

Diabetes self-management education interventions and self-management in low-resource settings; a mixed methods study  
--Manuscript Draft--

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<b>Full Title:</b>	Diabetes self-management education interventions and self-management in low-resource settings; a mixed methods study
<b>Short Title:</b>	Running title: Structured? No; Literate? No; Pamphlets? Yes!; DSME in resource-constrained settings
<b>Corresponding Author:</b>	Roberta Lamptey Korle Bu Teaching Hospital Accra, GHANA
<b>Keywords:</b>	Diabetes; self-management; Self-Care; education; Health Resources; Ghana
<b>Abstract:</b>	<p><b>Introduction</b> Diabetes is largely a self-managed disease and thus care outcomes are closely linked to self-management behaviours. However, structured self-management education (DSME) interventions are largely unavailable in Africa.</p> <p><b>Aim</b> We sought to characterise DSME interventions in two urban low-resource primary settings, and to explore diabetes self-management knowledge and behaviours of persons living with diabetes (PLD).</p> <p><b>Research design and Methods</b> A convergent parallel mixed-methods study was conducted between January to February 2021 in Accra, Ghana. A total enumeration was done for the cross-sectional study whilst purposive or judgemental sampling was used in selecting participants for the qualitative study. Multivariable regression models were used to study the association between diabetes self-management knowledge and behaviours. We employed inductive content analysis of informants' experiences and context to complement the quantitative findings.</p> <p><b>Results</b> In total 425 PLD (70.1 % (n=298) females, mean age 58 years (SD 12), mean blood glucose 9.4 mmol/l (SD 6.4)) participated in the quantitative study. Two managers, five professionals, two diabetes experts and 16 PLD participated in in-depth interviews. Finally, 24 PLD were involved in four focus group discussions. Median diabetes self-management knowledge score was 40 % ( IQR 20-60). Every 1 unit increase in diabetes self-management knowledge was associated with increased scores on diet ( 5%;[95% CI: 2%-9%, p&lt;0.05]), exercise (5%; [95% CI:2%-8%, p&lt;0.05]) and glucose monitoring (4%;[95% CI:2%-5%, p&lt;0.05]) domains of the diabetes self-care activities scale. The DSME interventions were unstructured and limited by resources. Financial constraints, conflicting messages, beliefs, and stigma were themes underpinning behaviours.</p> <p><b>Conclusions</b> The DSME interventions were under-resourced and unstructured. Diabetes self-management knowledge was limited and associated with self-management behaviour. DSME interventions in low resource settings should be culturally tailored and incorporate sessions on mitigating financial constraints. Future studies should focus on creating structured DSME interventions suitable for resource-constrained settings.</p>
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Kerstin Klipstein-Grobusch

**Response to Reviewers:**

We are highly indebted to the reviewers for their time. We deeply appreciate the time they have already committed to helping us improve our paper. We have uploaded a file with our point by point response in tabular form. We provide here a summary only.

We have reviewed the entire manuscript for clarity in communicating our processes and procedures. We were meticulous in our methods and we believe our work is technically sound.

We believe our analyses have been conducted appropriately and with rigour. We have reviewed the entire manuscript to ensure that the language used is suitable for a scientific paper. We have endeavoured to correct all language use errors. In our original submission, we addressed these issues. Please find our itemised responses below:

1. We stated that we used a convergent parallel design, a recognised type of mixed methods design for which we provided a reference. We also depicted the design graphically with Fig 1.

To explain the method in more detail we have now added this statement :  
“Thus, we merged the two research methods (quantitative and qualitative) to answer our research questions and achieve our study aims. In addition, the two methods converged at the point of analysing the results, and interpreting the data. Data for the quantitative study and qualitative study were collected simultaneously, in parallel. Moreover, we placed equal emphasis on qualitative and quantitative data in all aspects of the study.”

We believe this increases the reproducibility of our method. Thank you.

2. In the abstract we stated that “we employed inductive content analysis of informants’ experiences and context”.

In the main manuscript we explained further by stating “Data was analysed independently by RL, BB and a research assistant using an inductive thematic approach manually”-These explain the qualitative method

2.In the abstract we stated, “Financial constraints, conflicting messages, beliefs, and stigma were themes underpinning behaviours.”- These themes are our quantitative results

We then went on to describe the qualitative results in detail in the main manuscript. Thank you. In our original submission, we addressed these issues. Please find our itemised responses below:

:

**Type of study**

1. A convergent parallel mixed-methods study was conducted as earlier described

**Sample size**

2. sample size: In total 425 PLD.....

Two managers, five healthcare professionals, two diabetes experts and 16 PLD participated in in-depth interviews. Finally, 24 PLD participated in four FGD

**Sampling strategy**

3. sampling strategy: we stated the following in our original submission in the abstract  
“A total enumeration was done for the cross-sectional study whilst purposive or judgemental sampling was used in selecting participants for the qualitative study”.

**4.date and country of the study**

Thank you we have now included this “January to February 2021 in Accra, Ghana”

Thank you. We have re-written the entire introduction section.

We have modified our title to ensure that the title, new introduction, aims, and conclusions are congruent

Thank you. In our original submission, we provided an explanation for our choice.

We stated that “We employed qualitative methods to deepen our understanding (of generalizable) outcomes from the quantitative study”

Thank you. In our original submission, we addressed these issues. Please find our itemised responses below:

1. where we collected samples for the study : We stated that “The study was conducted in Korle Bu Teaching Hospital polyclinic (KBTH) and Weija Gbawe Municipal hospital (WGMH),

2. we stated that these two facilities were public primary care facilities located in Accra, Ghana.

Interviews were conducted at the study sites either in offices or large open spaces whilst observing prescribed COVID-19 protocols. Experts were interviewed virtually.”

3. year study conducted

We also stated that “Participant recruitment and data collection occurred between January and February 2021”

4.

exclusion and inclusion criteria: We also stated that “HCP and PLD were staff and attendants at the study sites respectively. Managers were the respective heads. PLD were 18 years or older, not known to have type 1 diabetes, cognitive or psychiatric impairment and ambulant.

” This section is now labelled clearly.

Thank you. In our original submission, we addressed these issues. Please find our itemised responses below:

We stated that “a total enumeration of all eligible clients seen at both study sites from December 2020 to January 2021 was done.” Thus the sampling strategy for the qualitative section was total enumeration.

We further explained that “Trained staff called all potential participants meeting eligibility criteria and invited them to participate.” This was how we accessed the sampling frame

We also stated that “PLD were identified through convenient sampling and snowballing for the qualitative study. Managers and healthcare professionals (HCPs) were sampled purposively, and judgemental sampling were used in identifying experts”. This explains the sampling method for the qualitative study.

Thank you. In our original submission, we addressed these issues. Please find our itemised responses below:

We stated that “The study was conducted in Korle Bu Teaching Hospital polyclinic (KBTH) and Weija Gbawe Municipal hospital (WGMH), two public primary facilities located in Accra, Ghana”. Thus, the facilities were government primary care facilities. They were not referral facilities.

In our original submission, we addressed these issues. Please find our itemised responses below:

Thank you.

We mentioned in our original submission that discrepancies were resolved through dialogue.

For the qualitative study, the interviews were one-on -one and for the FGD we had more than one facilitator per group including field note takers.

Response rate

Thank you. we have now included the non-response rate “21%”

#### Permissions

We had stated the following in our original submission "The head of each facility granted permission for the study after having obtained ethical clearance"

#### Participant recruitment

We stated the following in our original submission "Trained staff called all potential participants meeting eligibility criteria and invited them to participate. For each individual, three attempts were made to reach them."

In our original submission, we addressed these issues. Please find our itemised responses below:

Thank you.

We stated in our original submission that "The Good Reporting of a Mixed-Methods Study (GRAMMS)(5) and Consolidated Criteria for REporting Qualitative research (COREQ)(6) checklists were followed.

"

In response to the reviewer's comment, we now have added the COREQ checklist as supporting material." Thank you

In our original submission, we addressed these issues. Please find our itemised responses below:

Thank you.

We stated the following and provided details of our method  
1."using an inductive content analysis"

2."using an inductive thematic approach manually"

Thank you. The following statements have now been included "Our informants were fully engaged in all phases of our study. We selected participants who could best provide answers to our research question."

Thank you . The following statement has been added "Some of the PLD recruited from the KBTH study site might have known RL as a staff of that facility. All other PLD involved in the study did not have any prior relationship with the data collectors. Experts and Health Care Professionals were colleagues of RL. The roles of the researchers were to facilitate the FGD and conduct the interviews"

Our original discussion section included 14 references 9 which were published within the last 3 years and all the 14 references were published within the last 7 years.

We have in addition significantly increased the number of references in the introduction. Thank you.

2

We tried to rephrase the sentence to accommodate this suggestion however the sentence did not read well . We have therefore maintained the original sentence as is. We have increased the number of references in the introduction thank you.

The entire introduction has been re-written form clarity thank you.

Additional background information has been provided in the introduction for clarity. We have also replaced self-management program with self-management intervention.

Thank you

Thank you this has now been corrected by quoting a 6.5% prevalence.

Thank you. This entire section has been re-written

The title, study aim and conclusions have been re-written for clarity. Our manuscript is now more focused and congruent. Thank you

There is a fine line between various types of diabetes with some overlap, and often it is difficult to clinically distinguish between them. For example making a distinction between latent autoimmune diabetes in adults and type 2 diabetes or between type 1 diabetes in an adult and type 2 diabetes which is burnt out. Given that we did not do formal diagnostic testing e.g autoantibodies, c-peptide etc, we decided it was best to avoid classifying patients as type 2 diabetes.

The inclusion criteria was self-reported diabetes and we excluded those known to have type 1 diabetes. We have now included this statement in our limitation "our findings

	<p>may not be generalised to people known to have type 1 diabetes”  Thank you we have replaced DSME program with DSME intervention throughout the manuscript..  Thank-you. This statement has been modified We have now specified facility based DSME interventions.  “Additionally, sustainability of facility-based structured DSME interventions are influenced by facility-, patient-, and provider level factors.[13]”  Thank you  We have re-written the entire concluding paragraph . Those findings are limited to the two study sites.  “The DSME interventions studied were under-resourced and were not structured”  The aim has been re-stated for clarity and the study location included in the Abstract  “We sought to characterise DSME interventions in two urban low-resource primary settings, and to explore diabetes self-management knowledge and behaviours of persons living with diabetes (PLD).  ”</p> <p>The entire introduction has been re-written for clarity and to improve congruency with the other sections of the manuscript thank you.  The aim has been re-stated at the end of the introduction</p> <p>Our aim was rather to describe and characterise the existing DSME interventions</p> <p>The location within the city has been stated. “KBTH is located within the Ablekumah South Metropolitan district and WGMH is located in Ga West Municipal district.”</p> <p>Our aim was rather to describe and characterise the existing DSME interventions. The aim has been re-written. Thank you</p> <p>The abbreviations in the Figures have been corrected. Thank you.  The section on eligibility criteria has now been clearly labelled.</p> <p>Figure 1 has been reorganised as suggested  Figure 2- Abbreviations have been corrected  Figure 3 has been re-drawn; the major theme in that circle is stigma  The section on quantitative analysis has been titled to maintain formatting with the subsequent section</p> <p>Analysis has been changes to analyses</p> <p>The number of included participants have been corrected to 425. Thank you</p> <p>Table 1 has been re-formatted for clarity. The variables are now readily identifiable</p> <p>T in table 2 has been capitalised  We have updated our funding statement . Our amended funding statement is as follows:  “This study was funded in part by the UMC Utrecht Global Health Support PhD program. It had no role in the study design, collection, analysis, interpretation of data, writing of the report or decision to submit the article for publication.  ”</p>
<b>Additional Information:</b>	
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<p><b>Financial Disclosure</b></p> <p>Enter a financial disclosure statement that describes the sources of funding for the work included in this submission. Review</p>	<p>The author(s) received no specific funding for this work.</p>

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- Field research

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Ethical approval was granted by the Institutional Review Board of KBTH (STC/IRB/000175/2020) and the Ethics Review Committee of the Ghana Health Service (GHS-ERC 05/10/20).

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1 Diabetes self-management education interventions and self-  
2 management in low-resource settings; a mixed methods study

3 Running title: Structured? No; Literate? No; Pamphlets? Yes!; DSME  
4 in resource-constrained settings

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26

27

## 28 Abstract

### 29 Introduction

30 Diabetes is largely a self-managed disease and thus care outcomes are closely linked to self-  
31 management behaviours. However, structured self-management education (DSME) interventions are  
32 largely unavailable in Africa.

33

### 34 Aim

35 We sought to characterise DSME interventions in two urban low-resource primary settings, and to  
36 explore diabetes self-management knowledge and behaviours of persons living with diabetes (PLD).

37

### 38 Research design and Methods

39 A convergent parallel mixed-methods study was conducted between January to February 2021 in Accra,  
40 Ghana. A total enumeration in addition to consecutive sampling was done for the cross-sectional study  
41 whilst purposive or judgemental sampling was used in selecting participants for the qualitative study.  
42 Multivariable regression models were used to study the association between diabetes self-management  
43 knowledge and behaviours. We employed inductive content analysis of informants' experiences and  
44 context to complement the quantitative findings.

45

### 46 Results

47 In total 425 PLD (70.1 % (n=298) females, mean age 58 years (SD 12), mean blood glucose 9.4 mmol/l  
48 (SD 6.4)) participated in the quantitative study. Two managers, five professionals, two diabetes experts  
49 and 16 PLD participated in in-depth interviews. Finally, 24 PLD were involved in four focus group  
50 discussions.

51

52 Median diabetes self-management knowledge score was 40 % ( IQR 20-60). Every 1 unit increase in  
53 diabetes self-management knowledge was associated with increased scores on diet ( 5%;[95% CI: 2%-  
54 9%,  $p<0.05$ ]), exercise (5%; [95% CI:2%-8%,  $p<0.05$ ]) and glucose monitoring (4%;[95% CI:2%-5%,  
55  $p<0.05$ ]) domains of the diabetes self-care activities scale.

56

57 The DSME interventions studied were unstructured and limited by resources. Financial constraints,  
58 conflicting messages, beliefs, and stigma were themes underpinning behaviours.

59

### 60 Conclusions

61 The DSME interventions studied were under-resourced and unstructured. Diabetes self-management  
62 knowledge was limited and associated with self-management behaviour. DSME interventions in low  
63 resource settings should be culturally tailored and incorporate sessions on mitigating financial  
64 constraints. Future studies should focus on creating structured DSME interventions suitable for  
65 resource-constrained settings.

