding booklet which can be filled out by clinicians with the patient's blood results (HbA1c measurements, creatinine etc.) and other clinical variables (Table A.2; [37]). As the contents of the diabetes health passport can be checked by patients themselves, the three variables related to clinical exam adherence (retinopathy screening, foot examination by clinician and HbA1c test) are highly SMB-relevant and were therefore included in the present analysis.

2.4. Sociodemographic and disease-related variables

The study considered the following sociodemographic variables as covariates in the statistical models to control for potential confounding: sex, age, socioeconomic status (SES) [38], living alone or with a partner, and occupational status. Furthermore, we included the following disease-related variables: limitation due to illness for at least 6 months, patients' attentiveness towards own health, and time since the diagnosis of diabetes. Additionally, we took general self-efficacy measured by the General Self-efficacy Short Scale (ASKU [39]) into account. The analysed response categories of these variables are shown in Table 1.

2.5. Statistical analysis

Weighted prevalences, means and standard deviations stratified according to DSME-participation status were calculated, using weighting factors computed based on the national population statistics of 31.12.2014. This procedure took the multistage sampling of the GEDA 2014/2015-EHIS survey into account and allowed us to address potential sample-selection bias with regard to sex, age, community type and educational level [35,36]. We performed weighted logistic regression analyses, in which we used DSME-participation as a predictor for all examined SMB and clinical care variables, which served as outcomes. These analyses were expanded by a stepwise inclusion of the above named sociodemographic and disease-related confounders. All data was interpreted with reference to the final multivariable models. All analyses were performed using STATA version 16.1.

Table 1
Characteristics of the study population subgroups according to participation in a structured patient education program (DSME) (N = 1379, complete-case analysis).

		DSME-never participants		DSME-ever participants		*p*
		n/ M ± SD	%	n/ M ± SD	%	
N		515	37.3	864	62.7	
Sex[b)]	female	216	46.0	356	42.2	*0.272*
Age [years]		67.9 ± 12.6 (n = 515)		63.8 ± 13.4 (n = 864)		< 0.001
Age categorized	18–44 years	20	5.7	71	8.0	*< 0.001*
	45–64 years	167	32.2	328	39.2	
	65–79 years	241	43.9	390	44.9	
	80 years or older	87	18.2	75	7.8	
SES score categorized	low (3 - < 8.5)	135	30.6	212	28.8	*0.634*
	middle (8.5 - < 15)	276	55.9	492	59.0	
	high (15–21)	104	13.5	160	12.2	
Living together with partner[b)]	yes	368	68.8	626	71.5	*0.393*
Limitation due to illness for at least 6 months	severe	84	16.7	167	19.8	*0.029*
	moderate	165	30.7	295	36.1	
	none	266	52.7	402	44.2	
Occupational status	employed	132	25.7	279	31.5	*0.252*
	not employed[a)]	10	2.3	18	2.5	
	retired / disabled	373	71.9	567	66.0	
Self-efficacy beliefs [ASKU; 1–5]		3.9 ± 1.1		4.0 ± 0.9		*0.034*
General attention to own health categorized: high or very high[b)]	high / very high	252	49.8	445	50.2	
Time since DM diagnosis [years]		8.1 ± 8.4		12.8 ± 10.5		*< 0.001*
SMB related to patient behaviour						
Currently following a diet plan[b)]	yes	42	9.2	143	16.3	*0.004*
Currently keeping a diabetes diary[b)]	yes	94	18.6	387	47.5	*< 0.001*
Ever kept diabetes health passport[b)]	yes	103	20.6	533	62.8	*< 0.001*
Self-assessment of blood glucose[b)]	yes	255	48.9	660	78.0	*< 0.001*
Self-assessment of feet[b)]	daily or at least occasionally	307	58.8	676	79.1	*< 0.001*
Clinical examination adherence						
Examination of feet by clinicians in the last 12 months[b)]	at least once	216	44.1	642	75.2	*< 0.001*
Retinopathy screening in the last 12 months[b)]	yes	328	61.9	721	83.4	*< 0.001*
Assessment of HbA1c in the last 12 months[b)]	≥ 4 times	220	44.4	583	68.8	*< 0.001*

This table shows absolute unweighted frequencies as well as weighted prevalences in percent and weighted means and standard deviations. The tests for significance take weighting factors into account. Symbols: a) The category "not employed" includes students and homemakers. b) For dichotomous variables only one response category is shown.
Abbreviations: ASKU - Index of self-efficacy and attentiveness to own health. DM – diabetes mellitus, DSME – structured self-management education program for patients with diabetes mellitus, N or n - number, M ± SD – mean value ± standard deviation, SES- socioeconomic status, HbA1c- haemoglobin A1.

