Boosting diabetes and pre-diabetes screening in rural Ghana

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Abstract

Background: Diabetes is a growing worldwide disease with serious consequences to health and with a high financial burden. Ghana is one of the developing African countries where the prevalence of diabetes is increasing. Moreover, many cases remain undiagnosed, when along with pre-diabetic cases they can be easily detected. Pre-diabetes condition occurs when blood sugar levels are higher than normal but are not high enough to be classified as diabetes, and it is still reversible.

The main objective of this study is to propose a novel method to increase diabetes and pre-diabetes early detection in rural areas. A secondary aim is to look for new related behavioral determinants specific to rural Ghana, by comparing subjects at risk with those already diagnosed as diabetic.

Methods: The screening approach was based on tests performed pro-actively by community nurses using glucometers and mobile phone apps. As a pilot for future policies, glycemic tests were carried out on 101 subjects from rural communities in Ghana deemed at risk and unaware of their diabetic/pre-diabetic status. A comparison of dietary and lifestyle habits of the screened people was conducted in regards to a cohort of 103 diabetic patients from the same rural communities.

Results: The pilot screening detected 2 diabetic subjects (2% of the cohort) showing WHO diabetic glycemic values, and 20 pre-diabetic subjects (19.8% of the cohort) which showed the effectiveness of the user-friendly approach. The need for further campaigns about alcohol consumption and physical activities has emerged even in rural areas.

Conclusions: Policies based on prevention screening as reported in the manuscript have the potential to reduce diabetes incidence, if actions are taken while patients are pre-diabetic, reduce complication related to late diagnosis and indirectly related health-care costs in the country.

Keywords: diabetes, mHealth, community health workers, pre-diabetes, Ghana, rural health

List of abbreviations

IDF International Diabetes Federation

WHO World Health Organization

CHPS Community-based health planning and services

BMI body mass index

CDP confirmed diabetic people

USP unknown status of diabetes people

Introduction

Diabetes is one of the fastest growing non-communicable killer diseases in the world, claiming one life every eight seconds and a limb every 30 seconds [1]. Diabetes of all types can lead to complication in many parts of the body and can increase the overall risk of dying prematurely [2-7]. Pre-diabetes condition occurs when blood sugar levels are higher than normal, but are not high enough to be classified as diabetes; this often has no symptoms, and is reversible [3].

According to the latest 2016 data from the World Health Organization (WHO), among the adults living with diabetes mellitus, 80% live in low and middle-income countries such as those in the Asia and Eastern Pacific region. The largest number has been reported in China (90 million people [6]), followed by India (61.3 million people) and Bangladesh (8.4 million people) [5]. Complications of diabetes results in increased morbidity, disability, and mortality and have a high

48 economic cost, especially in developing countries [8]. More specifically, the reported prevalence
49 of type 2 diabetes ranges from 1% in rural Uganda to 12% in urban Kenya. While gestational
50 diabetes has been reported within the Sub-Saharan countries at different levels (e.g. from 0% in
51 Tanzania to 9% in Ethiopia [10]). Lastly, even considering those values an underestimate, it is
52 expected that the reported cases will reach 82 millions by the 2030 [9].

53 Ghana is challenged with the increasing prevalence of diabetes, similar to other African countries,
54 with a prevalence of 3.6% in adults and 518,000 diagnosed cases within the country [33]. More
55 specifically, The prevalence of diabetes in some parts of Ghana it has been identified as higher than
56 the world average of 6.4% [11,12]. Moreover, the 2015 report of the IDF indicated many other
57 cases probably remain undiagnosed, posing an increased danger of complications for people living
58 with diabetes unaware of the consequences. Previous studies in the country showed that low level of
59 physical activity and obesity were associated with increased risk of diabetes [4]. Additionally, old
60 age and level of education were also associated with increased risk of diabetes [4]. It has also been
61 observed that within Ghana sugary drinks consumption is linked to type 2 diabetes [13].
62 Community-based health planning and services (CHPS) is a national health program in Ghana
63 adopted in 1999 to reduce geographical barriers to health care access [14]. According to the CHPS
64 policy, relocating nurses directly to communities could outperform an entire sub-district health
65 center. The cost-effectiveness of CHPS for malaria, diarrhea, and pneumonia has been recently
66 reported [15]. However, specific implementations for non-communicable diseases such as diabetes
67 have not yet been investigated within the CHPS policy.