66

### 67 Key words

68 Diabetes, self-management, self-care, education, health resources, Ghana

69

## 70 Introduction

71 Globally 536 million people live with diabetes, and this number is projected to rise to 784 million by  
72 2045.[1] Eighty percent of these half a billion people live in low- and middle-income countries like  
73 Ghana.[1] Diabetes is a long-standing leading cause of morbidity and mortality[2] in Ghana and among  
74 adults the prevalence is 6.5%.[3]

75 Diabetes self-management education (DSME), being a bedrock of optimal diabetes care can effectively  
76 improve glycaemic control and ameliorate the disease burden. [4, 5] DSME involves equipping patients  
77 with knowledge for self-management and several models for DSME interventions exist.[4, 6]  
78 Characteristics of DSME interventions include duration, cultural and linguistic tailoring, theoretical  
79 underpinnings, structure/ curriculum, mode of delivery, instructor characteristics, and intensity.[6, 7]  
80 Examples of theories which have been studied in relation to diabetes self-management include the social  
81 cognitive theory and empowerment theory.[7, 8] It is uncertain which of these characteristics of DSME  
82 interventions account for effectiveness in improving glycaemic control and care outcomes.[9]

83 Ryan et al reported an improvement in glycaemic control, specifically a difference in mean HbA1c,  
84 following a 6-month DSME intervention among a predominantly black population. They also found  
85 significant improvements in knowledge in glucose monitoring, nutrition, complications, and  
86 management of diabetes.[10] Similarly, a randomised control trial comparing a culturally tailored  
87 DSME intervention in African-Americans to usual care reported significant reductions in HbA1c in the  
88 intervention arm at 6 months. However, at 12 and 18 months respectively, this difference was lost.[11]  
89 A DSME intervention trial among African Americans which emphasised patient empowerment theory  
90 reported significant improvements in self-care behaviours, quality of life and insulin use even after 2  
91 years.[12] Cunningham et al conducted a systematic review and meta-analysis of DSME intervention  
92 trials conducted exclusively African Americans. Contrary to the findings Ryan et al and Lynch et al,  
93 Cunningham et al reported a non-significant difference in mean HbA1c and no improvements in quality  
94 of life (QoL) between DSME intervention groups and usual care.[6]

95 In Africa DSME interventions are not widely available and studies on their effectiveness have likewise  
96 yielded conflicting results. An audit of interventions in S. Africa found 27 DSME interventions with  
97 five of these interventions offering structured education and the rest offering ad hoc education.  
98 Surprisingly, none of the interventions audited had guidelines specifically dedicated to DSME.[13]  
99 Additionally, sustainability of facility-based structured DSME interventions is influenced by facility-,  
100 patient-, and provider level factors.[14]

101 This limited availability of structured interventions in Africa, in particular, have consistently been  
102 reported in the literature.[15, 16] Likewise, the evidence on effectiveness of structured DSME  
103 interventions in Africa is sparse and inconclusive.[15, 17] Gathu et al conducted an RCT among 140  
104 adults with diabetes attending a Family Medicine clinic in Kenya and reported no significant difference  
105 in mean A1c between groups. Gathu et al compared DSME delivered by certified diabetes educators to  
106 comprehensive care delivered by Family Physicians.[18] In contrast, an RCT comparing intensive  
107 structured DSME to conventional education in a facility in Nigeria showed a significant reduction in  
108 mean A1c at 6mo in the intervention arm.[19] To date, there are no structured DSME interventions in  
109 Ghana.

110 Structured DSME interventions for low-resource settings should be tailor-made for such settings. Such  
111 DSME interventions should take into consideration patient-, provider- and facility-level factors. Using  
112 a mixed methods design, we therefore sought to characterise DSME interventions in two urban low-

113 resource primary settings, and to explore the (diabetes self-management) knowledge, and behaviours  
114 of persons living with diabetes (PLD).

115

## 116 2.Methods

### 117 2.1. Design

118 A convergent parallel design[20] with triangulation was used; enabling collection of complementary  
119 data (quantitative and qualitative) concurrently (Fig 1). Thus, we merged the two research methods  
120 (quantitative and qualitative) to achieve our study aims. Data for the quantitative study and qualitative  
121 study were collected simultaneously, in parallel. Beyond data collection, the two methods converged at  
122 the point of analysing our results and interpreting our data. Specifically, we employed qualitative  
123 methods to deepen our understanding (of generalizable) outcomes from the quantitative study. In all the  
124 various aspects of the study, we placed equal emphasis on qualitative and quantitative data. Good  
125 Reporting of a Mixed-Methods Study (GRAMMS)[21] and Consolidated Criteria for Reporting  
126 Qualitative research (COREQ)[22] checklists were followed.

### 127 2.2. Setting

128 The study was conducted at the Korle Bu Teaching Hospital polyclinic (KBTH) and Weija Gbawe  
129 Municipal hospital (WGMH), two public primary facilities located in the city of Accra, Ghana. KBTH  
130 is located within the Ablekumah South Metropolitan district and WGMH is located in Ga West  
131 Municipal district. We conducted one-on-one interviews and held focus group discussions with PLD in  
132 large open spaces at the study sites; Managers were also interviewed in-person on-site. Prescribed  
133 COVID-19 protocols were observed at all times. Experts were however, interviewed virtually.

### 134 2.3.Participant identification, study size and sampling

135 Participant recruitment and data collection occurred between January and February 2021. Using  
136 attendance records, a total enumeration of all eligible clients seen at both study sites from December  
137 2020 to January 2021 was done. These dates formed the frame and we included everyone within the  
138 frame, who met the eligibility criteria. The attendance records of each study site were used in retrieving  
139 the relevant information on potential participants. Trained staff called all potential participants meeting  
140 eligibility criteria and invited them to participate. For each individual, three attempts were made to  
141 reach them. Interested participants were given appointments for a screening visit at the study sites and  
142 to undergo study procedures. Participants received reimbursement for travel costs and time. On average,  
143 each focus group discussion (FGD) lasted about an hour.

144 We assumed a 50% prevalence of diabetes self-management knowledge and 10% non-response rate.  
145 [23, 24] The level of significance was set at 5%. A sample size of 425 PLD was therefore required for  
146 the cross-sectional study. Recruitment for in-depth interviews (IDI) continued until saturation was  
147 reached and no new themes emerged.

148 PLD were identified through convenient sampling and snowballing for the qualitative study. Managers  
149 and healthcare professionals (HCPs) were sampled purposively, and judgemental sampling were used  
150 in identifying experts.

151 Fig 1. Convergent parallel mixed methods study design.

152 Abbreviations: IDI- in-depth interview FGD-Focus Group Discussion HCP- healthcare professional EM-  
153 experts and managers

154

## 155 Eligibility criteria for PLD, HCP, managers and experts

156 Participants had to meet all the following eligibility criteria and none of the exclusion criteria to be  
157 included. Experts were nationally recognised diabetologists. HCP and PLD were staff and attendants at  
158 the study sites respectively. Managers were the respective heads. PLD were 18 years or older and  
159 ambulant at the time of recruitment. People known to have type 1 diabetes, or cognitive or psychiatric  
160 impairment were excluded.

## 161 2.4. Instrument development

162 As we anticipated heterogeneity in responses, because of the case-mix variation, we developed semi-  
163 structured interview guides to guide all interviews. RL and MAC, who both understand the local culture  
164 and norms, developed and refined these interview guides. The questions were informed by results of a  
165 literature review of DSME in low-resource settings conducted by RL. Participant information guides  
166 on the purpose and methods of the study and anonymity was developed by RL and reviewed by MAC  
167 and KKG.

## 168 2.5. Data collection

169 The study was conducted in line with the principles of the Declaration of Helsinki.[25] Prior to any  
170 study procedures, each participant provided written informed consent. Participants who consented to  
171 take part in FGD, also signed non-disclosure statements. These statements were an assurance that  
172 information divulged by participants during the FGD would remain within the group and not shared  
173 outside the group. Since the sessions were audio taped and transcribed, participants were assigned codes  
174 names. Participants were referred to by their code names rather than their real names to maintain their  
175 confidentiality during the FGDs. Access to each facility was granted by their respective heads.

### 176 2.5.1. Quantitative data collection

177 Diabetes self-management knowledge of PLD, the primary outcome variable, was measured on the  
178 spoken knowledge in low literacy persons with diabetes scale (SKILLD).[26] SKILLD is a 10-item  
179 questionnaire with each option giving a score of either 0(0%) or 10(100%). Higher scores indicate better  
180 diabetes self-management knowledge.

181 The variables which were modelled as explanatory variables were anthropometric measures, sitting  
182 blood pressure, duration of diabetes, insulin use, random blood glucose ,sex, family history of diabetes,  
183 income, educational level, occupation and the summary of diabetes self-care activities scores  
184 (SDSCA).[27]

### 185 Measurement procedures

186 We scrupulously followed standard recommended procedures for all measurements.[28-30] We used  
187 StatStrip Xpress glucometer( Onetouch, Taiwan) to measure random blood glucose[29], and Omron

188 M7 (Omron, Japan) to measure sitting blood pressure[28]. Omron digital scale, stadiometer, and  
189 inelastic tape measure were used to take anthropometric measurements.[30]

190 Duration of diabetes, insulin use, sex, family history of diabetes, income, educational level, and  
191 occupation were captured with a general questionnaire. The SKILLD and SDSCA instruments were  
192 interviewer administered.

193

194 Fig 2. Qualitative data collection procedures and number of informants.

195 Abbreviations: KBTH-Korle Bu Teaching Hospital; WGMH-Weija Gbawe Municipal Hospital  
196 interview FGD-Focus Group Discussion DM-duration of diabetes < less than > greater than yrs- years HCP-  
197 Health care professional PLD- person living with diabetes

198

## 199 2.5.2. Qualitative data collection

200 Fig 2 depicts the informants and qualitative procedures undertaken. RL and BB either conducted or  
201 coordinated the IDI and FGD. Interviews were conducted in in English, Twi, or Ga. Responses were  
202 audio-recorded digitally and handwritten field notes were taken. Some of the PLD recruited from the  
203 KBTH study site might have known RL as a staff of that facility. All other PLD involved in the study  
204 did not have any prior relationship with the data collectors. Experts and Health Care Professionals were  
205 colleagues of RL. The roles of the researchers were to facilitate the FGD and conduct the interviews.

## 206 2.6. Data management and analysis

### 207 2.6.1. Quantitative analysis

208 Total SKILLD score (knowledge) was analysed both as a continuous and categorical variable. The  
209 individual SKILLD items were dichotomised into correct and incorrect responses and summarised using  
210 counts (percentage).

211 To test the strength of the association between the total SKILLD score and SDSCA sub-domains, the  
212 Pearson's correlation was employed. The appropriate regression tests involving ordinary least squares  
213 regression or quantiles regression were performed to assess the association between total SKILLD  
214 score) and clinically relevant variables. All analyses were conducted with Stata v16.1. Statistical  
215 significance was set at a two-sided  $p$ -value  $< 0.05$ . REDCap data management system was used for data  
216 capture.

### 217 2.6.2. Qualitative analysis

218 Data was analysed independently by RL, BB and a research assistant using an inductive thematic  
219 approach manually. Audio-recordings were transcribed verbatim. Transcription, initial coding, and  
220 thematic analysis were done manually concurrently with data collection. We extracted both latent and  
221 manifest content. Transcripts were line searched for recurring words and phrases. Concepts were then  
222 used to generate initial codes and further expanded by applying the codes to additional transcripts (open  
223 coding). Sub-themes were identified by reviewing the data for repeating patterns in participant's  
224 responses. Sub-themes were merged into themes, ensuring themes closely described original content  
225 of transcripts. Emerging themes were categorized and compared across the various (informants) groups



226 using colour coded comparative charts. Direct quotes were extracted. Our informants were fully  
227 engaged in all phases of our study. We selected participants who could best provide answers to our  
228 research question. Data saturation was reached when no new themes emerged. Subsequently RL used  
229 Nvivo (released March 2020) to organise the data.

230 MAC reviewed the themes against the final organisation of the data to ensure that there was agreement  
231 in the data collected and its final presentation. Discrepancies and suggestions for review were resolved  
232 through dialogue.

233 Rigour

234 Data, informant, and investigator triangulation was used to ensure rigor and comprehension of concepts.  
235 The transcripts and subsequently thematic analysis were shared with informants to check for accuracy  
236 and to provide feedback. Team meetings with co-investigators experienced in qualitative methods  
237 enhance credibility of the data. Procedures have been described to allow replicability. Use of Nvivo  
238 improves transparency and reliability of the coding. Concurrent collection of quantitative and  
239 qualitative data improve internal validity.

240

## 241 2.7.Ethical approval

242 Ethical approval was granted by the Institutional Review Board of KBTH (STC/IRB/000175/2020) and  
243 the Ethics Review Committee of the Ghana Health Service (GHS-ERC 05/10/20). The head of each  
244 facility granted permission for the study after ethical clearance had been obtained.

245

## 246 3. Results

247 The quantitative results are summarised in tables and the qualitative results are presented by themes.  
248 All the quantitative results are presented first followed by the qualitative results.

### 249 3.1.Quantitative results

#### 250 3.1.1.Participant's flow and baseline characteristics

251 In total, 1202 participants out of 1735 potentially eligible clients were not included. Reasons for this  
252 were as follows: 54 participants had travelled (zero from WGMH), 1029 were unreachable by telephone  
253 (544 from WGMH), 95 declined (one from WGMH), 25 were dead (one from WGMM). As 112 out of  
254 533 eligible participants invited failed to report, four additional participants (0 from WGMH) were  
255 consecutively sampled. Finally, 425 participants were included in the analysis.

256 Participants' baseline socio-demographic and clinical characteristics are shown in Table 1.  
257 Additionally, the mean body weight was 98kg (SD 16). The mean waist circumference for males was  
258 94 cm (SD 16) and for females it was 98 cm (SD 16). The mean systolic and diastolic blood pressure  
259 were 133 mmHg (SD 21) and 81 mmHg (SD 12) respectively. The mean random blood glucose was  
260 9.4 mmol/l (SD 6.4) mmol/l.

261

Table 1. Descriptive (socio-demographic and clinical) characteristics of participants

Variable	Frequency	Percentage
Age(N=425)		
≤39	26	6
40-49	77	18
50-59	132	31
60-69	120	28
70+	70	17
Mean (SD)	581(SD 12)	
Sex (N=425)		
Female	298	70
Male	127	30
<b>Educational level (N=425)</b>		
None	52	12
Primary and middle	194	46
Secondary and vocational	118	27
Tertiary	58	14
Other	3	0.7
<b>Marital Status (N=425)</b>		
Married	245	58
Never married	24	5.7
Living together	1	0.2
Widowed	96	23
Divorced	59	14
Occupation (N=425)		
Professionals with university degrees	36	8.5
Professionals without university degree	30	7
Clerks, motor vehicle drivers, mechanic	89	21
Cooks, barbers, domestic staff, gas staff	36	8.5
Labourers and petty traders	86	20
Apprentices, educated youth, unemployed	148	35

Abbreviations; SD =Standard Deviation N=number of observations

Table 1 (continued). Descriptive (socio-demographic and clinical) characteristics of participants

Variable	Frequency	Percentage
Ethnicity (N=425)		
Akan	206	49
Ga/Adangbe	124	29
Ewe	53	13
Other	40	9.5
Religion (N=425)		
Christian	380	89
Islam	42	9.9
Other	3	0.7
Size of your household (N=412)		
1-2	91	22.09
3-4	136	33
5-6	116	28
6+	69	17
Min-Max	1-27	
Mean (SD)	5(3)	
Additional sources of income (N=417)		
No	342	82
Yes	75	18
Years of diabetes illness (N=416)		
≤1	48	12
2-3	95	23
4-9	138	33
10+	135	33
Min-Max	<1-45	
Mean (SD)	7.7 (0.3)	
Family history of diabetes (N=418)		
No	179	43
Yes	239	57
Have any device for checking blood sugar at home (N=418)		
No	252	60
Yes	166	40

266 Abbreviations; SD =Standard Deviation N=number of observations

### 267 3.1.2. Diabetes self-management knowledge among PLD

268 The median SKILLD score was 40 % (IQR 20-60). The results of the individual SKILLD items revealed  
 269 significant deficits in diabetes self-management knowledge. Only 13 (3%) participants knew the normal  
 270 HbA1c range and 162 (39%) knew the normal fasting glucose range. In total, 208 (50%) and 196 (40%)  
 271 knew the signs of hyperglycaemia and hypoglycaemia, respectively. Only 227 (54%) knew how to treat  
 272 hypoglycaemia. The importance of foot care was known by 135 (32%) and only 126 (30%) participants  
 273 knew the recommended frequency for foot examinations. The frequency of eye examinations and  
 274 exercise was known by 176 (42%) and 199 (48%) respectively. Finally, 247 (59%) participants knew  
 275 the long-term complications of diabetes.

