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1 Title:

2 The Effectiveness of Enhanced Primary Healthcare (EnPHC) Interventions on Type 2 Diabetes
3 Management in Malaysia: Difference-in-differences (DID) Analysis

4 *Masliyana Husin, MBChBAO (Hons)^a, Xin Rou Teh, BPharm (Hons)^a, Su Miin Ong (MSc)^a,*
5 *Yvonne Mei Fong Lim (MIS)^a, Swee Hung Ang (MD)^a, Chee Lee Chan (MRCPCH)^a, Ming Tsuey*
6 *Lim (MSc)^a, Sunita Shanmugam (MBBS)^b, Noraziani Khamis (DrPH), Faeiz Syezri Adzmin*
7 *Jaafar (MBBS)^b, Nor Idawaty Ibrahim (MPH)^c, Nazrila Hairizan Nasir (MMed)^c, Dian Kusuma*
8 *(ScD)^{e,f}, Anita Katharina Wagner (DrPH)^e, Dennis Ross-Degnan (ScD)^e, Rifat Atun (FRCP)^f,*
9 *Sheamini Sivasampu (MPH)^a*

10 ^a *Institute for Clinical Research, National Institutes of Health, Ministry of Health, No. 1, Jalan*
11 *Setia Murni U13/52, Seksyen U13 Setia Alam, 40170 Shah Alam, Selangor, Malaysia*

12 ^b *Institute for Health Management, National Institutes of Health, Ministry of Health, No. 1, Jalan*
13 *Setia Murni U13/52, Seksyen U13 Setia Alam, 40170 Shah Alam, Selangor, Malaysia*

14 ^c *Family Health Development Division, Ministry of Health Malaysia, Kompleks E, Pusat*
15 *Pentadbiran Kerajaan Persekutuan, 62590 Putrajaya, Malaysia*

16 ^d *Harvard Medical School and Harvard Pilgrim Health Care Institute, Landmark Center, 401*
17 *Park Dr #401, Boston, Massachusetts MA 02215, United States*

18 ^e *Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston, Massachusetts MA*
19 *02115, United States*

20 ^f *Department of Health Services Research and Management, School of Health & Psychological*
21 *Sciences, City University of London, London, United Kingdom*

22

23 Corresponding author:
24 Masliyana Husin
25 Institute for Clinical Research, National Institute of Health
26 Ministry of Health, Malaysia
27 No.1 Jalan Setia Murni U13/52 Seksyen U13
28 40170 Shah Alam, Selangor.
29 No. Tel : 03-33627700/ ext : 8816
30 E-mail: masliyana@crc.gov.my

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33

34 **Abstract**

35 **Aims:** To evaluate the effectiveness of the Enhanced Primary Healthcare (EnPHC) interventions
36 on process of care and intermediate clinical outcomes among type 2 diabetes patients.

37 **Methods:** This was a quasi-experimental controlled study conducted in 20 intervention and 20
38 control public primary care clinics in Malaysia from November 2016 to June 2019. Type 2
39 diabetes patients aged 30 years and above were selected via systematic random sampling.

40 Outcomes include process of care and intermediate clinical outcomes. Difference-in-differences
41 analyses was conducted.

42 **Results:** We reviewed 12,017 medical records of patients with type 2 diabetes. Seven process of
43 care measures improved: HbA1c tests (odds ratio (OR) 3.31, 95% CI 2.13, 5.13); lipid test (OR
44 4.59, 95% CI 2.64, 7.97), LDL (OR 4.33, 95% CI 2.16, 8.70), and urine albumin (OR 1.99, 95%
45 CI 1.12, 3.55) tests; BMI measured (OR 15.80, 95% CI 4.78, 52.24); cardiovascular risk
46 assessment (OR 174.65, 95% CI 16.84, 1810.80); and exercise counselling (OR 1.18, 95% CI
47 1.04, 1.33). We found no statistically significant changes in intermediate clinical outcomes (i.e.
48 HbA1c, LDL, HDL and BP control).

49 **Conclusions:** EnPHC interventions was successful in enhancing the quality of care, in terms of
50 process of care, by changing healthcare providers behaviour.