3. Results

3.1. Descriptive statistics

1712 participants aged at least 18 years and reporting to have diabetes mellitus in the past 12 months have participated in the survey. Of these, 1379 participants were included in the analysis. The corresponding exclusion criteria are presented in Fig. 1.

Of the 1379 participants included in the analyses, 515 never attended a DSME (37.3%), whereas 864 participated consistently in a DSME (62.7%) (Table 1). DSME-ever participants were significantly younger, more likely to report severe or moderate limitation due to illnesses, had slightly higher self-efficacy beliefs, and showed a longer duration of diabetes-illness than DSME-never participants. There were no significant bivariate differences between DSME-ever and never participants regarding sex, SES, living together with a partner, occupational status, and attentiveness towards their own health.

We performed a comparison of characteristics between the participants of complete-case analyses and the excluded participants (Table A.3). The excluded participants were more likely to be female, older than 65 years, retired and to have a low socioeconomic status, but did not differ significantly with respect to the SMB-outcomes examined.

3.2. Weighted logistic regression analyses of self-management behaviour

In multivariable logistic regressions (Table 2), DSME-ever participants were more likely to adhere to a diet plan (OR=1.88; [1.21 – 2.92]), to keep a diabetes diary (OR = 3.83 [2.74 – 5.36]) and a diabetes health passport 6.11 [4.40 – 8.48]) compared to never-DSME participants. Ever DSME-participants performed SMBG (OR=2.96; [2.20 – 3.98]) and daily self-examination of the feet (FSE; OR = 2.64; [2.01 – 3.47]) more frequently than never-participants. These associations between DSME and SMB were statistically significant in descriptive analyses (Table 1) as well as in all multivariable models (Table 2).

3.3. Weighted logistic regression analyses of clinical examination adherence

In multivariable logistic regressions (Table 3), DSME-participants were more likely to receive retinopathy screenings (OR = [3.30 [2.31 – 4.70]), foot examinations by medical staff (OR = 3.68 [2.76 – 4.89]) and regular HbA1c measurements (OR 2.58 [1.88 – 3.52]) than never-DSME participants. These associations between DSME and care-related SMB were statistically significant in descriptive analyses (Table 1) as well as in all multivariable models (Table 3).

4. Discussion and conclusion

4.1. Discussion

The present study is one of the few analyses using data from a nation-wide population-based survey to investigate the association of DSME-participation with SMB. Our analysis showed that even in routine health care, DSME-participation was strongly associated with keeping a diabetes health passport, a diabetes diary, SMBG, FSE and following a diet plan. Additionally, DSME-participants had