### 276 3.1.3. Factors associated with diabetes self-management knowledge

277 There was no association between SKILLD score and any of the baseline socio-demographic and  
278 clinical variables.

#### 279 3.1.4. Association between diabetes self-management knowledge and self- 280 management behaviour

281 Pairwise correlations showed that SKILLD score was positively correlated with behaviour (SDSCA).  
282 The correlation coefficient was 0.22 ( $p < 0.01$ ) for diet, 0.19 ( $p < 0.01$ ) for medication, 0.14 for exercise  
283 ( $p < 0.05$ ), 0.39 ( $p < 0.01$ ) for glucose testing and 0.38 ( $p < 0.01$ ) for foot care.

#### 284 3.1.5. Influence of diabetes-self-management knowledge (SKILLD) on Diabetes 285 Self-Care Activities Measure(SDSCA) sub-domains

286  
287 The effect of total SKILLD on self-management behaviours (SDSCA sub-domains), adjusted for age,  
288 education, diabetes duration, family history of diabetes and ownership of a glucometer is displayed in  
289 table 2.  
290

291 Table 2. Influence of Knowledge (spoken language in Low Literacy in Diabetes scale) on Diabetes  
 292 Self-Care Activities Measure sub-domains

Variable	Diabetes Self-Care Activities Measures				
	OLS		Quantile regression		
	Diet	Medication	Exercise	Blood testing	Foot
	aβ[95%CI]	aβ[95%CI]	aβ[95%CI]	aβ[95%CI]	aβ[95%CI]
SKILLED Knowledge	0.05[0.02-0.09]**	0.01[0.002-0.02]*	0.05[0.02-0.08]**	0.04[0.02-0.05]***	0.02[-0.02-0.05]
Age group					
≤39					
40-49	1.55[-2.39-5.48]	-0.73[-1.99-0.53]	1.00[-1.27-3.27]	1.07[-0.83-2.97]	0.33[-2.55-3.22]
50-59	1.21[-2.57-4.99]	0.37[-0.77-1.52]	2.00[-0.49-4.49]	0.93[-0.96-2.82]	0.17[-2.47-2.81]
60-69	1.03[-2.75-4.82]	0.20[-0.96-1.35]	1.00[-1.09-3.09]	1.07[-0.83-2.97]	0.33[-2.27-2.93]
70+	1.62[-2.46-5.70]	-0.03[-1.25-1.19]	0.50[-1.60-2.61]	2.07[-0.88-3.02]	0.33[-2.36-3.03]
Educational level					
None					-0.17[-1.57-1.24]
Primary	2.06[-0.93-5.05]	-0.96[-1.69- -0.24]**	1.22[-1.98-5.98]	-0.28[-0.94-0.37]	1.24
Middle	1.77[-0.90-4.45]	-1.02[-1.59- -0.45]***	-0.50[-2.33-1.33]	-0.50[-1.05-0.05]	-0.17[-1.46-1.13]
Secondary	3.19[0.33-6.04]*	0.71]***	2.50[-0.20-5.20]	0.07[-1.32-1.46]	0.17[-1.48-1.81]
Vocational	2.97[-2.19-4.83]	-1.28[-2.02- -0.36]**	-2.22[-3.32-6.32]	0.78[-2.57-4.14]	0.17[-2.97-3.31]
Tertiary	1.21[-2.19-4.62]	0.50]***	0.50[-2.16-3.16]	2.86[0.81-4.90]	1.00[-1.36-3.36]
Other	-2.54[-11.8-6.75]	0.08[-0.76-0.92]	10.0[-17.2-37.2]	7.07[2.85-11.3]***	7.00[1.98-12.0]**
Years of diabetes illness					
≤1					-0.17[-1.48-1.15]
2-3	0.38[-2.45-3.21]	0.99[-0.01-1.99]	2.66[-2.18-3.18]	-0.34[-1.01-0.29]	-0.33[-1.81-1.14]
4-9	0.34[-2.41-3.09]	0.93[-0.01-1.89]	3.11[-2.45-6.45]	-0.50[-1.15-0.15]	-0.17[-1.83-1.50]
10+	0.85[-1.98-3.68]	1.25[0.30-2.21]	0.50[-1.85-2.85]	-0.35[-1.19-0.48]	
Family history of diabetes					
No					-5.55[-1.00-5.99]
Yes	-1.06[-2.69-0.57]	0.13[-0.31-0.58]	-0.50[-1.92-0.92]	0.00[-0.48-0.49]	
Device for checking blood sugar					
No					
Yes	2.34[0.60-4.08]**	0.61[0.20-1.03]**	-1.00[-2.38-0.39]	1.00[0.32-1.67]**	0.17[-0.94-1.27]

293 NOTE: Abbreviation: SKILLED= Spoken Language in Low Literacy in Diabetes; OLS-ordinary least  
 294 squares regression; aβ= adjusted Coefficient estimate. Covariates used age, education, duration of  
 295 diabetes and family history. P-value Notation; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 type of test multiple  
 296 linear regression

### 297 3.2. Qualitative results

### 298 3.2.1.Participants

299 Fig 2 depicts the types of informants and data gathering techniques used.

### 300 3.2.2.Emerging themes

301 The themes identified are displayed in Fig 3 and include health numeracy and financing, logistics and  
302 norms.

303

304

305 Fig 3. Thematic areas DSME needs in resource constrained settings.

#### 306 i. DSME interventions

307 We found that PLD received DSME from nurses, doctors, and or nutritionists. The education was un-  
308 structured, didactic, group-based and delivered in-person prior to consultations. Groups typically had  
309 about 20 PLD per group and sessions lasted for about 30 minutes, on average.

310 We observed that varied perceptions among informants resulted in contrasting perspectives on existing  
311 DSME interventions. For example, PLD generally favoured group over individualised education,  
312 placing value on peer-to-peer learning. The consensus among PLD seemed to be that individualised  
313 education provided prior to a consultation was inadequate. They pointed out that the group sessions  
314 inadvertently provided avenues for newly diagnosed persons to draw on the experience and diabetes  
315 self-management knowledge of their peers. All patient groups interviewed, recommended that peers,  
316 together with health workers should be used as diabetes educators.

317 PLD described existing DSME interventions as beneficial but reported that teaching aids were not  
318 culturally or linguistically adapted.

319 R5 FGD KBTH –“*often the books available on diabetes have examples of foods eaten abroad*”

320 R4 FGD WGMH- “*....we have been given a book that teaches us how to manage diabetes. The book is*  
321 *normally read to me....* “

322 R5 FGD WGMH: “*.....about the pamphlet. It sometimes contains foreign information which is their*  
323 *food and what they need to do in order to take care of themselves so I think they should be limited to*  
324 *our local activities*”

325 R3 FGD WGMH: “*.....I prefer all the teachings in a leaflet form.... Those who can't read the leaflet*  
326 *personally, can allow their children or friends to help them read*”

327 In contrast to PLD, providers and diabetes experts thought existing DSME interventions were at best  
328 parsimonious. Human resource constraints, lack of logistics, unavailability of academic courses, and a  
329 policy direction were challenges identified. Except for the doctors, none of the other participant groups  
330 were familiar with structured DSME.

331 The unstructured nature of existing DSME interventions meant PLD continued with self-management  
332 education classes ad-infinitum. Our informants appreciated the knowledge reinforcement.

333 R IDI KBTH: "...[They] *are doing their best because the doctors really educate the patients on how*  
334 *they can manage the diabetes themselves.*"

335 PLD used DSME interchangeably with health education. They recommended that churches and other  
336 community spaces and mass media communication channels be used for DSME.

337 Most informants preferred the existing in-person format to virtual sessions.

338 ii. Diabetes self-management knowledge

339 Knowledge on self-management was deficient and self-care practices among PLD were inadequate.

340 R4 FGD KBTH: "*I used to inject the insulin in the house but anytime I inject it, my sugar level rises so*  
341 *a doctor friend of mine advised me that the insulin should be injected in the hospital and by a doctor so*  
342 *for 5years now I have stop using the insulin.*"

343 PLDs echoed several myths as truths. Notwithstanding, PLD bemoaned the inconsistencies in  
344 nutritional recommendations.

345 iii. Self-management behaviours

346 PLD knew more about the importance of medication use, self-blood glucose testing, meal planning,  
347 exercise, and routine reviews than about foot care. None of the PLD and HCPs mentioned foot care.  
348 Contrastingly, foot care, routine investigations and eye screening were mentioned by the experts as  
349 being important components of self-management.

350 Several barriers to self-care, even when diabetes self-management knowledge was apparently adequate,  
351 were enumerated by all informants.

352 iv. Finance

353 Among persons with low health numeracy in resource constrained settings there's little choice in  
354 lifestyle. Poverty is the common pathway for restricted access to information, food, care, and  
355 medication. PLD described dependence on literate relatives to access useful information contained in  
356 patient education leaflets.

357 PLDs and HCPs enumerated the cost constraints faced by PLD and how those influenced food  
358 consumption patterns. HCPs were empathetic and yet seemingly frustrated by the vicious cycle of high  
359 carbohydrate consumption and hyperglycaemia among PLD. PLD and HCPs both indicated that  
360 consumption of fresh produce was dependent on seasonality.

361 PLD described frequent stockout of medications covered by insurance. None of the PLD groups  
362 complained about costs associated with home glucose testing. The experts however noted that patient's  
363 inability to afford home glucose monitoring was a barrier to optimising glycaemic control.

364 v. Norms and belief systems

365 Finances were not the only determinants of meal patterns. PLD voiced the conflict between their  
366 intentions and actions. They recounted the difficulty of executing planned behaviour ( such as portion  
367 control). They described nutritional recommendations as a deviation from cultural norms. PLD  
368 described wanting to 'belong' at social gatherings. HCP and PLD alike alluded to the fact that diabetes  
369 (especially among young persons) was stigmatised.

370 PLD said they received conflicting messages from traditional herbal and alternative medicine  
371 practitioners, religious leaders, and HCPs. Furthermore, they expressed a belief in destiny and the  
372 existence of an external locus of control. These belief systems contributed to poor self-care.

## 373 4. Discussion

374 We sought to characterize DSME interventions and to explore the self-management knowledge and  
375 behaviours of persons living with diabetes. The interventions studied were unstructured, group-based  
376 and delivered in-person mostly by nurses. Self-management knowledge and behaviours were sub-  
377 optimal and influenced by conflicting messaging, financial constraints, culture, beliefs, and stigma.

### 378 Existing DSME interventions

379 The unstructured nature of the DSME interventions and use of group delivery methods probably reflects  
380 an attempt to increase the accessibility of DSME despite resource constraints. Building sustainability  
381 into DSME interventions for resource constrained settings, is key. The use of “non-internet” mass media  
382 to disseminate DSME interventions, as proposed by our informants might be a sustainable option.  
383 Moreover, since most of our informants found repetition of content useful, mass media channels may  
384 be well patronised. Similar to our findings, the importance of the traditional media in disseminating  
385 DSME was identified in another African study.[31] However, people living with long-standing diabetes  
386 in Iran reported that repetition of DSME content was not useful. A direct contrast to the views of  
387 informants in our study. Importantly, the population studied in Iran had significantly higher literacy  
388 levels relative to our study population and this difference may account for the disparities.[32] In Iran,  
389 health literacy has been shown to be positively correlated with health behaviours.[33]

### 390 Diabetes self-management knowledge and it’s relation with self- 391 management behaviours

392 Our findings of limited diabetes self-management knowledge echo those of previous studies.[34, 35]  
393 The extremely low SKILLD scores from our quantitative study reflect the depth of lack of knowledge  
394 on self-care. The themes we identified in this study provide some explanations for and elaborate on the  
395 inadequate diabetes self-management knowledge among PLD. In particular, the low literacy levels and  
396 inconsistent messaging are plausible explanations for the low SKILLD scores.

397

398 Despite the seemingly insurmountable barriers to self-care expressed by PLD, our results show that  
399 diabetes self-management knowledge is positively associated with several self-management  
400 behaviours. In congruence with our findings, a multi-centre cross-sectional study in Ghana found  
401 diabetes self-management knowledge to be a predictor of self-care: every 1 unit increase in knowledge  
402 was associated with 20 times the odds of higher SDSCA scores.[36] Although, the proportion of people  
403 with tertiary education was comparable to our study, the proportion of people with no education, was  
404 50% higher relative to our study population.[36] Efforts at improving self-management knowledge  
405 might therefore ultimately also translate into better self-care behaviours among PLD in low-resource  
406 settings.

407 Our findings suggest, formal education is not associated with self-management behaviours except for  
408 adherence to medication. In contrast, Rothman et al found that having tertiary education was associated



409 with a 12% increase in SDSCA scores, indicating better self-care behaviours.[26] Surprisingly, a cross-  
410 sectional multi-centre study from Ethiopia, observed, that not having formal education was associated  
411 with increased odds of having good self-care behaviours (AOR = 2.6, 95% CI = 1.32-5.25).[37] This  
412 estimate of the effect of formal education on self-management behaviour could have been biased by the  
413 absence of a control group.

## 414 Diabetes self-management behaviours

415 Our findings of low scores across all domains of the SDSCA parallel findings from a multi-centre study  
416 in the Northern region of Ghana. [35] The socio-demographic and clinical profiles of the participants  
417 in these two studies were similar except for diabetes duration. The duration of diabetes was longer in  
418 the study by Mogre et al. [35], however, despite having had diabetes for longer, the self-management  
419 behaviours were just as sub-optimal as in our study. The low SDSCA scores from the quantitative study  
420 and the qualitative results from the IDI and FGDs both indicate poor self-management among PLD. It  
421 is plausible poor self-care behaviours are fuelled by both factors within and beyond the individual's  
422 control; particularly the financial challenges enumerated earlier. A cross-sectional study involving PLD  
423 in a specialist clinic of a tertiary teaching hospital in Nigeria also echo our findings of low scores on  
424 all domains of SDSCA.[38]

425 The alarmingly low knowledge scores on foot care, and correspondingly poor practice of foot care, in  
426 our study is disturbing. Our findings provide strong justification for emphasising foot care in DSME  
427 interventions. Curricula which emphasise the relation between amputations, glycaemic control,  
428 routines, and daily lifestyle choices would be beneficial. The qualitative results from our study provide  
429 further insight into the low scores in the domain of foot care and parallel findings from other sub-  
430 Saharan African countries[39] and other regions of Ghana.[35] Our findings also resonate with a  
431 qualitative facility-based study among a predominantly agricultural community.[34] Bossman et al  
432 reported deficits in diabetes self-management knowledge and self-care behaviours in the domains of  
433 nutrition, exercise, and foot care with foot care being the least known and practiced.[34] It is thus not  
434 surprising that, amputations are major causes of morbidity among PLD in Ghana and other sub-Saharan  
435 African countries.[40]

436 Our findings indicate a high demand for diabetes self-management information, especially, culturally  
437 tailored information on nutrition therapy albeit poor adherence to nutritional recommendations.  
438 Unfortunately, the edicts of self-care behaviours particularly in the domain of nutrition deviate from  
439 local cultural norms and this could contribute to the poor adherence. Furthermore, Unavailability of  
440 formal training in DSME for providers, could contribute to inconsistent messaging on nutritional  
441 therapy. Our findings parallel those from a study conducted in specialist clinic in Nigeria which reported  
442 confusion about nutritional recommendations, and the unacceptability of nutritional  
443 recommendations.[41]

444 We found that behaviour change seemed to be a hurdle that persisted despite adequate diabetes self-  
445 management knowledge. Our results suggest that our informants' capacity to modify established  
446 behaviours might be limited. Previous behaviour is a known predictor of adherence to self-care  
447 recommendations.[42] Incorporating education on behaviour change strategies may therefore be a  
448 useful addition to the existing DSME interventions.