51 **Keywords:** Type 2 diabetes, primary health care, multifaceted intervention, intermediate clinical
52 outcomes, process of care, difference-in-difference

53

54 Introduction

55 Type 2 diabetes impacts individuals, health systems, and society by diminishing productivity
56 [1] and increasing mortality [2]. In 2015, 415 million people worldwide (1 in 11 adults) lived
57 with diabetes, with the estimated absolute global economic burden of 1.3 trillion U.S. dollars [3].
58 In Malaysia, approximately 1 in 6 adults had type 2 diabetes in 2015 [4] with an estimated
59 yearly direct cost of over 600 million U.S. dollars [5]. This translates to 2% of Malaysian
60 Growth Domestic Product, which is higher than the global cost of diabetes expressed as share of
61 global Growth Domestic Product of 1.8% [3].

62 Despite medications with proven efficacy, studies from Malaysia and other regions of the world
63 show that glycemic control is suboptimal [6,7]. For diabetes management, a continuum of
64 services, including disease detection, treatment and monitoring need to be implemented. This
65 sequence of services is referred to as the type 2 diabetes “*cascade of care*”. Increasing
66 engagement at all levels of the cascade may allow early detection and minimise morbidity and
67 mortality from diabetes. A previous cascade of care analysis revealed that as many as 50% of
68 individuals with type 2 diabetes in Malaysia were undiagnosed and even after receiving a
69 diagnosis, only 22% had good glycemic control [8].

70 Integrated care models have been shown to improve patient satisfaction, perceived quality of care
71 and access to care [9]. For type 2 diabetes care, integrated care models have been shown to
72 reduce HbA1c levels in individuals with suboptimal control [10,11]. However, most evaluations
73 were carried out in high-income countries. The effectiveness of type 2 diabetes integrated care
74 models is still inconclusive in low- and middle-income countries [12–15]. In addition to disease
75 burden differences, the healthcare systems in these countries have different constraints and

76 insufficiencies [16] relative to those in high-income countries which must be considered when
77 designing care models.

78 Malaysia has a two-tier primary healthcare delivery system involving both public and private
79 health care providers. These differ in governance, financial arrangement, and types of services
80 provided. The public sector is run by the government and funded by general taxation [17], while
81 the private sector charges fee-for-service. The Malaysian Health System Research project,
82 following an extensive analysis of the health system, found uneven distribution of disease burden
83 and resource allocation between sectors [18]. The majority of type 2 diabetes patients were
84 managed in the public primary care setting [4,5,19]. Despite that, only a small fraction of total
85 government healthcare expenditures is devoted to primary care; most expenditures fund hospital
86 care [20]. Constraints in continuity and coordination of care, organisational management of
87 healthcare providers, extensive waiting times and limited operational hours, lack of screening and
88 counselling activities, low awareness of the need for screening and preventive care and
89 suboptimal therapeutic prescribing in type 2 diabetes were evident in primary healthcare clinics
90 [18]. An attempt was made to reform the public primary healthcare services in 2016 to address
91 these care gaps , as part of a global effort to reduce the prevalence and management of non-
92 communicable diseases (NCDs).

93 An integrated care model consisting of multifaceted interventions known as Enhanced Primary
94 Healthcare (EnPHC) was introduced to 20 public primary health care clinics as a demonstration
95 project. This new framework, uses primary healthcare as an agent of change to deliver efficient
96 service and aim to improve existing health care services in terms of type 2 diabetes management
97 and prevention while making efficient use of existing infrastructure and human resource [21].
98 EnPHC framework was designed using a health system approach to conceptualise multiple

99 evidence-based interventions along the cascade of care that has been described in detail in the
100 study protocol [8].

101 In parallel, an impact evaluation of EnPHC consisting of an evaluation at the community and at
102 the primary care facility level was conducted . A process evaluation was also performed at the
103 primary care facilities to improve implementation of the interventions. This study focused on the
104 impact evaluation of EnPHC on diabetes care at the primary care facility level. The primary
105 objective was to evaluate the effectiveness of EnPHC interventions on process of care in type 2
106 diabetes patients in primary care facilities. Our secondary objective is to determine the
107 effectiveness of EnPHC in improving intermediate clinical outcomes in type 2 diabetes.

108

109 Materials and Methods

110 *Study Design*

111 Twenty intervention and twenty control clinics in two states in the central region (Selangor) and
112 the southern region (Johor) in Malaysia were matched. Random allocation were performed
113 between the pairs into intervention or control arm by flip of a coin [22]. However, treatment
114 statuses were reassigned for two clinics and randomization was compromised henceforth
115 addressed using quasi-experimental approaches to analysis. The selected clinics served
116 populations of between 12,069 and 500,000 individuals with daily attendances of between 150
117 and 800 patients. They were located in rural areas or small towns, and had either a permanent or a
118 visiting Family Medicine Specialist. ArcGIS software was used to ensure that the matched clinic
119 pairs were in different districts to minimize possible contamination [23].