68 Vulnerable populations such as those in low- and middle-income countries are generally more
69 affected by diabetes related complications [16]. As in several fields of healthcare, mobile health
70 (mHealth) has the potential of reducing for vulnerable populations with diabetes [17]. This can
71 occur either by sending reminders or by increasing access to patient management [18]. Despite the
72 plethora of studies on mHealth and diabetes management [18,19, 20], no study has been carried out

73 in rural Africa with the aim of improving detection of diabetes and pre-diabetes by using mobile
74 technologies and community nurses.

75 This study proposes a novel screening approach based on community nurses using glucometers and
76 mobile phones, performing tests on undiagnosed and diagnosed subjects proactively within the
77 community without waiting for participants to present at the clinic. The main objective is to
78 develop a novel method to increase diabetes and pre-diabetes detection, and to find new behavioral
79 determinants related to those conditions. In particular, the purpose of the mobile app is to simplify
80 the tracking operations of the nurses and to collect the data into a centralized secure server. For
81 this purpose, a pilot project was carried out in rural communities of the Central Region of Ghana to
82 assess the feasibility of the approach. A secondary objective was to look for new behavioral
83 determinants related to the rural Ghanaian populations by carrying out a comparison with a group of
84 subjects diagnosed with diabetes from the same communities. Similar to a project carried out in the
85 same area about improving prenatal care [21], the project utilized community nurses instead of the
86 participants to assure reliable glucose level data collection.

87 **Methods**

88 **Study design**

89 We performed a community-based cross-sectional study using mixed methods of quantitative and
90 qualitative analysis.

91 Data were collected by community nurses by using a mobile phone application and sent to a secure
92 database. The inclusion criteria for the participants were that they were members of the study
93 communities, the exclusion criteria included being <18 years and having a prior diagnosis of
94 diabetes of any type. A proportional comparison group with diabetes was also recruited, with the
95 aim of possibly finding common dietary habits with the screened subjects found to be diabetic/pre-
96 diabetics in both groups. By the same token, the inclusion criteria for the subjects in the comparison

group were of being already diagnosed with Diabetes type-2 in the past, being part of rural communities, and being older than 18 years, No specific age limits were set, as age is not a primary effect, but an indirect effect related to fat deposition and physical inactivity [23]. However, in the view to propose a screening which avoid particular overtime for the nurses during their outreach, we excluded children and young adult under the age of 18 years and we acknowledge this is a limitation of the study.

Subjects were assessed as “non-diabetic” according to their diabetes status awareness, obtained by the following question: "Has a doctor or another health professional ever diagnosed you have diabetes?" Further variables analyzed were: family history (family member diagnosed with diabetes); pregnancy; history of hypertension; screened glucose level; lifestyle characteristics (going to sleep within 1 hour after dinner and level of physical activities); body mass index (BMI), and diet (consumption per typical week of dishes based on staple or maize/corn, root and tuber-potatoes/cassava, and alcohol). Those variables are further described in the following sections as whether they were assessed by the nurses or self-reported.

Data source

The research was conducted in the central region of Ghana, specifically within the Biriwa and Anomabo communities. These two communities are in the Mfantseman Municipal District and based on the 2010 census, the two towns have a population of about 7,500 and 14,389 respectively. Those communities have been chosen due to them being relatively close to a main road connecting urban centers. The assumption is that the members of those communities are more prone to adopt unhealthy habits (such as smoking and drinking) which are more common in urban centers.