## 449 Financial constraints

450 In this study, financial constraints transcend multiple aspects of diabetes self-management: adherence  
451 to self-management recommendations, keeping clinic appointments and purchasing medications. In  
452 particular, medications which were unavailable on the National Health Insurance were largely  
453 inaccessible. Likewise, for many of our informants, accessibility of vegetables was determined by their  
454 seasonality. Our findings collaborate previous findings from Ghana [43], and Benin.[44] de-Graft  
455 Aikins et al have previously shown that cost was a major and important limiting factor in several  
456 domains of self-management. [43]

## 457 Norms and belief systems

458 Some of our informants expressed the belief that the locus of control resides outside the individual. We  
459 found a belief in “divinity” which influenced perceptions of diabetes and diseases in general as reported  
460 widely in previous studies from Ghana[41, 43], Benin[44], Malawi and Mozambique.[31] Potentially,  
461 the local beliefs systems could adversely affect attitudes to self-care and self-care behaviours. This  
462 indicates a need to include sessions on the locus of control when designing DSME interventions for  
463 such settings.

## 464 Stigma

465 Hospital based DSME was more valued than community-based DSME because of diabetes-related  
466 stigma. Our finding that diabetes is stigmatised suggests that, having support persons as part of DSME  
467 interventions might be beneficial. Using peer educators may offer net-working opportunities for PLD  
468 and discussing disclosure may improve effectiveness of DSME interventions. The finding of stigma  
469 and lack of family support was also reported by Mogre et al. [45] Among Ghanaians, family non-support  
470 has been found to be negatively correlated with diabetes self-management behaviours.[46] Family  
471 support has a linear relation with self-care.[47]

## 472 Strengths and limitations

473 Quantitative analysis enabled us to generate valid unbiased estimates of diabetes self-management  
474 knowledge, and behaviours. The mixed methods design provided additional qualitative data and insights  
475 into the results of the quantitative study. The data was coded and analysed by researchers well  
476 accustomed to the Ghanaian culture. Data was generated from a variety of informants and study  
477 participants, managers, PLD, HCPs and experts.

478 The generalisability of the study to the Ghanaian population, however, is limited because the study was  
479 conducted only in two facilities within the Greater Accra region. However, the clientele of KBTH come  
480 from all over Ghana. Our findings may also not be generalised to people known to have type 1 diabetes.  
481 Furthermore, the use of consecutive sampling may limit the representativeness of our sample.

482

## 483 Conclusion

484 The DSME interventions studied were under-resourced and were not structured. Our findings indicate  
485 very limited diabetes self-management knowledge and poor adherence to self-care recommendations.  
486 Barriers to self-care included cost constraints, cultural norms, stigma and belief systems. DSME  
487 interventions should incorporate sessions on mitigating these barriers. They should be culturally tailored

488 and linguistically modified for people with low literacy. This may improve self-management, ultimately  
489 reducing the difficulties of PLD in resource constrained settings. Future mixed-methods cohort studies  
490 should focus on elucidating factors associated with effectiveness of DSME interventions in low resource  
491 settings.

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494

495

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497

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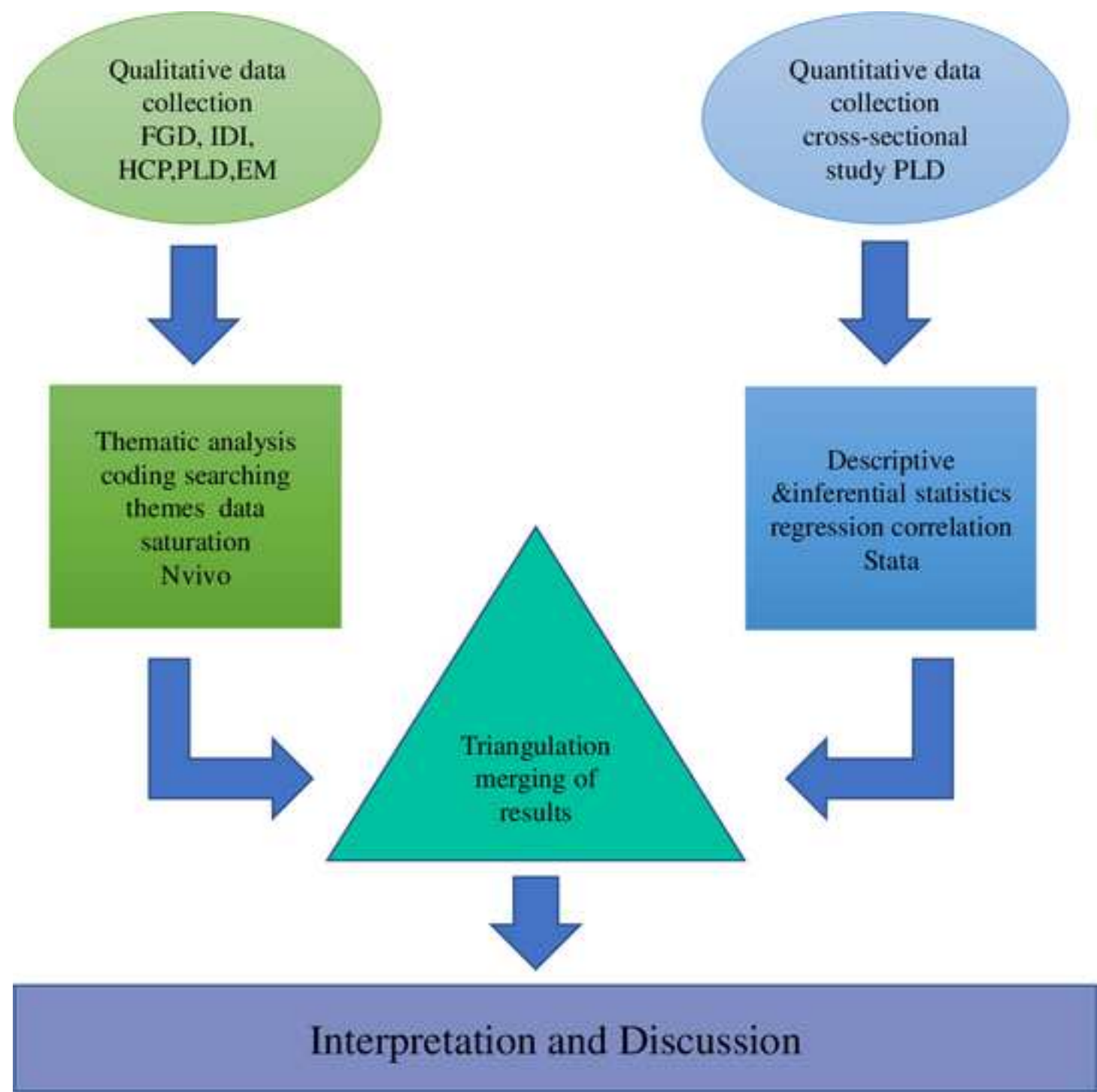
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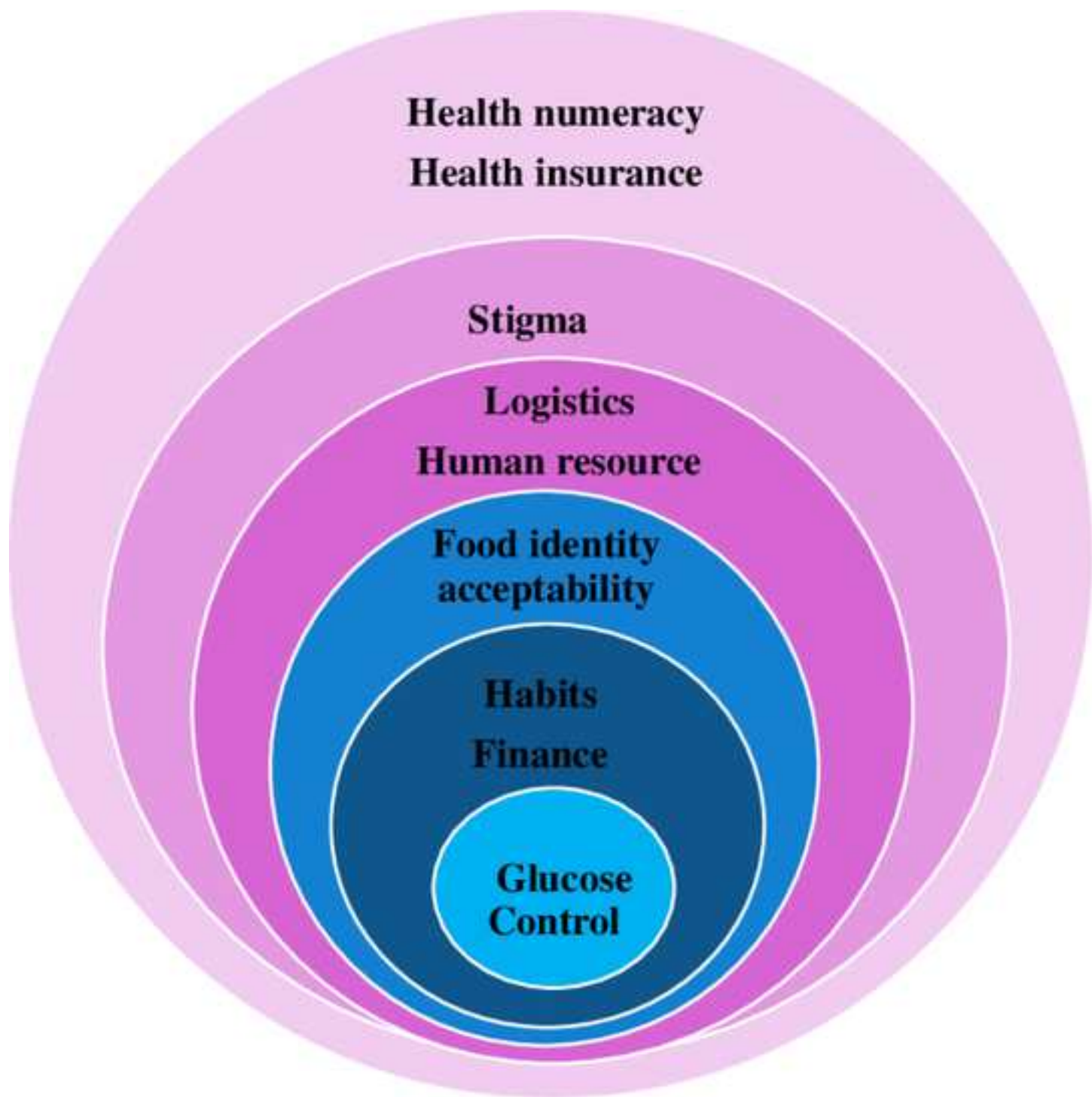
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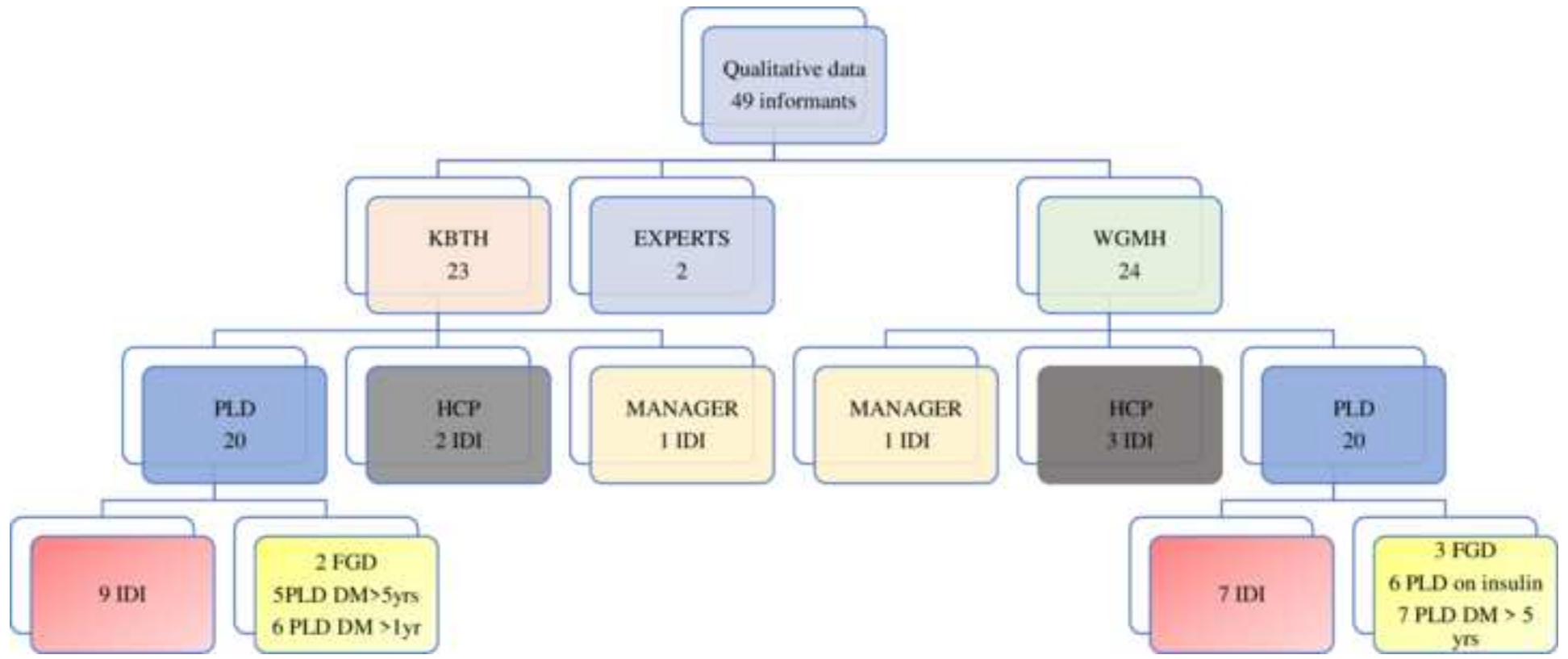
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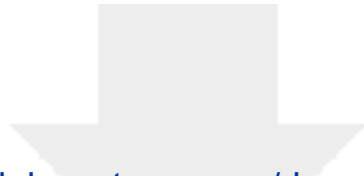








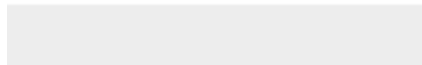


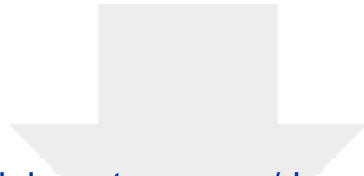


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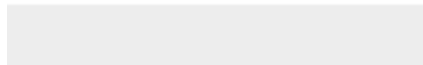
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1 **Diabetes self-management education interventions and**  
2 **self-management in low-resource settings; a mixed**  
3 **methods study**

4 **Running title: Structured? No; Literate? No; Pamphlets? Yes!;**  
5 **DSME in resource-constrained settings**

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27

28



## 29 Abstract

### 30 Introduction

31 Diabetes is largely a self-managed disease and thus care outcomes are closely linked to self-  
32 management behaviours. However, structured self-management education (DSME) interventions are  
33 largely unavailable in Africa.

34

### 35 Aim

36 We sought to characterise DSME interventions in two urban low-resource primary settings, and to  
37 explore diabetes self-management knowledge and behaviours of persons living with diabetes (PLD).