120

121 *EnPHC Interventions*

122 The EnPHC interventions implemented in the 20 intervention clinics beginning in July 2017
123 encompassed: i) an Integrated Care Pathway ; ii) a patient visit checklist; iii) Integrated Specialized
124 Services by allied health professionals; iv) NCD screening and cardiovascular risk stratification;
125 v) an NCD care form; vi) the Family Health Teams concept; vii) involvement of a care coordinator;
126 viii) pharmacist-led Cardiovascular Care Bundle Medication Therapy Adherence Clinic; ix)
127 clinical and prescribing audits; and x) structured communication across primary and secondary
128 care levels with a fast track referral system. Details of each intervention is available in Additional
129 File 1. Further details on the study design have been described elsewhere [8].

130 *Theoretical model for the evaluation*

131 Figure 1 shows our theoretical model for this evaluation study, which was drawn from
132 Donabedian’s Social Cognitive Theory model, the Translating Research Into Action for Diabetes
133 (TRIAD) model, and a local study [24–27]. EnPHC interventions were targeted at the health care
134 system and health care providers within the clinics. Hence, we incorporated EnPHC interventions
135 as one of the facility factors in this theoretical model. In addition, clinic type was a proxy for the
136 availability of equipment and workload of a clinic. We hypothesised that EnPHC interventions
137 will improve the process of care through health care providers’ behaviour changes, which would
138 in turn improve patients’ behaviour and ultimately clinical outcomes. Clinical outcomes may be
139 influenced directly by patient factors or indirectly through improved process of care and
140 associated changes in patients’ behaviour.

141

142 **Figure 1 – Theoretical model of the study.**

143

144 *Subjects*

145 All Malaysian patients aged 30 years and above with a documented diagnosis of type 2 diabetes
146 who visited the study clinics for diabetes management within the month of interest were
147 included in the study. The age cut-off followed the enrolment age for the intervention. Pregnant
148 women were excluded as the management of gestational diabetes follows a separate care
149 pathway.

150

151 *Sample size calculation*

152 With a sample of 1800 patient visits, we had 80% power to detect a relative increase of 28% in
153 the proportion of patients receiving an annual HbA1c from the baseline proportion of 52.5%.

154

155 *Data Extraction*

156 Data were collected from November 2016 to June 2017 for the pre-intervention period and from
157 October 2018 to June 2019 for the post-intervention period. Repeated cross-sectional data were
158 created for each monthly time point based on the most comprehensive list of patient visits
159 available in an individual clinic (either the patient register or appointment book). In terms of the
160 timing, there are 17 time points (in month) of data in total: eight time points before and 9 time
161 points after the intervention with 15 months look-back period to let the changes occur. Medical
162 records of eligible patients were retrospectively sampled using systematic random sampling and
163 data were extracted using a mobile tablet. To ensure data quality, we recruited and trained
164 personnel with medical background for data extraction, incorporated validation rules in the
165 electronic data extraction form and performed real-time data quality checks.

166

167 *Outcomes*

168 The main outcomes evaluated in this study were process of care and intermediate clinical
169 outcomes for type 2 diabetes patients. We measured 14 process indicators based on
170 recommendations from the Malaysian Clinical Practice Guideline for Type 2 Diabetes (5th
171 Edition) [28] which comprised laboratory investigations, clinical assessments, counselling and
172 prescription. Measures of recommended laboratory investigations were: i) HbA1c test within the
173 past three months; ii) glucose test (fasting blood glucose or random blood glucose) at every visit;
174 iii) lipid test (total cholesterol or triglycerides) in the past year; iv) low-density lipoprotein (LDL)
175 test in the past year; v) urine protein or urine microalbumin (UMA) test in the past year; and vi)
176 liver function test (LFT) in the past year. Measures of clinical assessments were: vii) blood
177 pressure (BP) measurement at every visit; viii) body mass index (BMI) measured in the past six
178 months; ix) fundus examination in the past year; x) foot examination (ulcer, neurological and
179 vascular assessment) in the past year; and xi) cardiovascular disease (CVD) risk assessment using
180 the Framingham Risk Score in the past year. Counselling and prescription measures consisted of:
181 xii) exercise counselling; xiii) diet counselling; xiv) lipid lowering drug prescription. For
182 intermediate clinical outcomes, we measured the percentages of type 2 diabetes patients who
183 achieved the following targets: i) HbA1c $\leq 7\%$ (53 mmol/mol); ii) BP $\leq 135/75$ mmHg; iii) LDL
184 ≤ 2.6 mmol/L and iv) high-density lipoprotein (HDL) > 1.0 mmol/L (male) or HDL > 1.2 mmol/L
185 (female).