Community nurses from rural clinics were instructed to visit rural communities performing glucose screening, when fasted if possible or alternatively at random. Those tested were subjects known to have diabetes, subjects deemed at risk or those willing to be tested. A total of 204 people were

121 tested in a window period of 6 months (from June to December 2017). This sample size was
 122 reached following the minimum sample size for the study given by two populations of $n=86$
 123 subjects. This minimum sample size was computed by using the GPower software (<http://>
 124 <http://gpower.hhu.de/>) for an *a priori* two-tail t-test with $\alpha = 0.05$, effect size 0.5 and power
 125 0.90. The quantified sample size also matches constraints according to logistics related to the
 126 community nurses. Indeed, the aim was for the proposed screening to be performed by the nurses
 127 in addition to their normal activities without resulting in the need for overtime or compromising the
 128 other activities were carrying out. As one community nurse per community was used, in this pilot
 129 two nurses were employed.

130 The nurses were equipped with glucometers and low-cost Android smart phones. They received a
 131 short (less than one day) training on the app and were supported on its use during the first week of
 132 the project. Data were stored through the mobile phone app and sent to a server to improve
 133 management and facilitate eventual longitudinal screening. The developed app was based on the
 134 [CommcareHQ framework](#), and comprised a series of guided questions that the nurses completed in
 135 addition to the glucose test. Some screen-shots of those questions are depicted in Figure 1. If
 136 network was not available at the point of data collection, information could be sent later when the
 137 network was available. CommcareHQ is a popular mobile data collection, and it has been used in
 138 several projects. For a review on projects using the CommcareHQ platform, the reader is addressed
 139 to [30].

140 Figure 1. Screen-shots showing some of the guided questions the community nurse were
 141 completing while performing the glucose tests. The questions related to diet were referred to the
 142 general consumption for a typical week and not the current one.

143 Figure 2 shows the typical two steps of the screening, first a nurse is performing a glucose test (on
 144 the left), and then the data are recorded through the app (on the right). Collected data from
 145 respondents were from the rural communities, both male and female, including pregnant women
 146 with the intent of capturing eventual gestational diabetes case [22]. The sampling of candidates at
 147 risk was based on physical factors and at the nurse's discretion. During regular visits to the rural
 148 communities the nurses assessed whether the person to be tested was a potential diabetic candidate
 149 and therefore deemed to be tested (e.g. appearing overweight), paying particular attention to
 150 pregnant women. By doing this we have introduced a piloted biases (as overweight people, pregnant
 151 women and other cases were deemed at risk by the nurses). Therefore, with those biases, the
 152 resulting statistics is not representative of a random screening in the national population.

153 . Nevertheless, our focus is not to estimate total incidence of undetected diabetes or pre-diabetes,
 154 but to propose an approach that can detect as many as possible cases which otherwise would go
 155 unnoticed.

156

157 Figure 2 A typical two steps screening, first a nurse is performing a glucose test (on the left), and
158 then the data are recorded through the app (on the right).

159

160 However, to avoid a strong bias people deemed healthy that were willing to be tested were included.
161 Any detected diabetic or pre-diabetic cases should be addressed to immediately change their
162 lifestyle or start pharmaceutical therapies. Data were collected on known diabetic patients as well,
163 to evaluate the differences or similarities in lifestyle among the various groups.