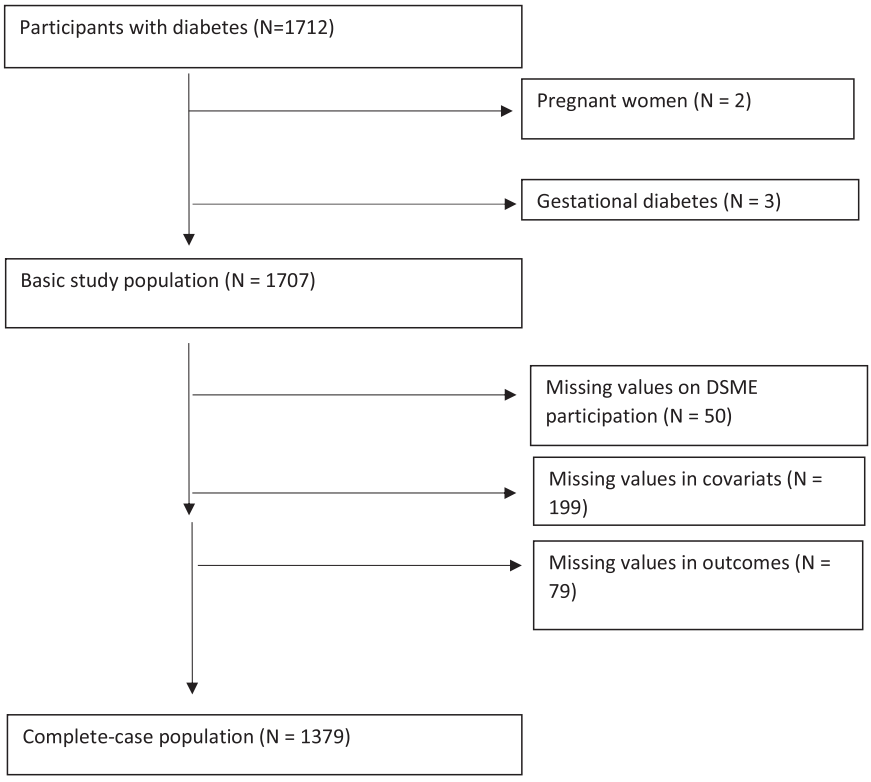

Fig. 1. : Flowchart for study participant selection. Subheading: This figure illustrates the case selection process for analyses. Abbreviations: N – number.

significantly higher clinical examination adherence with respect to HbA1c measurement, retinopathy screenings and foot examination by a clinician. Achieving a good SMB is crucial for supporting an optimal diabetes therapy [5] and a relevant factor for the prognosis of diabetes [26].

4.1.1. Findings in the context of the current literature

4.1.1.1. General aspects. Data on SMB and DSME based on nation-wide and population-based studies are rare. To our knowledge, most published population-based studies on this topic are limited to either local federal [40], regional samples [41], or to specific age groups [40,41]. Although we analysed data obtained in 2014/2015, our study with its rare nation-wide population-based sample covering all adult age groups and its large set of SMB variables contributes further to the body of knowledge on DSME.

Our results are in accordance with international literature. Various RCTs have shown significant improvements of SMB for DSME-participants compared to never-participants [22,42–44]. Only a few studies have examined the effect of DSME on SMB in real-world health care [40,41,45]. A large study in the USA showing a significant, modest positive correlation of DSME-ever participation for SMBG and FSE supports our results [45]. Likewise, our results are supported by a German regional population-based study among persons with type 2 diabetes aged 65 years or older which indicated that DSME-participation was associated with a higher SMB index [41]. In accordance with our results, a large Canadian population-based study in persons aged 65 years and older has shown that

Table 2
Association of DSME-participation with self-management behaviour, calculated by weighted logistic regression analyses (N = 1379; complete-case analysis).

	Currently following a diet plan			Currently keeping a diabetes diary			Ever kept a diabetes health passport			Self-assessment of blood glucose		
	OR	*[95% CI]*		*OR*	*[95% CI]*		*OR*	*[95% CI]*		*OR*	*[95% CI]*	
model 1	1.91	[1.23;	2.96]	3.97	[2.86;	5.49]	6.49	[4.71;	8.96]	3.70	[2.82;	4.87]
model 2	1.96	[1.28;	2.98]	4.27	[3.10;	5.88]	6.60	[4.81;	9.06]	3.67	[2.77;	4.86]
model 3	1.83	[1.20;	2.80]	3.85	[2.76;	5.38]	6.10	[4.41;	8.44]	2.97	[2.21;	4.00]
model 4	1.78	[1.15;	2.73]	3.85	[2.75;	5.38]	6.17	[4.44;	8.56]	2.93	[2.17;	3.95]
model 5	1.79	[1.15;	2.77]	3.88	[2.77;	5.44]	6.18	[4.45;	8.57]	2.94	[2.18;	3.95]
model 6	1.88	[1.21;	2.92]	3.83	[2.74;	5.36]	6.11	[4.40;	8.48]	2.96	[2.20;	3.98]
	Self-assessment of feet											
	OR	*[95% CI]*										
model 1	2.65	[2.03;	3.46]									
model 2	3.04	[2.31;	4.00]									
model 3	2.67	[2.02;	3.54]									
model 4	2.62	[1.98;	3.46]									
model 5	2.63	[1.99;	3.46]									
model 6	2.64	[2.01;	3.47]									