38

### 39 Research design and Methods

40 A convergent parallel mixed-methods study was conducted between January to February 2021 in  
41 Accra, Ghana. A total enumeration in addition to consecutive sampling was done for the cross-  
42 sectional study whilst purposive or judgemental sampling was used in selecting participants for the  
43 qualitative study. Multivariable regression models were used to study the association between diabetes  
44 self-management knowledge and behaviours. We employed inductive content analysis of informants'  
45 experiences and context to complement the quantitative findings.

46

### 47 Results

48 In total 425 PLD (70.1 % (n=298) females, mean age 58 years (SD 12), mean blood glucose 9.4 mmol/l  
49 (SD 6.4)) participated in the quantitative study. Two managers, five professionals, two diabetes experts  
50 and 16 PLD participated in in-depth interviews. Finally, 24 PLD were involved in four focus group  
51 discussions.

52

53 Median diabetes self-management knowledge score was 40 % ( IQR 20-60). Every 1 unit increase in  
54 diabetes self-management knowledge was associated with increased scores on diet ( 5%;[95% CI: 2%-  
55 9%,  $p<0.05$ ]), exercise (5%; [95% CI:2%-8%,  $p<0.05$ ]) and glucose monitoring (4%;[95% CI:2%-5%,  
56  $p<0.05$ ]) domains of the diabetes self-care activities scale.

57

58 The DSME interventions studied were unstructured and limited by resources. Financial constraints,  
59 conflicting messages, beliefs, and stigma were themes underpinning behaviours.

60

### 61 Conclusions

62 The DSME interventions studied were under-resourced and unstructured. Diabetes self-management  
63 knowledge was limited and associated with self-management behaviour. DSME interventions in low  
64 resource settings should be culturally tailored and incorporate sessions on mitigating financial  
65 constraints. Future studies should focus on creating structured DSME interventions suitable for  
66 resource-constrained settings.

67

### 68 Key words

69 Diabetes, self-management, self-care, education, health resources, Ghana

70

## 71 Introduction

72 Globally 536 million people live with diabetes, and this number is projected to rise to 784 million by  
73 2045.[1] Eighty percent of these half a billion people live in low- and middle-income countries like  
74 Ghana.[1] Diabetes is a long-standing leading cause of morbidity and mortality[2] in Ghana and among  
75 adults the prevalence is 6.5%.[3]

76 Diabetes self-management education (DSME), being a bedrock of optimal diabetes care can  
77 effectively improve glycaemic control and ameliorate the disease burden. [4, 5] DSME involves  
78 equipping patients with knowledge for self-management and several models for DSME  
79 interventions exist.[4, 6] Characteristics of DSME interventions include duration, cultural and  
80 linguistic tailoring, theoretical underpinnings, structure/ curriculum, mode of delivery, instructor  
81 characteristics, and intensity.[6, 7] Examples of theories which have been studied in relation to  
82 diabetes self-management include the social cognitive theory and empowerment theory.[7, 8] It is  
83 uncertain which of these characteristics of DSME interventions account for effectiveness in  
84 improving glycaemic control and care outcomes.[9]

85 Ryan et al reported an improvement in glycaemic control, specifically a difference in mean  
86 HbA1c, following a 6-month DSME intervention among a predominantly black population. They  
87 also found significant improvements in knowledge in glucose monitoring, nutrition,  
88 complications, and management of diabetes.[10] Similarly, a randomised control trial comparing  
89 a culturally tailored DSME intervention in African-Americans to usual care reported significant  
90 reductions in HbA1c in the intervention arm at 6 months. However, at 12 and 18 months  
91 respectively, this difference was lost.[11] A DSME intervention trial among African Americans  
92 which emphasised patient empowerment theory reported significant improvements in self-care  
93 behaviours, quality of life and insulin use even after 2 years.[12] Cunningham et al conducted a  
94 systematic review and meta-analysis of DSME intervention trials conducted exclusively African  
95 Americans. Contrary to the findings Ryan et al and Lynch et al, Cunningham et al reported a  
96 non-significant difference in mean HbA1c and no improvements in quality of life (QoL) between  
97 DSME intervention groups and usual care.[6]

98 In Africa DSME interventions are not widely available and studies on their effectiveness have  
99 likewise yielded conflicting results. An audit of interventions in S. Africa found 27 DSME  
100 interventions with five of these interventions offering structured education and the rest offering  
101 ad hoc education. Surprisingly, none of the interventions audited had guidelines specifically  
102 dedicated to DSME.[13] Additionally, sustainability of facility-based structured DSME  
103 interventions is influenced by facility-, patient-, and provider level factors.[14]

104 This limited availability of structured interventions in Africa, in particular, have consistently  
105 been reported in the literature.[15, 16] Likewise, the evidence on effectiveness of structured  
106 DSME interventions in Africa is sparse and inconclusive.[15, 17] Gathu et al conducted an RCT  
107 among 140 adults with diabetes attending a Family Medicine clinic in Kenya and reported no  
108 significant difference in mean A1c between groups. Gathu et al compared DSME delivered by  
109 certified diabetes educators to comprehensive care delivered by Family Physicians.[18] In  
110 contrast, an RCT comparing intensive structured DSME to conventional education in a facility  
111 in Nigeria showed a significant reduction in mean A1c at 6mo in the intervention arm.[19] To  
112 date, there are no structured DSME interventions in Ghana.

113 **Structured DSME interventions for low-resource settings should be tailor-made for such settings.**  
114 **Such DSME interventions should take into consideration patient-, provider- and facility-level**  
115 **factors. Using a mixed methods design, we therefore sought to characterise DSME interventions**  
116 **in two urban low-resource primary settings, and to explore the (diabetes self-management)**  
117 **knowledge, and behaviours of persons living with diabetes (PLD).**

118

## 119 **2.Methods**

### 120 **2.1. Design**

121 A convergent parallel design[20] with triangulation was used; enabling collection of complementary  
122 data (quantitative and qualitative) concurrently (Fig 1). **Thus, we merged the two research methods**  
123 **(quantitative and qualitative) to achieve our study aims. Data for the quantitative study and**  
124 **qualitative study were collected simultaneously, in parallel. Beyond data collection, the two**  
125 **methods converged at the point of analysing our results and interpreting our data. Specifically,**  
126 **we employed qualitative methods to deepen our understanding (of generalizable) outcomes from**  
127 **the quantitative study. In all the various aspects of the study, we placed equal emphasis on**  
128 **qualitative and quantitative data.** Good Reporting of a Mixed-Methods Study (GRAMMS)[21] and  
129 Consolidated Criteria for Reporting Qualitative research (COREQ)[22] checklists were followed.

### 130 **2.2. Setting**

131 The study was conducted at the Korle Bu Teaching Hospital polyclinic (KBTH) and Weija Gbawe  
132 Municipal hospital (WGMH), two public primary facilities located in the city of Accra, Ghana. **KBTH**  
133 **is located within the Ablekumah South Metropolitan district and WGMH is located in Ga West**  
134 **Municipal district.** We conducted **one-on-one** interviews and **held focus group discussions with PLD**  
135 **in large open spaces at the study sites; Managers were also interviewed in-person on-site.** Prescribed  
136 COVID-19 protocols were observed at all times. **Experts were however, interviewed virtually.**

### 137 **2.3.Participant identification, study size and sampling**

138 **Participant recruitment and data collection occurred between January and February 2021. Using**  
139 **attendance records, a total enumeration of all eligible clients seen at both study sites from December**  
140 **2020 to January 2021 was done. These dates formed the frame and we included everyone within**  
141 **the frame, who met the eligibility criteria. The attendance records of each study site were used in**  
142 **retrieving the relevant information on potential participants.** Trained staff called all potential  
143 participants meeting eligibility criteria and invited them to participate. For each individual, three  
144 **attempts were made to reach them.** Interested participants were given appointments for a screening visit  
145 at the study sites and to undergo study procedures. Participants received reimbursement for travel costs  
146 and time. On average, each focus group discussion (FGD) lasted about an hour.

147 We assumed a 50% prevalence of diabetes self-management knowledge and 10% non-response rate.  
148 [23, 24] The level of significance was set at 5%. A sample size of 425 PLD was therefore required for  
149 the cross-sectional study. Recruitment for in-depth interviews (IDI) continued until saturation was  
150 reached and no new themes emerged.

151 PLD were identified through convenient sampling and snowballing for the qualitative study. Managers  
152 and healthcare professionals (HCPs) were sampled purposively, and judgemental sampling were used  
153 in identifying experts.

154 Fig 1. Convergent parallel mixed methods study design.

155 Abbreviations: IDI- in-depth interview FGD-Focus Group Discussion HCP- healthcare professional EM-  
156 experts and managers

157

## 158 **Eligibility criteria for PLD, HCP, managers and experts**

159 Participants had to meet all the following eligibility criteria and none of the exclusion criteria to be  
160 included. Experts were nationally recognised diabetologists. HCP and PLD were staff and attendants at  
161 the study sites respectively. Managers were the respective heads. PLD were 18 years or older and  
162 ambulant at the time of recruitment. People known to have type 1 diabetes, or cognitive or psychiatric  
163 impairment were excluded.

## 164 **2.4. Instrument development**

165 As we anticipated heterogeneity in responses, because of the case-mix variation, we developed semi-  
166 structured interview guides to guide all interviews. RL and MAC, who both understand the local culture  
167 and norms, developed and refined these interview guides. The questions were informed by results of a  
168 literature review of DSME in low-resource settings conducted by RL. Participant information guides  
169 on the purpose and methods of the study and anonymity was developed by RL and reviewed by MAC  
170 and KKG.

## 171 **2.5. Data collection**

172 The study was conducted in line with the principles of the Declaration of Helsinki.[25] Prior to any  
173 study procedures, each participant provided written informed consent. Participants who consented to  
174 take part in FGD, also signed non-disclosure statements. These statements were an assurance that  
175 information divulged by participants during the FGD would remain within the group and not shared  
176 outside the group. Since the sessions were audio taped and transcribed, participants were assigned codes  
177 names. Participants were referred to by their code names rather than their real names to maintain their  
178 confidentiality during the FGDs. Access to each facility was granted by their respective heads.

### 179 **2.5.1. Quantitative data collection**

180 Diabetes self-management knowledge of PLD, the primary outcome variable, was measured on the  
181 spoken knowledge in low literacy persons with diabetes scale (SKILLD).[26] SKILLD is a 10-item  
182 questionnaire with each option giving a score of either 0(0%) or 10(100%). Higher scores indicate better  
183 diabetes self-management knowledge.

184 The variables which were modelled as explanatory variables were anthropometric measures, sitting  
185 blood pressure, duration of diabetes, insulin use, random blood glucose ,sex, family history of diabetes,  
186 income, educational level, occupation and the summary of diabetes self-care activities scores  
187 (SDSCA).[27]

### 188 **Measurement procedures**

189 We scrupulously followed standard recommended procedures for all measurements.[28-30] We used  
190 StatStrip Xpress glucometer( Onetouch, Taiwan) to measure random blood glucose[29], and Omron  
191 M7 (Omron, Japan) to measure sitting blood pressure[28]. Omron digital scale, stadiometer, and  
192 inelastic tape measure were used to take anthropometric measurements.[30]

193 Duration of diabetes, insulin use, sex, family history of diabetes, income, educational level, and  
194 occupation were captured with a general questionnaire. The SKILLD and SDSCA instruments were  
195 interviewer administered.

196

197 Fig 2. Qualitative data collection procedures and number of informants.

198 Abbreviations: KBTH-Korle Bu Teaching Hospital; WGMH-Weija Gbawe Municipal Hospital IDI- in-depth  
199 interview FGD-Focus Group Discussion DM-duration of diabetes < less than > greater than yrs- years HCP-  
200 Health care professional PLD- person living with diabetes

201

## 202 **2.5.2. Qualitative data collection**

203 Fig 2 depicts the informants and qualitative procedures undertaken. RL and BB either conducted or  
204 coordinated the IDI and FGD. Interviews were conducted in in English, Twi, or Ga. Responses were  
205 audio-recorded digitally and handwritten field notes were taken. Some of the PLD recruited from the  
206 KBTH study site might have known RL as a staff of that facility. All other PLD involved in the study  
207 did not have any prior relationship with the data collectors. Experts and Health Care Professionals were  
208 colleagues of RL. The roles of the researchers were to facilitate the FGD and conduct the interviews.

## 209 **2.6. Data management and analysis**

### 210 **2.6.1. Quantitative analysis**

211 Total SKILLD score (knowledge) was analysed both as a continuous and categorical variable. The  
212 individual SKILLD items were dichotomised into correct and incorrect responses and summarised using  
213 counts (percentage).

214 To test the strength of the association between the total SKILLD score and SDSCA sub-domains, the  
215 Pearson's correlation was employed. The appropriate regression tests involving ordinary least squares  
216 regression or quantiles regression were performed to assess the association between total SKILLD  
217 score) and clinically relevant variables. All analyses were conducted with Stata v16.1. Statistical  
218 significance was set at a two-sided  $p$ -value < 0.05. REDCap data management system was used for data  
219 capture.

### 220 **2.6.2. Qualitative analysis**

221 Data was analysed independently by RL, BB and a research assistant using an inductive thematic  
222 approach manually. Audio-recordings were transcribed verbatim. Transcription, initial coding, and  
223 thematic analysis were done manually concurrently with data collection. We extracted both latent and  
224 manifest content. Transcripts were line searched for recurring words and phrases. Concepts were then  
225 used to generate initial codes and further expanded by applying the codes to additional transcripts (open  
226 coding). Sub-themes were identified by reviewing the data for repeating patterns in participant's

227 responses. Sub-themes were merged into themes, ensuring themes closely described original content  
228 of transcripts. Emerging themes were categorized and compared across the various (informants) groups  
229 using colour coded comparative charts. Direct quotes were extracted. Our informants were fully  
230 engaged in all phases of our study. We selected participants who could best provide answers to our  
231 research question. Data saturation was reached when no new themes emerged. Subsequently RL used  
232 Nvivo (released March 2020) to organise the data.

233 MAC reviewed the themes against the final organisation of the data to ensure that there was agreement  
234 in the data collected and its final presentation. Discrepancies and suggestions for review were resolved  
235 through dialogue.

### 236 **Rigour**

237 Data, informant, and investigator triangulation was used to ensure rigor and comprehension of concepts.  
238 The transcripts and subsequently thematic analysis were shared with informants to check for accuracy  
239 and to provide feedback. Team meetings with co-investigators experienced in qualitative methods  
240 enhance credibility of the data. Procedures have been described to allow replicability. Use of Nvivo  
241 improves transparency and reliability of the coding. Concurrent collection of quantitative and  
242 qualitative data improve internal validity.

243

## 244 **2.7.Ethical approval**

245 Ethical approval was granted by the Institutional Review Board of KBTH (STC/IRB/000175/2020) and  
246 the Ethics Review Committee of the Ghana Health Service (GHS-ERC 05/10/20). The head of each  
247 facility granted permission for the study after ethical clearance had been obtained.

248

## 249 **3. Results**

250 The quantitative results are summarised in tables and the qualitative results are presented by themes.  
251 All the quantitative results are presented first followed by the qualitative results.

### 252 **3.1.Quantitative results**

#### 253 **3.1.1.Participant's flow and baseline characteristics**

254 In total, 1202 participants out of 1735 potentially eligible clients were not included. Reasons for this  
255 were as follows: 54 participants had travelled (zero from WGMH), 1029 were unreachable by telephone  
256 (544 from WGMH), 95 declined (one from WGMH), 25 were dead (one from WGMM). As 112 out of  
257 533 eligible participants invited failed to report, four additional participants (0 from WGMH) were  
258 consecutively sampled. Finally, 425 participants were included in the analysis.