164 With the mobile phone app, the community nurses could also keep track of longitudinal changes or
165 whether a subject has been already tested, in a similar manner of a project conducted in the same
166 area about boosting prenatal care [21]. Subjects who came into contact with community nurses
167 were asked the last time they had a meal, and based on the response blood glucose measurements
168 were classed as either fasting blood sugar levels or random blood sugar levels. Furthermore, the
169 following information were recorded from the subject a) Anthropometric indices (weight, height,
170 BMI) measured by the nurses b) Demographic Information (sex, age) self-reported c) Blood glucose
171 measurement (fasting or random sugar test) measured by the nurses d) Information on risk factors
172 (pregnancy, family history of diabetes, history of hypertension, kidney disorder, alcoholism, low

173 levels of exercise and unhealthy eating habits) self-reported. OneTouch Ultra (Milpitas, CA, USA)
 174 and Accu-Check (Hoffmann–La Roche SA, Basel, Switzerland) strips and glucometers were used to
 175 measure the blood glucose level. According to the WHO classification [24], a fasting blood glucose
 176 level greater 110 mg/dL but less than 126 mg/dL was considered pre-diabetic. A fasting blood sugar
 177 level 126 mg/dL or above was considered diabetic. A random blood sugar level greater 140 mg/dL
 178 but less 200 mg/dL was considered pre-diabetic. Above 200mg/dL was considered diabetic. Family
 179 history of diabetes is referred to occurrence of diabetes in close relatives defined as either father,
 180 mother, siblings or offspring. Most of the data were assessed by the nurse though some were self-
 181 reported by the subjects and this might represent a limitation. The data entered through the
 182 developed Android app were stored in the secure server provided by Dimagi. This cloud-based
 183 server is physically located in Cambridge, Massachusetts, USA was used. Data were entered in the
 184 forms of the mobile app and transmitted, encrypted, to the cloud-based server, where they were
 185 accessed and downloaded via a password-protected web interface.

186

187 **Analytical approach**

188 The main aim of the study was to determine if it is possible to easily detect diabetic and pre-diabetic
 189 subjects through community nurses already involved and active within the CHPS policy.
 190 Additionally, dietary habits and demographic information were collected by the community nurses
 191 along with glucose level to explore novel determinants related to the disease, which have not been
 192 reported in literature so far.

193 The data entered through the mobile phone app were downloaded and analyzed by [R](#) computing
 194 software version 3.5.2. Quality check on the data was performed and forms deemed clearly
 195 erroneous were removed. Statistically significant relationships among the collected information
 196 were sought comparing the population at risk and the population with assessed diabetes by using a

two-tail t-test, and the related p-value less or equal to 0.05 was considered to indicate a significant value.

The study also took advantage of the screening process to collect further insights through qualitative methods. Hence, the quantitative information was complemented with qualitative data obtained through semi-structured interviews performed by the authors with the community nurses to identify further relevant elements at the end of the pilot project. After revision of notes, the transcripts were typed and coded by using [the software NVivo](#) 10 (QSR International, Melbourne, Australia). The interviews were thus analyzed by using qualitative conventional content analysis. The starting open questions were “what are your general comments about the projects?”, “Which shortcomings did you notice?”, “What are your suggestions?”.

207

208

Results

The diabetes screening saw over 204 inhabitants in Anomabo and Biriwa over a period of 6 months. Of those, 103 were previously confirmed diabetic participant (CDP) with an average age of 62.9 ±11.2 years, and 101 people, with an average age of 30 ±9.7 years, with unknown status of diabetes participant (USP). Originally 211 forms were completed, however, 7 of them were deemed erroneous during the quality check and therefore were removed before the analysis. For each person data were collected only once. The CDP cohort comprised 66 female and 37 male subjects, while the USP cohort comprised 95 female and 6 male subjects. Details of some characteristics revealed for the two groups are reported in Table 1. Community nurses see on average 20 patients per day 5 times a week. Their duties mainly encompass malaria, diarrhea, and pneumonia treatments which are generally perceived as more urgent. During the pilot, the total number of people approached for the diabetes screening was 240 with a participation rate of 88%. The 12% of

220 who refused the screening reported as the main motivation the unwillingness to sign the written
221 consent for the study.

222 Table 1: Summary of demographic characteristics for the cohorts reported as mean and standard
223 deviation, (co-) occurrence of hypertension or close relative with diabetes. .