Model 1: zero-order association between DSME-participation und SMB without adjustments; model 2: model 1 + adjustment for age (categorized as shown in Table 1*), sex, SES (categorized as shown in* Table 1*), occupational status and status of living together or alone; model 3: model 2 + additionally adjusted for time since diabetes diagnosis (as linear predictor in years); model 4: model 3 + adjusted for limitation due to chronic illnesses (categorized as shown in* Table 1*); model 5: model 4 + adjusted for attentiveness towards one own health (categorized as shown in* Table 1*); model 6: model 5 + adjusted for ASKU-index of self-efficacy (as linear predictor); Abbreviations: OR – odds ratio; CI – confidence interval.*

Table 3
Association of DSME-participation with clinical examination adherence, calculated by weighted logistic regression analyses (N = 1379; complete-case analysis).

	Retinopathy screening			HbA1c assessment			Examination of feet by clinician		
	OR	*[95% CI]*		*OR*	*[95% CI]*		*OR*	*[95% CI]*	
model 1	3.09	[2.27;	4.21]	2.76	[2.05;	3.71]	3.85	[2.96;	5.02]
model 2	3.69	[2.70;	5.04]	2.87	[2.13;	3.87]	4.04	[3.08;	5.30]
model 3	3.25	[2.31;	4.58]	2.56	[1.88;	3.51]	3.73	[2.80;	4.98]
model 4	3.30	[2.33;	4.68]	2.55	[1.86;	3.49]	3.69	[2.77;	4.91]
model 5	3.36	[2.36;	4.78]	2.55	[1.86;	3.49]	3.70	[2.77;	4.93]
model 6	3.30	[2.31;	4.70]	2.58	[1.88;	3.52]	3.68	[2.76;	4.89]

Model 1: zero-order association between DSME-participation und SMB without adjustments; model 2: model 1 + adjustment for age (categorized as shown in Table 1*), sex, SES (categorized as shown in* Table 1*), occupational status and status of living together or alone; model 3: model 2 + additionally adjusted for time since diabetes diagnosis (as linear predictor in years); model 4: model 3 + adjusted for limitation due to chronic illnesses (categorized as shown in* Table 1*); model 5: model 4 + adjusted for attentiveness towards one's own health (categorized as shown in* Table 1*); model 6: model 5 + adjusted for ASKU-index of self-efficacy (as linear predictor); Abbreviations: OR – odds ratio; CI – confidence interval; HbA1c – haemoglobin A1c.*

attending retinopathy screening could be significantly increased by DSME-participation [40].

4.1.1.2. DSME. The attendance rate for DSME was 62.7% in our survey, which is higher than that reported in other population-based studies, e.g. 53.7% in the US [45], 53% in a German regional study [41] and 7.6% in a Canadian study [40]. The differences can be explained by different health systems, accessibility to a free DSME and localized samplings within these surveys. In contrast, the present study includes a nationwide sample covering all adult age groups. Analyses from the German chronic care program (disease management program; DMP) suggest profound regional differences of DSME-participation between 29.3% in Bavaria [46] and 41.1% of the DMP participants in North Rhine-Westphalia [47]. To our knowledge, our study is the only nationwide survey examining DSME-participation in Germany.

4.1.1.3. Specific SMB variables. DSME participants performed SMBG significantly more often. This is in agreement with other studies, which have shown a long-term increase in SMBG for DSME-participants [21,22,42]. However, the importance of SMBG has decreased in the care of type 2 diabetes in Germany over the last few years, as the coverage of the SMBG test kits in Germany by health insurance is limited to persons receiving insulin treatment. Regular SMBG for persons with type 2 diabetes without insulin treatment is no longer recommended by national guidelines [5].