259 Participants' baseline socio-demographic and clinical characteristics are shown in Table 1.  
260 Additionally, the mean body weight was 98kg (SD 16). The mean waist circumference for males was  
261 94 cm (SD 16) and for females it was 98 cm (SD 16). The mean systolic and diastolic blood pressure  
262 were 133 mmHg (SD 21) and 81 mmHg (SD 12) respectively. The mean random blood glucose was  
263 9.4 mmol/l (SD 6.4) mmol/l.

264

Table 1. Descriptive (socio-demographic and clinical) characteristics of participants

Variable	Frequency	Percentage
Age(N=425)		
≤39	26	6
40-49	77	18
50-59	132	31
60-69	120	28
70+	70	17
Mean (SD)	581(SD 12)	
Sex (N=425)		
Female	298	70
Male	127	30
Educational level (N=425)		
None	52	12
Primary and middle	194	46
Secondary and vocational	118	27
Tertiary	58	14
Other	3	0.7
Marital Status (N=425)		
Married	245	58
Never married	24	5.7
Living together	1	0.2
Widowed	96	23
Divorced	59	14
Occupation (N=425)		
Professionals with university degrees	36	8.5
Professionals without university degree	30	7
Clerks, motor vehicle drivers, mechanic	89	21
Cooks, barbers, domestic staff, gas staff	36	8.5
Labourers and petty traders	86	20
Apprentices, educated youth, unemployed	148	35

266

Abbreviations; SD =Standard Deviation N=number of observations

267

268

Table 1 (continued). Descriptive (socio-demographic and clinical) characteristics of participants

Variable	Frequency	Percentage
<b>Ethnicity (N=425)</b>		
Akan	206	49
Ga/Adangbe	124	29
Ewe	53	13
Other	40	9.5
<b>Religion (N=425)</b>		
Christian	380	89
Islam	42	9.9
Other	3	0.7
<b>Size of your household (N=412)</b>		
1-2	91	22.09
3-4	136	33
5-6	116	28
6+	69	17
Min-Max	1-27	
Mean (SD)	5(3)	
<b>Additional sources of income (N=417)</b>		
No	342	82
Yes	75	18
<b>Years of diabetes illness (N=416)</b>		
≤1	48	12
2-3	95	23
4-9	138	33
10+	135	33
Min-Max	<1-45	
Mean (SD)	7.7 (0.3)	
<b>Family history of diabetes (N=418)</b>		
No	179	43
Yes	239	57
<b>Have any device for checking blood sugar at home (N=418)</b>		
No	252	60
Yes	166	40

269

Abbreviations; SD =Standard Deviation N=number of observations

### 270 3.1.2. Diabetes self-management knowledge among PLD

271 The median SKILLD score was 40 % (IQR 20-60). The results of the individual SKILLD items revealed  
 272 significant deficits in diabetes self-management knowledge. Only 13 (3%) participants knew the normal  
 273 HbA1c range and 162 (39%) knew the normal fasting glucose range. In total, 208 (50%) and 196 (40%)  
 274 knew the signs of hyperglycaemia and hypoglycaemia, respectively. Only 227 (54%) knew how to treat  
 275 hypoglycaemia. The importance of foot care was known by 135 (32%) and only 126 (30%) participants  
 276 knew the recommended frequency for foot examinations. The frequency of eye examinations and  
 277 exercise was known by 176 (42%) and 199 (48%) respectively. Finally, 247 (59%) participants knew  
 278 the long-term complications of diabetes.

### 279 3.1.3. Factors associated with diabetes self-management knowledge



280 There was no association between SKILLD score and any of the baseline socio-demographic and  
281 clinical variables.

### 282 **3.1.4. Association between diabetes self-management knowledge and self-** 283 **management behaviour**

284 Pairwise correlations showed that SKILLD score was positively correlated with behaviour (SDSCA).  
285 The correlation coefficient was 0.22 ( $p<0.01$ ) for diet, 0.19 ( $p<0.01$ ) for medication, 0.14 for exercise  
286 ( $p<0.05$ ), 0.39 ( $p<0.01$ ) for glucose testing and 0.38 ( $p<0.01$ ) for foot care.

### 287 **3.1.5. Influence of diabetes-self-management knowledge (SKILLD) on** 288 **Diabetes Self-Care Activities Measure(SDSCA) sub-domains**

289  
290 The effect of total SKILLD on self-management behaviours (SDSCA sub-domains), adjusted for age,  
291 education, diabetes duration, family history of diabetes and ownership of a glucometer is displayed in  
292 table 2.  
293

294 Table 2. Influence of Knowledge (spoken language in Low Literacy in Diabetes scale) on Diabetes  
 295 Self-Care Activities Measure sub-domains

Variable	Diabetes Self-Care Activities Measures				
	OLS		Quantile regression		
	Diet	Medication	Exercise	Blood testing	Foot
	aβ[95%CI]	aβ[95%CI]	aβ[95%CI]	aβ[95%CI]	aβ[95%CI]
SKILLED Knowledge	0.05[0.02-0.09]**	0.01[0.002-0.02]*	0.05[0.02-0.08]**	0.04[0.02-0.05]***	0.02[-0.02-0.05]
Age group					
≤39					
40-49	1.55[-2.39-5.48]	-0.73[-1.99-0.53]	1.00[-1.27-3.27]	1.07[-0.83-2.97]	0.33[-2.55-3.22]
50-59	1.21[-2.57-4.99]	0.37[-0.77-1.52]	2.00[-0.49-4.49]	0.93[-0.96-2.82]	0.17[-2.47-2.81]
60-69	1.03[-2.75-4.82]	0.20[-0.96-1.35]	1.00[-1.09-3.09]	1.07[-0.83-2.97]	0.33[-2.27-2.93]
70+	1.62[-2.46-5.70]	-0.03[-1.25-1.19]	0.50[-1.60-2.61]	2.07[-0.88-3.02]	0.33[-2.36-3.03]
Educational level					
None					-0.17[-1.57-1.24]
Primary	2.06[-0.93-5.05]	-0.96[-1.69- -0.24]**	1.22[-1.98-5.98]	-0.28[-0.94-0.37]	1.24
Middle	1.77[-0.90-4.45]	-1.02[-1.59- -0.45]***	-0.50[-2.33-1.33]	-0.50[-1.05-0.05]	-0.17[-1.46-1.13]
Secondary	3.19[0.33-6.04]*	0.71]***	2.50[-0.20-5.20]	0.07[-1.32-1.46]	0.17[-1.48-1.81]
Vocational	2.97[-2.19-4.83]	-1.28[-2.02- -0.36]**	-2.22[-3.32-6.32]	0.78[-2.57-4.14]	0.17[-2.97-3.31]
Tertiary	1.21[-2.19-4.62]	0.50]***	0.50[-2.16-3.16]	2.86[0.81-4.90]	1.00[-1.36-3.36]
Other	-2.54[-11.8-6.75]	0.08[-0.76-0.92]	10.0[-17.2-37.2]	7.07[2.85-11.3]***	7.00[1.98-12.0]**
Years of diabetes illness					
≤1					-0.17[-1.48-1.15]
2-3	0.38[-2.45-3.21]	0.99[-0.01-1.99]	2.66[-2.18-3.18]	-0.34[-1.01-0.29]	-0.33[-1.81-1.14]
4-9	0.34[-2.41-3.09]	0.93[-0.01-1.89]	3.11[-2.45-6.45]	-0.50[-1.15-0.15]	-0.17[-1.83-1.50]
10+	0.85[-1.98-3.68]	1.25[0.30-2.21]	0.50[-1.85-2.85]	-0.35[-1.19-0.48]	
Family history of diabetes					
No					-5.55[-1.00-5.99]
Yes	-1.06[-2.69-0.57]	0.13[-0.31-0.58]	-0.50[-1.92-0.92]	0.00[-0.48-0.49]	
Device for checking blood sugar					
No					
Yes	2.34[0.60-4.08]**	0.61[0.20-1.03]**	-1.00[-2.38-0.39]	1.00[0.32-1.67]**	0.17[-0.94-1.27]

296 NOTE: Abbreviation: SKILLED= Spoken Language in Low Literacy in Diabetes; OLS-ordinary least  
 297 squares regression; aβ= adjusted Coefficient estimate. Covariates used age, education, duration of  
 298 diabetes and family history. P-value Notation; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 type of test multiple  
 299 linear regression

### 300 3.2. Qualitative results

### 301 3.2.1.Participants

302 Fig 2 depicts the types of informants and data gathering techniques used.

### 303 3.2.2.Emerging themes

304 The themes identified are displayed in Fig 3 and include health numeracy and financing, logistics and  
305 norms.

306

307

308 Fig 3. Thematic areas DSME needs in resource constrained settings.

#### 309 i. DSME interventions

310 We found that PLD received DSME from nurses, doctors, and or nutritionists. The education was un-  
311 structured, didactic, group-based and delivered in-person prior to consultations. Groups typically had  
312 about 20 PLD per group and sessions lasted for about 30 minutes, on average.

313 We observed that varied perceptions among informants resulted in contrasting perspectives on existing  
314 DSME interventions. For example, PLD generally favoured group over individualised education,  
315 placing value on peer-to-peer learning. The consensus among PLD seemed to be that individualised  
316 education provided prior to a consultation was inadequate. They pointed out that the group sessions  
317 inadvertently provided avenues for newly diagnosed persons to draw on the experience and diabetes  
318 self-management knowledge of their peers. All patient groups interviewed, recommended that peers,  
319 together with health workers should be used as diabetes educators.

320 PLD described existing DSME interventions as beneficial but reported that teaching aids were not  
321 culturally or linguistically adapted.

322 R5 FGD KBTH –“often the books available on diabetes have examples of foods eaten abroad”

323 R4 FGD WGMH- “...we have been given a book that teaches us how to manage diabetes. The book is  
324 normally read to me.... “

325 R5 FGD WGMH: “.....about the pamphlet. It sometimes contains foreign information which is their  
326 food and what they need to do in order to take care of themselves so I think they should be limited to  
327 our local activities”

328 R3 FGD WGMH: “.....I prefer all the teachings in a leaflet form.... Those who can't read the leaflet  
329 personally, can allow their children or friends to help them read”

330 In contrast to PLD, providers and diabetes experts thought existing DSME interventions were at best  
331 parsimonious. Human resource constraints, lack of logistics, unavailability of academic courses, and a  
332 policy direction were challenges identified. Except for the doctors, none of the other participant groups  
333 were familiar with structured DSME.

334 The unstructured nature of existing DSME interventions meant PLD continued with self-management  
335 education classes ad-infinitum. Our informants appreciated the knowledge reinforcement.

336 R IDI KBTH: "...[They] *are doing their best because the doctors really educate the patients on how*  
337 *they can manage the diabetes themselves.*"

338 PLD used DSME interchangeably with health education. They recommended that churches and other  
339 community spaces and mass media communication channels be used for DSME.

340 Most informants preferred the existing in-person format to virtual sessions.

#### 341 **ii. Diabetes self-management knowledge**

342 Knowledge on self-management was deficient and self-care practices among PLD were inadequate.

343 R4 FGD KBTH: "*I used to inject the insulin in the house but anytime I inject it, my sugar level rises so*  
344 *a doctor friend of mine advised me that the insulin should be injected in the hospital and by a doctor so*  
345 *for 5years now I have stop using the insulin.*"

346 PLDs echoed several myths as truths. Notwithstanding, PLD bemoaned the inconsistencies in  
347 nutritional recommendations.

#### 348 **iii. Self-management behaviours**

349 PLD knew more about the importance of medication use, self-blood glucose testing, meal planning,  
350 exercise, and routine reviews than about foot care. None of the PLD and HCPs mentioned foot care.  
351 Contrastingly, foot care, routine investigations and eye screening were mentioned by the experts as  
352 being important components of self-management.

353 Several barriers to self-care, even when diabetes self-management knowledge was apparently adequate,  
354 were enumerated by all informants.

#### 355 **iv. Finance**

356 Among persons with low health numeracy in resource constrained settings there's little choice in  
357 lifestyle. Poverty is the common pathway for restricted access to information, food, care, and  
358 medication. PLD described dependence on literate relatives to access useful information contained in  
359 patient education leaflets.

360 PLDs and HCPs enumerated the cost constraints faced by PLD and how those influenced food  
361 consumption patterns. HCPs were empathetic and yet seemingly frustrated by the vicious cycle of high  
362 carbohydrate consumption and hyperglycaemia among PLD. PLD and HCPs both indicated that  
363 consumption of fresh produce was dependent on seasonality.

364 PLD described frequent stockout of medications covered by insurance. None of the PLD groups  
365 complained about costs associated with home glucose testing. The experts however noted that patient's  
366 inability to afford home glucose monitoring was a barrier to optimising glycaemic control.

#### 367 **v. Norms and belief systems**

368 Finances were not the only determinants of meal patterns. PLD voiced the conflict between their  
369 intentions and actions. They recounted the difficulty of executing planned behaviour ( such as portion  
370 control). They described nutritional recommendations as a deviation from cultural norms. PLD  
371 described wanting to 'belong' at social gatherings. HCP and PLD alike alluded to the fact that diabetes  
372 (especially among young persons) was stigmatised.

373 PLD said they received conflicting messages from traditional herbal and alternative medicine  
374 practitioners, religious leaders, and HCPs. Furthermore, they expressed a belief in destiny and the  
375 existence of an external locus of control. These belief systems contributed to poor self-care.

## 376 **4. Discussion**

377 We sought to characterize DSME interventions and to explore the self-management knowledge and  
378 behaviours of persons living with diabetes. The interventions studied were unstructured, group-based  
379 and delivered in-person mostly by nurses. Self-management knowledge and behaviours were sub-  
380 optimal and influenced by conflicting messaging, financial constraints, culture, beliefs, and stigma.

### 381 **Existing DSME interventions**

382 The unstructured nature of the DSME interventions and use of group delivery methods probably reflects  
383 an attempt to increase the accessibility of DSME despite resource constraints. Building sustainability  
384 into DSME interventions for resource constrained settings, is key. The use of “non-internet” mass media  
385 to disseminate DSME interventions, as proposed by our informants might be a sustainable option.  
386 Moreover, since most of our informants found repetition of content useful, mass media channels may  
387 be well patronised. Similar to our findings, the importance of the traditional media in disseminating  
388 DSME was identified in another African study.[31] However, people living with long-standing diabetes  
389 in Iran reported that repetition of DSME content was not useful. A direct contrast to the views of  
390 informants in our study. Importantly, the population studied in Iran had significantly higher literacy  
391 levels relative to our study population and this difference may account for the disparities.[32] In Iran,  
392 health literacy has been shown to be positively correlated with health behaviours.[33]

### 393 **Diabetes self-management knowledge and it’s relation with self- 394 management behaviours**

395 Our findings of limited diabetes self-management knowledge echo those of previous studies.[34, 35]  
396 The extremely low SKILLD scores from our quantitative study reflect the depth of lack of knowledge  
397 on self-care. The themes we identified in this study provide some explanations for and elaborate on the  
398 inadequate diabetes self-management knowledge among PLD. In particular, the low literacy levels and  
399 inconsistent messaging are plausible explanations for the low SKILLD scores.

400

401 Despite the seemingly insurmountable barriers to self-care expressed by PLD, our results show that  
402 diabetes self-management knowledge is positively associated with several self-management  
403 behaviours. In congruence with our findings, a multi-centre cross-sectional study in Ghana found  
404 diabetes self-management knowledge to be a predictor of self-care: every 1 unit increase in knowledge  
405 was associated with 20 times the odds of higher SDSCA scores.[36] Although, the proportion of people  
406 with tertiary education was comparable to our study, the proportion of people with no education, was  
407 50% higher relative to our study population.[36] Efforts at improving self-management knowledge  
408 might therefore ultimately also translate into better self-care behaviours among PLD in low-resource  
409 settings.