Cohort/Features	Age (year)	BMI	Occurrence of hypertension	Close relatives with diabetes
confirmed diabetic people (CDP) n=103	62.9 ±11.2	24.2±5.1	N=63 (61.2%)	N=72 (69.1%)
unknown diabetic status people (USP) n=101	30 ±9.7	26.7±4.6	N = 2 (1.9%)	N = 33 (32.7%)

224

225 Two-sample *t*-test performed comparing the BMIs was statistically significant according to a p-
226 value threshold of 0.05 although they were both normoweight. Some subjects of the CDP cohort
227 also presented with co-occurrence of ulcers (n=4), asthma (n=1), arthritis or rheumatism (n=3), and
228 kidney disease (n=1). At time of testing participants in the USP cohort presented with co-occurrence
229 of asthma (n=4), arthritis and rheumatism (n=1), and typhoid fever (n=1). The subject presenting
230 typhoid fever showed a random glucose blood level of 132 mg/dL which could not be considered
231 neither diabetic nor pre-diabetic. Therefore, typhoid fever was not considered a confounding factor
232 as the tested participant did not show a high value due to this. and the subject was included in the
233 statistics. These results are summarized in Table 2.

234

235

Table 2: Co-occurrence of disease within the two cohorts.

Disease	confirmed diabetic people (CDP) n=103	unknown status of diabetes people (USP) n=101
Ulcers	0	0
Asthma	1	4
arthritis or rheumatism	3	1
kidney disease	1	0
Typhoid fever	0	1

Cases detection

During the proactive screening performed by the community nurses, two subjects (1 female, not pregnant, with hypertension, 35.4 BMI; 1 male 25.7 BMI) were found to be hyperglycemic at fasting which would diagnose them as diabetic according to the current WHO threshold [24]. These subjects were not aware of their condition despite close relatives with diagnosed diabetes (son in one case and siblings in the other). They did not present any further symptoms, and they were not habitual consumer of alcohol or red meat. However, their diet was based on dishes with large amounts of maize corn, cassava and rice.

In total, 20 pre-diabetic cases were identified according to the WHO threshold, four tested at fasting and 16 at random (19 female; 1 male). No hypertension or other symptoms were identified, and 5 of had relatives with diabetes (mother or father). Half of the detected subjects reported consuming red meat almost daily, and all claimed to avoid alcohol consumption. They also reported consuming very frequently dishes with maize corn, cassava and rice, averaging respectively 8.5, 8.5 and 3.5 times per week.

252 All subjects of both groups claimed they were used to perform physical activities due to their daily
253 job. No statistical difference (p-value threshold 0.05) across the two cohorts was detected regarding
254 weekly consumption of red meat, maize corn, cassava or rice. The mean consumption of alcohol
255 across the two populations was also not significantly different (alpha-threshold 0.05), however, in
256 the CDP cohort 14 subjects declared to consume typically at least 1 alcoholic beverage per week
257 (plus 10 claimed to be former alcohol drinkers before their diagnosis and then changed this
258 behavior) while in the USP cohort only 6 participants declared to consume typically at least 1
259 alcoholic beverage per week. Furthermore, in the CDP cohort 3 subjects claimed to have reduced the
260 consumption of cassava based products, and another 2 for red meat. 88 subjects reported to have
261 drastically reduced the consumption of sugar, salt or both but not to have altered their diet. No case
262 of gestational diabetes was detected. Table 3 reports the mean and standard deviation of the blood
263 glucose level for both cohorts, distinguishing whether tests were fasting or random. Summarizing
264 qualitatively, no specific novel determinant was found.

265

266 Table 3. Mean glucose levels with standard deviation for the two groups and the types of screening
267 and the related p-value.