Our data showed a strong correlation between DSME-participation and keeping a diabetes health passport, diabetes diary and following a diet plan. In accordance with our results, Becker et al. have observed that DSME-ever participants were more likely to keep a diabetes diary than non-participants [41]. Diabetes diaries are more common with those patients who receive insulin. Unfortunately, in the absence of sufficient data on insulin treatment we could not control this confounder. The moderate association between DSME-participation and adherence to a diet plan has similarly been reported in the literature [41]. It is noteworthy that the importance of following a strict diet plan to manage diabetes has declined in German diabetes care in the last few years and is no longer addressed in current DSME curricula [5].

Our study showed a substantial, positive association between DSME-participation and FSE. FSE is recommended by national [48] and international [49] guidelines for patients with diabetes on a regular basis. In our study, 79.1% of ever-DSME participants performed FSE daily or occasionally compared to 58.8% of never-DSME participants. Other studies have reported lower rates of participants' FSE, i.e. 56.2% [41] or 63.0% [45], but did not distinguish between ever- or never-DSME participants. However, this also implies that a considerable proportion of DSME-participants and an even larger proportion of never-participants never engaged in FSE, i.e. 20.9% or 41.2% based on results from the present study.

Furthermore, our analyses showed a correlation between DSME participation and clinical examination adherence. This may not be primarily an effect of patient education, but rather of care-related organisation. Nonetheless, these associations could also be attributed to the fact that trained patients are more likely to raise these issues in clinical care. Also, DMP-registration may be a central confounder in this context, which we could not control for, as no data on DMP participation was available.

In our study, DSME-attenders had significantly more foot examinations by clinicians than never-attenders. German national guidelines recommend foot checks by clinicians at least once per year [5]. However, within our study 24.8% of ever-DSME participants and 55.9% of never-DSME participants reported that they had no foot check in the last 12 months by a clinician.

Participation in retinopathy screening showed a significant association with DSME-participation. Within our survey, 16.6% of the ever-DSME participants and, more seriously, 38.1% of the never-DSME participants, did not attend a yearly retinopathy screening. At the time of data collection, German national guidelines recommended participation in retinopathy screening once a year for all persons with diabetes from the time of their diagnosis [12]. We are aware that these recommendations were changed by 2018, recommending a screening every second year for those without retinopathy. Diabetic retinopathy is a common cause of visual impairment [50] and early detection, treatment and careful monitoring is the most effective way to manage this [51].

German guidelines for DMP Diabetes and national guidelines recommend a regular HbA1c measurement, once every quarter year but at least once every six months [10]. In our study, DSME-participation was associated with a significant higher frequency of HbA1c measurement. The majority of DSME ever-participants (87.3%) had HbA1c measurements twice or more often in the last 12 months. Contrarily, 30.2% of DSME never-participants never had an HbA1c measurement or only once in the last 12 months (Table A.1). Note that GEDA 2014/2015-EHIS does not provide data on actual HbA1c values. However, we believe that the frequency of HbA1c reflects the status of delivered care and therefore constitutes a meaningful parameter.

4.1.2. Strengths and limitations

We present the results of a population-based study, investigating the association of DSME-participation and SMB in a real-world setting based on a large nationwide sample. Furthermore, our study covers all adult age group and provides a wide range of SMB and clinical detailed information to adjust for relevant confounders. SMB parameters are not easily available in most routine care settings. For example, they are not provided by claims data analyses, which are often used to describe routine care settings. Therefore, we believe that our analyses offer important information regarding how DSME-

participation correlates with SMB under routine health care conditions.

Our data suggest that DSME participation enables effective SMB in routine health care conditions. However, we cannot assume any causal relationships, as our data were not subject to a controlled randomization or a prospective study-design. Therefore, it is equally plausible that persons with a higher frequency of SMB are more likely to participate in DSME. Such recruitment effects should be addressed by future research. Prospective studies should be conducted in order to validate the present findings.

Our study is limited to cross-sectional data, and is therefore not able to assess longitudinal trends. All health outcomes and variables in the GEDA 2014/2015-EHIS study are based on the participant's own report. Social desirability and recall errors may bias our data. In respect to the response rate of 26.9%, a further bias due to unit-nonresponse is suspected. Individual interest in the topic of a survey is a significant predictor of the willingness to participate in written questionnaires [52,53]. As this interest is presumably associated with both DSME training and SMB in the present survey, a corresponding overrepresentation is possible, constituting an additional confounding variable. Even though a selection bias cannot be ruled out, the weighting carried out according to age, gender, education and region addresses important sources of deviations between the present survey and the German general population.