410 Our findings suggest, formal education is not associated with self-management behaviours except for  
411 adherence to medication. In contrast, Rothman et al found that having tertiary education was associated

412 with a 12% increase in SDSCA scores, indicating better self-care behaviours.[26] Surprisingly, a cross-  
413 sectional multi-centre study from Ethiopia, observed, that not having formal education was associated  
414 with increased odds of having good self-care behaviours (AOR = 2.6, 95% CI = 1.32-5.25).[37] This  
415 estimate of the effect of formal education on self-management behaviour could have been biased by the  
416 absence of a control group.

## 417 **Diabetes self-management behaviours**

418 Our findings of low scores across all domains of the SDSCA parallel findings from a multi-centre study  
419 in the Northern region of Ghana. [35] The socio-demographic and clinical profiles of the participants  
420 in these two studies were similar except for diabetes duration. The duration of diabetes was longer in  
421 the study by Mogre et al. [35], however, despite having had diabetes for longer, the self-management  
422 behaviours were just as sub-optimal as in our study. The low SDSCA scores from the quantitative study  
423 and the qualitative results from the IDI and FGDs both indicate poor self-management among PLD. It  
424 is plausible poor self-care behaviours are fuelled by both factors within and beyond the individual's  
425 control; particularly the financial challenges enumerated earlier. A cross-sectional study involving PLD  
426 in a specialist clinic of a tertiary teaching hospital in Nigeria also echo our findings of low scores on  
427 all domains of SDSCA.[38]

428 The alarmingly low knowledge scores on foot care, and correspondingly poor practice of foot care, in  
429 our study is disturbing. Our findings provide strong justification for emphasising foot care in DSME  
430 interventions. Curricula which emphasise the relation between amputations, glycaemic control,  
431 routines, and daily lifestyle choices would be beneficial. The qualitative results from our study provide  
432 further insight into the low scores in the domain of foot care and parallel findings from other sub-  
433 Saharan African countries[39] and other regions of Ghana.[35] Our findings also resonate with a  
434 qualitative facility-based study among a predominantly agricultural community.[34] Bossman et al  
435 reported deficits in diabetes self-management knowledge and self-care behaviours in the domains of  
436 nutrition, exercise, and foot care with foot care being the least known and practiced.[34] It is thus not  
437 surprising that, amputations are major causes of morbidity among PLD in Ghana and other sub-Saharan  
438 African countries.[40]

439 Our findings indicate a high demand for diabetes self-management information, especially, culturally  
440 tailored information on nutrition therapy albeit poor adherence to nutritional recommendations.  
441 Unfortunately, the edicts of self-care behaviours particularly in the domain of nutrition deviate from  
442 local cultural norms and this could contribute to the poor adherence. Furthermore, Unavailability of  
443 formal training in DSME for providers, could contribute to inconsistent messaging on nutritional  
444 therapy. Our findings parallel those from a study conducted in specialist clinic in Nigeria which reported  
445 confusion about nutritional recommendations, and the unacceptability of nutritional  
446 recommendations.[41]

447 We found that behaviour change seemed to be a hurdle that persisted despite adequate diabetes self-  
448 management knowledge. Our results suggest that our informants' capacity to modify established  
449 behaviours might be limited. Previous behaviour is a known predictor of adherence to self-care  
450 recommendations.[42] Incorporating education on behaviour change strategies may therefore be a  
451 useful addition to the existing DSME interventions.

## 452 **Financial constraints**

453 In this study, financial constraints transcend multiple aspects of diabetes self-management: adherence  
454 to self-management recommendations, keeping clinic appointments and purchasing medications. In  
455 particular, medications which were unavailable on the National Health Insurance were largely  
456 inaccessible. Likewise, for many of our informants, accessibility of vegetables was determined by their  
457 seasonality. Our findings collaborate previous findings from Ghana [43], and Benin.[44] de-Graft  
458 Aikins et al have previously shown that cost was a major and important limiting factor in several  
459 domains of self-management. [43]

## 460 **Norms and belief systems**

461 Some of our informants expressed the belief that the locus of control resides outside the individual. We  
462 found a belief in “divinity” which influenced perceptions of diabetes and diseases in general as reported  
463 widely in previous studies from Ghana[41, 43], Benin[44], Malawi and Mozambique.[31] Potentially,  
464 the local beliefs systems could adversely affect attitudes to self-care and self-care behaviours. This  
465 indicates a need to include sessions on the locus of control when designing DSME interventions for  
466 such settings.

## 467 **Stigma**

468 Hospital based DSME was more valued than community-based DSME because of diabetes-related  
469 stigma. Our finding that diabetes is stigmatised suggests that, having support persons as part of DSME  
470 interventions might be beneficial. Using peer educators may offer net-working opportunities for PLD  
471 and discussing disclosure may improve effectiveness of DSME interventions. The finding of stigma  
472 and lack of family support was also reported by Mogre et al. [45] Among Ghanaians, family non-support  
473 has been found to be negatively correlated with diabetes self-management behaviours.[46] Family  
474 support has a linear relation with self-care.[47]

## 475 **Strengths and limitations**

476 Quantitative analysis enabled us to generate valid unbiased estimates of diabetes self-management  
477 knowledge, and behaviours. The mixed methods design provided additional qualitative data and insights  
478 into the results of the quantitative study. The data was coded and analysed by researchers well  
479 accustomed to the Ghanaian culture. Data was generated from a variety of informants and study  
480 participants, managers, PLD, HCPs and experts.

481 The generalisability of the study to the Ghanaian population, however, is limited because the study was  
482 conducted only in two facilities within the Greater Accra region. However, the clientele of KBTH come  
483 from all over Ghana. **Our findings may also not be generalised to people known to have type 1**  
484 **diabetes. Furthermore, the use of consecutive sampling may limit the representativeness of our**  
485 **sample.**

486

## 487 **Conclusion**

488 **The DSME interventions studied** were under-resourced and were not structured. Our findings indicate  
489 very limited diabetes self-management knowledge and poor adherence to self-care recommendations.  
490 Barriers to self-care included cost constraints, cultural norms, stigma and belief systems. **DSME**

491 interventions should incorporate sessions on mitigating these barriers. They should be culturally tailored  
492 and linguistically modified for people with low literacy. This may improve self-management, ultimately  
493 reducing the difficulties of PLD in resource constrained settings. Future mixed-methods cohort studies  
494 should focus on elucidating factors associated with effectiveness of DSME interventions in low resource  
495 settings.

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498

499



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31<sup>st</sup> October, 2022

The Editorial Office  
PLOS ONE

Dear Jamie Males,

### **RESPONSE TO REVIEWERS' COMMENTS**

#### **PONE-D-22-15096: DIABETES SELF-MANAGEMENT EDUCATION IN LOW-RESOURCE SETTINGS: A MIXED METHODS NEEDS ASSESSMENT OF PROVIDERS AND PEOPLE LIVING WITH DIABETES**

We are deeply indebted to the reviewers for their time. We highly appreciate the time you and the team of editors have already committed to helping us improve our paper. Please find a point-by-point response to each comment in the table below. Our paper has been revised with these responses.

We have also modified the funding statement as follows:

#### Funding

The study was funded in part by the UMC Utrecht Global Health Support PhD program. It had no role in the study design, collection, analysis, interpretation of data, writing of the report or decision to submit the article for publication.

No	Reviewer's comment	Response to reviewer's comment
	<p>1. Is the manuscript technically sound, and do the data support the conclusions?</p> <p>The manuscript must describe a technically sound piece of scientific research with data that supports the conclusions. Experiments must have been conducted rigorously, with appropriate controls, replication, and sample sizes. The conclusions must be drawn appropriately based on the data presented.</p> <p>Reviewer #1: No</p>	<p>Thank you.</p> <p>We have reviewed the entire manuscript for clarity in communicating our processes and procedures. We were meticulous in following research methods, and we believe our work is technically sound.</p>

	<p>Reviewer #2: Partly</p> <p>Reviewer #3: Partly</p>	
	<p>2. Has the statistical analysis been performed appropriately and rigorously?</p> <p>Reviewer #1: I Don't Know</p> <p>Reviewer #2: Yes</p> <p>Reviewer #3: I Don't Know</p>	<p>We believe our analyses have been conducted appropriately and with rigour.</p>
	<p>3. Have the authors made all data underlying the findings in their manuscript fully available?</p> <p>The <a href="#">PLOS Data policy</a> requires authors to make all data underlying the findings described in their manuscript fully available without restriction, with rare exception (please refer to the Data Availability Statement in the manuscript PDF file). The data should be provided as part of the manuscript or its supporting information, or deposited to a public repository. For example, in addition to summary statistics, the data points behind means, medians and variance measures should be available. If there are restrictions on publicly sharing data—e.g. participant privacy or use of data from a third party—those must be specified.</p> <p>Reviewer #1: Yes</p> <p>Reviewer #2: Yes</p> <p>Reviewer #3: Yes</p>	<p>--</p>
	<p>4. Is the manuscript presented in an intelligible fashion and written in standard English?</p>	<p>In response to reviewer 1, We have further reviewed the entire manuscript to ensure</p>

<p>PLOS ONE does not copyedit accepted manuscripts, so the language in submitted articles must be clear, correct, and unambiguous. Any typographical or grammatical errors should be corrected at revision, so please note any specific errors here.</p> <p>Reviewer #1: No</p> <p>Reviewer #2: Yes</p> <p>Reviewer #3: Yes</p>	<p>that the language used is suitable for a scientific paper. We have endeavoured to correct all language use errors.</p>
<p>Reviewer 1</p>	
<p>Reviewer #1: a. I applaud the authors for conducting an interesting article. However, is still needed to improve the quality of this paper. Please revise the manuscript to address the expressed concerns. After thorough review, I am recommending some revisions. In this regard, kindly address the following comments and suggestions to further improve your manuscript</p>	<p>Thank you.</p>
<p>b. There are some spelling and grammatical errors in the text. Please correct them</p>	<p>We have reviewed the manuscript and endeavoured to correct all language use errors.</p>
<p>c. Explain about the qualitative method in the abstract method section and mention the important qualitative results in the abstract results section</p>	<p>These were previously done. In our original submission we stated the following:</p> <p>1.A convergent parallel—This explains the mixed method both qualitative and quantitative. In response to the reviewer’s comment, in addition to the reference already provided, and Figure 1, we have modified the section</p>



		<p>2.1 design and included this further explanation:</p> <p>“Thus, we merged the two research methods (quantitative and qualitative) to answer our research questions and achieve our study aims. In addition, the two methods converged at the point of analysing the results and interpretating the data. Data for the quantitative study and qualitative study were collected simultaneously, in parallel. Moreover, we placed equal emphasis on qualitative and quantitative data in all aspects of the study.”</p> <p>We believe this increases the reproducibility of our method. Thank you.</p> <p>2. In the abstract we stated that “we employed inductive content analysis of informants’ experiences and context”.</p> <p>In the main manuscript we explained further by stating “Data was analysed independently by RL, BB and a research assistant using an inductive thematic approach manually”-These explain the qualitative method</p> <p>2.In the abstract we stated, “Financial constraints, conflicting messages, beliefs, and stigma were themes underpinning behaviours.”- These are the quantitative results</p>
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		<p>We then went on to describe the qualitative results in detail in the main manuscript.</p>
	<p>d. Please write the type of study, sample size, sampling strategy and date and country of study in abstract</p>	<p>These were previously done. We stated the following in our original submission:</p> <ol style="list-style-type: none"> <li>1. A convergent parallel mixed-methods study was conducted . We went on to describe this method further in the main manuscript. In response to the reviewers comment we have provided further and better particulars of this type of study in addition to the reference already provided</li>   <li>2. sample size: In total 425 PLD..... Two managers, five professionals, two diabetes experts and 16 PLD participated in in-depth interviews. Finally, 24 PLD</li>   <li>3. We have now provided further clarity to our sampling strategy.</li> </ol> <p>, a total enumeration of all eligible clients seen at both study sites from December 2020 to January 2021 was done. <b>These dates formed the frame and we included everyone within the frame, who met the eligibility criteria. The attendance records of each study site were used in retrieving the relevant</b></p>

		<p><b>information on potential participants. “</b></p> <p>“PLD were identified through convenient sampling and snowballing for the qualitative study. Managers and healthcare professionals (HCPs) were sampled purposively, and judgemental sampling were used in identifying experts.”</p> <p>4.date and country of the study Thank you we have included this “January to February 2021 in Accra, Ghana”</p>
	<p>e. The introduction section need some revision. You could summarize this section a bit more for readers. Write about the problems, the novelty of your study, the limitations of prior research might also be mentioned by the authors as further support for their present investigation and your study goals within the introduction. In this section, you can use the following articles:</p> <p>1- “ Application of the Social Cognitive Theory to Predict Self-Care Behavior among Type 2 Diabetes Patients with Limited Health Literacy”</p> <p>2- “The Relationship Between Health Literacy and Health Promoting Behaviors in Patients with Type2 Diabetes”</p>	<p>We have re-written the entire introduction section.</p> <p>We have modified our title to ensure that the title, new introduction, aims, and conclusions are congruent</p> <p>We have found it useful to include the suggested references in the introduction and discussion sections of the manuscript respectively.</p> <p>Thank you for helping us improve our manuscript.</p>
	<p>f. In the introduction, you should fully explain why you used the qualitative method?</p>	<p>This was previously done. We stated that “We employed qualitative methods to deepen our understanding (of generalizable) outcomes from the quantitative study”</p>
	<p>g. The materials &amp; methods section is relatively immature. You could expand it a bit more clearly for readers. For example, Where have</p>	<p>These were previously done</p> <p>1. Name and place where we did the study : We stated that</p>

	<p>you collected samples? Write the year and the name of place in which you had done this survey. Furthermore, write about all applied exclusion and inclusion criteria a bit more clearly by which you selected samples for this survey.</p>	<p>“The study was conducted in Korle Bu Teaching Hospital polyclinic (KBTH) and Weija Gbawe Municipal hospital (WGMH),</p> <p>2. where samples were collected: two public primary facilities located in Accra, Ghana.</p> <p>Interviews were conducted at the study sites either in offices or large open spaces whilst observing prescribed COVID-19 protocols. Experts were interviewed virtually.</p> <p>”</p> <p>3. year study conducted: We also stated that “Participant recruitment and data collection occurred between January and February 2021”</p> <p>4. applied exclusion and inclusion criteria: We also stated that “HCP and PLD were staff and attendants at the study sites respectively. Managers were the respective heads. PLD were 18 years or older, not known to have type 1 diabetes, cognitive or psychiatric impairment and ambulant.</p> <p>”</p>
	<p>h. Discuss more about your sampling strategy in both qualitative and quantitative section? The structure of your sampling is so vague and understandable. Did you have sampling frame? how did you access to this frame</p>	<p>This was previously done. We stated that “a total enumeration of all eligible clients seen at both study sites from December 2020 to January 2021 was done.” For clarity we have added this sentence: “These dates formed the frame and we included</p>

		everyone within the frame, who met the eligibility criteria “
	What are the data extract’s center characteristics? is it governmental or private, is it referral or not referral and so on, discuss more about it	This was previously done.  We stated that “The study was conducted in Korle Bu Teaching Hospital polyclinic (KBTH) and Weija Gbawe Municipal hospital (WGMH), two public primary facilities located in Accra, Ghana”. The facilities were government primary care facilities
	j. How many observers did you have? if you had more than one observer, you must mention agreement	Thank you. We mentioned in our original submission that discrepancies were resolved through dialogue. We had 3 observers engaging the PLD . One observer engaged both managers 2 observers engaged the HCW. 2 observers engaged the Experts.
	k. The methods need to be improved by providing more detail information related to participant’s selection (e.g. respond rate; necessary permissions from who? How did the researcher contact the potential participants?)	Response rate: We have now included the non-response rate “21%”  Permissions: We had stated the following in our original submission”The head of each facility granted permission for the study after having obtained ethical clearance”  We previously stated the following in our original submission “Trained staff called all potential participants meeting eligibility criteria and invited them to participate. For each individual, three attempts were made to reach them.”
	l. Please prepare a method section	This was previously done . We stated in our original