Cohort/Glucose level	confirmed diabetic people (CDP) n=103	unknown status of diabetes people (USP) n=101	p-value
Fasting	160.6 ± 71.6	103.1 ± 181	<0.001
Random	173.9 ± 65.4	123.3 ± 20.6	0.002

268

269 3.2. Qualitative comments from the nurses

270 The two nurses who performed the screening in the rural areas were asked to give their qualitative
271 opinion at the end of the 6 months pilot. The following are extracts of those interviews.

272 - , Enrolled community nurse, Anomabo Health Centre, Anomabo:

273 *“There should be continuous education of the masses on diabetes to create awareness. There should*
274 *also be financial support from governments, and non-governmental organizations to aid routine*
275 *check up of known diabetes patients, this will encourage them to always take their medication as*
276 *regular checking of blood glucose level for free help them to know the progress with their*
277 *condition.”*

278 *“Medication as insulin is covered by national insurance but not the needles for the screening, and*
279 *this can make people refrain from screening.”*

280 - Enrolled community nurse, Boabab Health Clinic, Biriwa:

281 *“Most patients were willing to be tested and ready to give any information on their personal*
282 *lifestyle, diet and medication. There is a general trust in tests performed by clinical personnel*
283 *regardless on cultural beliefs and on the fact that we are a small clinic.”*

284 *“Particularly, female clients above the age of forty were pleased to participate in the screening*
285 *exercise.”*

286 *“Furthermore, some clients were not able to provide precise information about their diet and family*
287 *history.”*

288 *“Screened people reported to perform some kind of sport activity related to their job, believing it*
289 *was sufficient to keep them healthy.”*

290

291 **Discussions**

292 Mobile phone apps and pro-active screening can help community nurses to spot new cases of
 293 diabetes and pre-diabetes. In particular, the proposed approach was based on pro-actively
 294 performing blood screening during rural visits of the community nurses, who were collecting
 295 information via the mobile phone app. This can also help tracking and monitoring, as the nurses can
 296 follow up the status of the participants in future visits .

297 Our findings indicate that some individuals in vulnerable populations, such as those in rural Ghana,
 298 are not aware of becoming diabetic or being in diabetic condition. We report two cases of diabetic
 299 participants in the USP cohort (2%) and 20 as pre-diabetic (19.8%), which are believed to be high
 300 numbers compared to previously reported statistics [34]. However, it must be taken into account
 301 that the cohort selection was not purely random, and piloted bias was introduced as the subjects to
 302 be tested were chosen according to the nurse's discretion. Therefore, these percentages should not
 303 be taken as a representative sample of the national population. The proposed approach aims instead
 304 at detecting as many cases as possible of diabetics and pre-diabetics which otherwise would go
 305 unnoticed. For this purpose it proved to be successful, inexpensive and easily integrated into the
 306 standard duties of community nurses.

307 Initially the nurses were equipped with ihealth glucometer dongles for the smartphone (ihealth,
 308 Mountain View, CA, USA). The anecdotal comments from nurses were that, despite the initial
 309 interest, they were not practical to collect data, though they might be suitable for a single individual.
 310 The reason can be related to the familiarity of the nurses to known tools such as Accu-Check and
 311 OneTouch, or the cumbersome use of switching continuously between the mobile app of the
 312 glucometer dongle and the app to record the data. The motivation behind using a mobile app for
 313 tracking data related to diabetes in Ghana is mostly related to the possibility of large institutions to
 314 easily monitor status in rural areas, as the data are collected in a secure centralized server. Moreover,
 315 mobile apps appear more user friendly for the nurse in comparison to cumbersome paperwork.

316 During the qualitative interviews, one nurse pointed out that despite the marginal costs of glucose
 317 tests both patients and government are not promoting them, while it could be cost-effective for
 318 Ghanaian institutions to detect pre-diabetic cases instead of dealing with a growing diabetic
 319 population, as has been shown for similar vulnerable populations [25]. Despite the progresses made
 320 in Ghana to achieve universal health access and coverage, financial barriers to diabetes service
 321 utilization still exist. Subjects usually refrain from undergoing glucose tests, as they are out-of-
 322 pocket., and not included in the reimbursements of standard insurances, similarly to Nigeria and
 323 Tanzania [26]. The other nurse mentioned that subjects were often not able to report their dietary
 324 habits, and they were not aware of the impact they had on their health. ... Conversely to prenatal care
 325 [31], it appears that generally the members of the communities trust the personnel of the clinics for
 326 this type of tests.