The GEDA 2014/2015-EHIS questionnaire does not distinguish between diabetes type 1 or 2. However, in consideration of the high proportion of persons with type 2 diabetes in Germany, we can assume that most of the participants were persons with type 2 diabetes. Additionally, DSME-participation was limited to the dichotomous definition of "ever" or "never" participants. Therefore, we could not provide data on the type of DSME, repetition of DSME, or time duration between diabetes diagnosis and DSME-participation. However, analyses as "ever" or "never" DSME participants were also common for cohort studies analysing DSME effects [5,40,41,45]. Furthermore, GEDA 2014/2015-EHIS does not provide data on inscription in a specialized DMP. This could be a confounder in our data, as DMP diabetes offers all participants quarterly consultations with their clinicians and access to a free DSME-participation. To our knowledge, no nationwide data on the proportion of persons with diabetes inscribed in a DMP is available for Germany, and regional differences of inscription rates are reported [46,47]. Additionally, it is unclear, how many DMP participants actually participate in a DSME on a nation-wide level. Local samples show a large heterogeneity in German DSME participation rates, which vary from 29% to 41.1% among DMP participants depending on the area of residence [47,54]. Thus, it may be assumed that a relatively large proportion of DMP participants does not participate in DSME.

It was necessary to exclude cases due to missing values. These were significantly more likely to be female, older than 65 years and of low SES than cases included in the analyses. In our opinion, this does not change our results, as we observed no significant differences concerning the analysed outcomes between included and excluded cases (Table A.3).

4.2. Conclusion

DSME-participation is associated with higher frequencies of various SMB and clinical care variables in routine care. Within the present population-based study, DSME participants were significantly more engaged in FSE, keeping a diabetes health passport and a diabetes diary, performing SMBG, and following a dietary plan than never-DSME participants. Our results further indicate that, compared to never-DSME participants, DSME participants are more likely to have more frequent preventive or monitoring examinations, i.e. HbA1c measurements, retinopathy screening, and foot care by a clinician.

4.3. Practical implications

Our results suggest that DSME should be available for every person with diabetes, since it is associated with adherence in diabetes therapy. Ideally, clinicians should make every effort to recommend that their diabetic patients take part in a DSME at least once. In Germany, DSME is often provided in the framework of DMP. Official German regulators may reconsider the rule that patients are to be excluded from DMP in case they do not participate in a DSME 6 months after the recommendation by the clinician. This may hinder clinicians from referring patients for DSME, as they may face financial cut-backs if the patient then drops out of the DMP.

Clinicians should pay particular attention to never-DSME participants, as they are more likely to have a weaker SMB and seem not to receive preventive examinations for their diabetes as regularly as ever-DSME participants. For example, our results suggest that amongst never-DSME participants non-adherence to the HbA1c therapy goal might be detected later than among ever-DSME participants. Therefore, clinicians should pay attention to the regular follow-up of never-DSME participants, including regular HbA1c measurements. Especially never-DSME-participants, who have foot checks less frequently and perform FSE less often, may be more likely to be afflicted by diabetic foot syndrome and should be a particular focus of clinicians. Our data suggest that teaching patients how to perform FSE regularly should be increasingly emphasized in education sessions for clinicians providing care to persons with diabetes.

For future studies, the associations within our results imply that those analysing SMB outcomes should consider DSME-participation status as a confounder.

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CRediT authorship contribution statement

SC AF, MH, CH, JB, YD developed the research question and planned the analysis. CH, YD and JB were part of the Robert Koch Institute's study team, which were involved in designing the questionnaire module on diabetes of the GEDA- 2014/2015 study. MH performed statistical analysis. SC, AF, MH preformed data interpretation, TF gave critical comments. SC wrote the manuscript; all authors gave critical comments to the draft. All authors have read and approved the final version of the manuscript.

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Declaration of interests

None.

We confirm, that all personal identifiers have been removed or disguised so the participating persons described are not identifiable and cannot be identified through the details of the story.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.pec.2021.07.017.

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