	<p>based on consolidated criteria for reporting qualitative research (COREQ) guidelines</p>	<p>submission that “The Good Reporting of a Mixed-Methods Study (GRAMMS)(5) and Consolidated Criteria for REporting Qualitative research (COREQ)(6) checklists were followed. ” In response to the reviewer, we now have added the COREQ checklist as supporting material.” Thank you</p>
	<p>m. Please write the type of Qualitative study (for example Grounded Theory, Content analysis, ...) sample size, sampling strategy in qualitative method section</p>	<p>This was previously done in the abstract as well as in the main manuscript. We stated the following and provided details of our method 1.”using an inductive content analysis”  2.”using an inductive thematic approach manually”</p>
	<p>n. Sampling in qualitative section was done until redundancy in data was reached? the types and levels of participation of the participants should also be described</p>	<p>Thank you. The following statements have now been included “Our informants were fully engaged in all phases of our study. We selected participants who could best provide answers to our research question.”</p>
	<p>o. The researcher's role(s), level of participation and relationship with participants also needs to be described in qualitative section, as they can influence the findings</p>	<p>Thank you . The following statement has been added “Some of the PLD recruited from the KBTH study site might have known RL as a staff of that facility. All other PLD involved in the study did not have any prior relationship with the data collectors. Experts and Health Care Professionals were colleagues of RL. The roles of the researchers were to facilitate the FGD and conduct the interviews”</p>
	<p>p. You could increase the number of more recently studies in the reference section. You should have comprehensive and reliable comparisons between your findings</p>	<p>Our original discussion section included 14 references 9 which were published within the last 3 years and all the 14</p>

	<p>with the other previous studies. In the discussion, you did not include related previous studies in relation to the findings of the current study. Please search and cite related studies and include them in your discussion</p>	<p>references were published within the last 7 years.</p> <p>We have in addition significantly increased the number of references in the introduction. Thank you.</p>
	<p>q. In the discussion section, more interpretations are needed</p>	<p>This has been done . Thank you. We have done a thorough review of the entire discussion section</p>
	<p>Reviewer #2: Thank you for the opportunity to review this paper. It is a very interesting and well written paper. It addresses a very important topic. I provide my suggestions below which the authors may use for further improvement.</p>	<p>Thank you</p>
	<p>1. Abstract: Lines 50-52, the authors may revise the statement to include the percentage increase in the sentence, then the CI and the range are put in parentheses.</p>	<p>We tried to rephrase the sentence to accommodate this suggestion however the sentence did not read very well .</p>
	<p>2. The introduction is not sufficiently grounded in the literature. The authors have not demonstrated their knowledge of what has been done already on the topic. Also, they have not provided enough justification for a need for the study. What is the research gap? And why is the study important for policy and practice.</p>	<p>We have increased the number of references in the introduction thank you.</p> <p>The introduction has been re-written form clarity thank you.</p>
	<p>Self-Management Education is a behavior change intervention that is less known and implemented in Africa. Authors should therefore provide sufficient information so readers will not confuse it with the normal self-management education that is provided to patients with diabetes when they seek routine clinical care. The topic is about diabetes self-management education (DSME). What is this DSME? Such background information is necessary.</p>	<p>Additional background information has been provided in the introduction for clarity. We have also replaced self-management program with self-management intervention. Thank you</p>
	<p>3. The diabetes prevalence rate of 26% among the adult population in Ghana</p>	<p>Thank you this has now been corrected to 6.5% prevalence.</p>

<p>attributed to Jie Li et al., 2018 (lines 68 and 69) as the source may be incorrect. Jie Li et al. were talking about the prevalence of cardiovascular disease (CVD) risk factors and 26.1% was attributed to diabetes mellitus. They were not talking about diabetes prevalence among adult population in Ghana. They were talking about diabetes mellitus being a risk factor of CVD.</p>	
<p>4. Lines 70-78, the entire two paragraphs have no single citation. Are the assertions based on the authors opinion? If the answer is no, then they need to credit the sources.</p>	<p>Thank you. This entire section has been re-written</p>
<p>5. I am a little bit confused about the study aim and the conclusion drawn. The aim of the study is to understand DSME needs of patients and care providers. The conclusion is that "Diabetes self-management education tailored to resource-constrained settings are needed". What exact DSME needs of patients and providers did they find? It is already a known fact that DSMEs are needed for patients so they could self-manage their conditions. If the authors want to justify the need of DSME for patients, then the study aim has to be reconstructed. Also, what is understanding DSME needs of providers? Knowledge? resources? Some clarity is needed. It should also be noted that self-management needs are not the same as self-management education needs. Self-management education is an intervention provided to patients to build their capacity to self-manage their disease or engage in effective self-care behaviors.</p>	<p>The title, study aim, and conclusions have been re-written for clarity and is now more focused and congruent. Thank you</p>
<p>6. Authors need to be specific about the type of diabetes patients being studied. People living with diabetes (PLD) means all diabetes types including type 1. But from line 116, they have stated that PLD were 18 years and above and not known to have type 1 diabetes. This means they are</p>	<p>There is a fine line between various types of diabetes and often it is clinically difficult to distinguish between for example latent autoimmune diabetes in adults and type 2 diabetes. Given that we did not</p>



<p>taking about people with type 2 diabetes. This should be used instead of people living with diabetes, Gestational diabetes is also a form of diabetes. Thus, authors should be specific right from the outset of the paper about the specific type of diabetes patients being referred to.</p>	<p>do formal testing we decided it was best to avoid classifying patients as type 2 diabetes. The inclusion criteria was self-reported diabetes and we excluded those known to have type 1 diabetes. We have now included this in our limitation “our findings may not be generalised to people known to have type 1 diabetes”</p>
<p>7. Lines 261 and 262, authors state “PLD receive DSME from nurses, doctors, and or nutritionists. It is un-structured, didactic, group based and delivered in-person prior to consultations”. A clear distinction needs to be made between the diabetes education given to patients during routine clinical care and diabetes self-management education program, which is a behavior change intervention designed and delivered to improve patients' self-efficacy in self-managing their conditions. Diabetes self-management education programs are underpinned by behavior change theories and models such as Bandura’s Self-Efficacy Theory. Thus, the routine education on self-care given to patients during clinical visits could not be classified as a self-management education program, although it is self-management education. Authors therefore need to be clear whether they are referring to self-management education given to patients during routine clinic visits or DSME which is a new model of diabetes care and which aims at empowering patients to engage in effective self-care behaviors. The majority of DSMEs are delivered in non-clinical settings and some are led by laypersons or peer educators (people with diabetes trained as educators).</p>	<p>Thank you we have replaced dsme program with dsme intervention throughout the manuscript..</p>
<p>8. This takes me back to lines 77 and 78. The statement that “Sustainability and by extension availability of DSME is influenced by patient-, provider- and facility-level factors” holds for DSMEs</p>	<p>Thank-you. This statement has been modified We have now specified facility-based DSME.</p>

<p>delivered in clinic-settings. In other settings, DSMEs are provided by NGOs and these have nothing to do with providers and facility-based factors. Some DSMEs are even delivered I churches. And it must be stated that the facilitator of DSME is not always a clinician. DSME is separate from clinical care. The current literature calls for its integration in routine clinical care.</p>	<p>“Additionally, sustainability of facility-based structured DSME interventions are influenced by facility-, patient-, and provider level factors.[13]”</p>
<p>. Conclusion: The first sentence reads “Existing DSME services are under-resourced and there are no structured DSME programs available.” Are they talking about the two study sites or the entire country? I think being specific rather than providing general statements will help.</p>	<p>Thank you We have re-written the entire concluding paragraph . Those findings are limited to the two study sites. “The DSME interventions studied were under-resourced and were not structured”</p>
<p>10. Authors may do thorough proofreading as there are some identified typos in the work.</p>	<p>Thank you this has been done</p>
<p>Reviewer #3: I would like to thank the authors for their important work on assessing management of diabetes and educational needs in LMICs, this is a critical topic and this work is an important contribution to the field. The research question and methods need to be articulated clearly from the beginning however, the rest of the manuscript is clear.</p>	<p>Thank you</p>
<p>Abstract</p> <ul style="list-style-type: none"> <li>• Overall, Adequately described</li> <li>• Clarify aim regarding what exactly will you be studying from the provider group</li> <li>• Line 41: Designate the location of the study as Accra, Ghana</li> </ul>	<p>The aim has been re-stated for clarity and the study location included in the Abstract “We sought to characterise DSME interventions in two urban low-resource primary settings, and to explore diabetes self-management knowledge and behaviours of persons living with diabetes (PLD). ”</p>

<p>Introduction</p> <ul style="list-style-type: none"> <li>• Overall: a brief overview of diabetes self-management (DSME)</li> <li>• Minor grammatical errors</li> <li>• Authors should clarify early on that this study is reviewing the existing DSME in Accra, Ghana in two hospitals and its beliefs of and impact on patients, experts, and health care providers (HCPs). This should clearly be stated at the end of the introduction as the research question.</li> <li>• Similarly, the methods do not describe the existing DSME intervention as what is being studied <ul style="list-style-type: none"> <li>o This is in the results section ◊ existing DSME programs that are unstructured and they are reviewing whether the programs were helpful to the patients, HCP, and experts - -- tlead with this and that you are observing its efficacy, usage, and public reaction</li> </ul> </li> <li>• Line 81: Designate the location with the city - Accra, Ghana</li> </ul>	<p>The entire introduction has been re-written for clarity and to improve congruency with the other sections of the manuscript thank you.</p> <p>The aim has been re-stated at the end of the introduction</p> <p>Our aim was rather to describe and characterise the existing DSME interventions</p> <p>The location within the city has been designated</p>
<p>Methods</p> <ul style="list-style-type: none"> <li>• Overall: Provided a thorough list of methods with minimal grammatical errors and information regarding ethical considerations</li> <li>• Actual intervention being studied is missing, it is critical to describe what is being evaluated so the reader understands the setting. Thorough descriptions of necessary sample size and methods of recruitment is there but what is being assessed is not included here and needs to be.</li> <li>• Ethical considerations found in Data collection section: written informed consent, non-disclosure statements; codes assigned to maintain confidentiality</li> <li>• Transcripts and analysis were shared with informants to check for accuracy and provide feedback- sounds excellent!</li> <li>• Ethical approval: IRB from KBTH and Ethics review committee of Ghana Health Service</li> </ul> <p>Line Edits</p>	<p>Our aim was rather to describe and characterise the existing DSME interventions. The aim has been re-written. Thank you</p> <p>The abbreviations in the Figures have been corrected. Thank you.</p> <p>The section on eligibility criteria has now been clearly labelled.</p> <p>Figure 1 reorganised as suggested</p> <p>Figure 2- Abbreviations have been corrected</p> <p>Figure 3 has been re-drawn; the major theme in that circle is stigma</p> <p>The section on quantitative analysis has been titled to maintain formatting with the subsequent section</p>

<ul style="list-style-type: none"> <li>• Line 93: Figure 1 (found on pg. 32 of PDF) – missing information in square boxes?, Top left oval box could be organized a bit more clearly</li> <li>• Line 115-116: are these the eligibility criteria of the study participants? <ul style="list-style-type: none"> <li>o What makes participants ineligible?</li> </ul> </li> <li>• Line 126: Capitalize Declaration</li> <li>• Line 128-129: Clarify this sentence</li> <li>• Line 152: Figure 2 (found on pg. 32 of PDF) – no label for HCW but label for HCP which is not in the boxes; boxes with HCW letters are spelled differently in either box; FGD box on the left spelled FDG</li> <li>• Line 155: title the section quantitative analysis to maintain formatting with next section</li> <li>• Line 162: Change analysis to analyses</li> <li>• Line 248: Figure 3 (found on pg. 33 on PDF) – “Norms stigma seasons” are these individual themes in this section?</li> </ul>	<p>Analysis has been changes to analyses</p>
<p>Results</p> <ul style="list-style-type: none"> <li>• Overall: fully inclusive results section with both quant and qual data</li> <li>• Authors include exclusion criteria here in the quant section. Maybe consider moving up or also including in methods?</li> <li>• Line 200: Says they included 427 participants? Differs from Abstract. Please confirm which one is correct</li> <li>• Page 11: Table 1 could be organized a bit more clearly/create subsections for each section. May just be because of the formatting change.</li> <li>• Line 233: Capitalize T in Table 2.</li> </ul>	<p>The number of included participants have been corrected to 425 thank you</p> <p>Table 1 has been re-formatted for clarity. The variables are now readily identifiable</p> <p>T in table 2 has been capitalised</p>
<p>Discussion</p> <ul style="list-style-type: none"> <li>• Overall: makes appropriate connections to quant and qual results and other studies that have been reviewed with individual components</li> <li>• Line 380: remove second "had"</li> </ul>	<p>This sentence has been rephrased. Thank you.</p>
<p>Conclusion</p>	

	<ul style="list-style-type: none"> <li>• Pulls everything together, does not over-emphasize any of the results/data</li> </ul>	
	<p>additional requirements.</p> <p>1. Please ensure that your manuscript meets PLOS ONE's style requirements, including those for file naming. The PLOS ONE style templates can be found at <a href="https://journals.plos.org/plosone/s/file?id=wjVg/PLOOne_formatting_sample_main_body.pdf">https://journals.plos.org/plosone/s/file?id=wjVg/PLOOne_formatting_sample_main_body.pdf</a> and <a href="https://journals.plos.org/plosone/s/file?id=ba62/PLOOne_formatting_sample_title_authors_affiliations.pdf">https://journals.plos.org/plosone/s/file?id=ba62/PLOOne_formatting_sample_title_authors_affiliations.pdf</a></p>	<p>This has been done.</p>
	<p>2. Thank you for stating the following in the Acknowledgments Section of your manuscript:</p> <p>RL is supported by the UMC Utrecht Global Health Support PhD programme. It had no role in the study design, collection, analysis, interpretation of data, writing of the report or decision to submit the article for publication.</p> <p>We note that you have provided funding information that is not currently declared in your Funding Statement. However, funding information should not appear in the Acknowledgments section or other areas of your manuscript. We will only publish funding information present in the Funding Statement section of the online submission form.</p> <p>Please remove any funding-related text from the manuscript and let us know how you would like to update your Funding Statement. Currently, your Funding Statement reads as follows:</p> <p>The author(s) received no specific funding for this work.</p> <p>Please include your amended statements within your cover letter; we will change</p>	<p>We have updated our funding statement .</p>

	the online submission form on your behalf.	
	3. We note that you have stated that you will provide repository information for your data at acceptance. Should your manuscript be accepted for publication, we will hold it until you provide the relevant accession numbers or DOIs necessary to access your data. If you wish to make changes to your Data Availability statement, please describe these changes in your cover letter and we will update your Data Availability statement to reflect the information you provide.	This is well noted with thanks
	4a. Please include captions for your Supporting Information files at the end of your manuscript,  4b. and update any in-text citations to match accordingly. Please see our Supporting Information guidelines for more information: <a href="http://journals.plos.org/plosone/s/supporting-information">http://journals.plos.org/plosone/s/supporting-information</a> .	This is not applicable thank you  This has been done . thank you

We trust that you will find our revised paper suitable for publication in Plos One.

Sincere regards,

Dr Roberta Lamptey  
On behalf of all co-authors  
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