327 At population level the CDP and USP cohort were normoweight (having a BMI between 18.5 and
 328 24,99), though there were subjects which were obese and with hypertension in both groups. It is
 329 worthwhile to mention that the CDP subjects might have some dietary changes already after being
 330 informed of being diabetic, which could have affected their weight and other measurements.
 331 However, from the interviews it seems that the major changes were the reduction of consumption of
 332 salt and sugar, some increased their consumption of vegetables and fruit, and some reducing the
 333 consumption of alcohol beverages. The study did not track behavioral changes, but we can presume
 334 that these may have occurred and can represent confounding factor. No statistically significant
 335 difference in alcohol consumption between the two groups was detected. However this could be due
 336 to the fact that some individuals in the CDP cohort changed their dietary habits (10 people reported
 337 to have cut out alcohol consumption after their diagnosis). Moreover, the nurses were instructed to
 338 focus for both groups on women which might consume less alcoholic beverages than men.
 339 Nevertheless, the general impression of the nurses was that the alcohol consumption had an impact.
 340 With the increase in quality of life in the country, western habits such as alcohol consumption might

341 be also increasing, and therefore augmenting the risk of diabetes. It has been noticed that people
342 informed of their condition tend to change their dietary habits. Nevertheless, but given the country-
343 wide growing trend in alcohol consumption, social marketing campaign related to this [27] should
344 be performed.

345 Almost all subjects of both groups reported to perform regular physical activities related to their
346 job. However, this information seems vague and it is not clear whether this physical activity is
347 aerobic or resistance or whether it is sufficient to keep a healthy glucose level. Most likely further
348 activities should be proposed. Jogging and other sport activities are inexpensive and easy to
349 promote. Therefore, promoting this type of sport activities can address this issue. Moreover, it
350 appears necessary in the future to use more detailed investigations about sport activities, such as
351 using the WHO global physical activity questionnaire [32].

352 Ghana has experienced an exponential increase of the mobile network, social media and
353 smartphones in the recent years [28]. Beyond the screening of the population carried out by nurses,
354 smartphones can have an impact on glycemic control, as smartphone dongles can be inexpensive
355 and attractive to young users. Strategies such as gamification, and social media should be explored
356 to increase awareness on glycemic levels as shown in other contexts [29].

357

358 **Conclusions**

359 Proactive glycemic screening on vulnerable population – such as those living in rural areas – can be
360 effective in detecting new cases of diabetes and pre-diabetes. Our approach using community nurses
361 screening subjects deemed at risk and collecting data on mobile phone was found to be effective,
362 and suitable for longitudinal studies. Campaigns increasing awareness of alcohol consumption,
363 physical activity, nutrition and healthy habits should be emphasized in any prevention strategy as
364 the population seems to still be unaware of the consequences.

365 Despite this, studies with larger population are required to confirm the results. The diabetes and pre-
366 diabetes screening described in this manuscript can be easily included into the national CHPS
367 policy with several potential benefits. Those benefits include reducing incidence by detecting cases
368 of pre-diabetes which hopefully will not convert into type-2 diabetes and enabling timely treatment
369 of diabetes patients avoiding complications related to delays in treatment.

370 **Ethics and consent**

371 All procedures performed in studies involving human participants were in accordance with the
372 ethical standards of the institutional and/or national research committee and with the 1964 Helsinki
373 declaration and its later amendments or comparable ethical standards. Written consent for the
374 reported data was collected.

375 **Competing interests**

376 No competing interests were disclosed

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380

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