186

187

188 *Data Analysis*

189 We used difference-in-differences (DID) analysis to determine the effect of EnPHC interventions
190 in intervention compared to control clinics. Data from November 2016 until June 2017 were
191 grouped to create baseline measures, while a subsequent 15-month phase-in period allowed for
192 the intervention to reach full implementation. Data from October 2018 until June 2019 were
193 pooled to estimate post-intervention outcomes. Missing data for intermediate clinical outcomes
194 ranged from 0 to 11%. The reason for missing included processes not being performed
195 Therefore complete case analysis was carried out. We conducted univariate comparisons of pre-
196 intervention characteristics between the intervention and control groups using the independent t-
197 tests, Wilcoxon rank sum tests, or chi-square tests depending on the data type. Patient visits are
198 clustered within each clinic and accounted for using robust standard errors in the GEE model.
199 Patient and clinic level covariates stated in the theoretical model were added to the models to
200 adjust for confounders. The "parallel trends" assumption was tested statistically to ensure internal
201 validity (see Additional file 1). A Benjamin-Hochberg correction was applied for multiple testing
202 adjustment on all outcomes. A *p-value* of <0.05 was considered significant.

203 We used R software, version 3.0.1 [29] to analyse our data. The “geeglm” function from the
204 “geepack” package [30] in R were used to perform the DID analysis.

205

206 *Results*

207 A total of 6719 type 2 diabetes patients were identified in the pre-intervention phase and 5298 in
208 the post-intervention phase. Table 1 shows the pre-intervention characteristics of patients in the
209 intervention and control groups. Type 2 diabetes patients in both groups were predominantly
210 women with a mean age of 60 years. The intervention group had more patients of Malay and

211 Chinese ethnicity and fewer patients with dyslipidaemia as comorbidity. There were slightly
212 more patients with newly diagnosed type 2 diabetes in the control group (11.0%, vs 9.0% in the
213 intervention group). The median HbA1c was also higher in the control group (8.0% or 64
214 mmol/mol) compared to the intervention group (7.7% or 61 mmol/mol). The median HbA1c was
215 7.8% (61 mmol/mol) in the control group and 7.5% (58 mmol/mol) in the intervention group in
216 the post-intervention period (not shown in table). The mean BMI of patients in both groups was
217 28kg/m², which falls into the obese category.

218

219 **Table 1: Pre-intervention patient characteristics**

220

221 After the EnPHC interventions, there were significant relative changes in eight out of 14 process
222 of care measures in the intervention group as shown in Table 2. Compared to controls, the
223 intervention clinics showed significant improvement in performance of four of six laboratory
224 investigations: HbA1c tests in the past three months (OR 3.31, 95% CI, 2.13, 5.13), lipid test in
225 the past one year (OR 4.59, 95% CI, 2.64, 7.97), LDL test in the past one year (OR 4.33, 95% CI,
226 2.16, 8.70), and UMA test in the past one year (OR 1.99, 95% CI, 1.12, 3.55). Conversely,
227 patients in intervention clinics were three times less likely to have a blood glucose test on the day
228 of visit. There was no significant change for LFT (OR 1.08, 95% CI, 0.51, 2.27).

229 There were two improvement observed out of five clinical management measures. BMI measured
230 in the past six months showed improvement with a relative odds of 15.80 (95% CI, 4.78, 52.24)
231 and CVD risk assessment in the past one year showed a marked increase in the intervention
232 group with a relative odds of 174.65 (95% CI, 16.84, 1810.80). BP measurement at every visit
233 showed high baseline values ranging from 97%-98.9% in both groups with little room for

234 improvement.. As for counselling and prescription, the intervention group exhibited a significant
235 post-intervention increase in exercise counselling with an odds ratio of 1.18 (95% CI, 1.04, 1.33).
236 Although a higher odds of dietary counselling was observed in the intervention group, it was not
237 significant (OR 1.86, 95% CI, 1.02, 3.38). Use of lipid-lowering medication exhibited high
238 baseline values of over 98% in both groups with no significant change after the intervention (OR
239 0.97, 95% CI, 0.22, 4.31).

240 Three of four intermediate clinical outcomes showed improvement (i.e., HbA1c, LDL and HDL
241 within target range), but none of the changes were statistically significant. Detailed results are
242 shown in Table 3. We separately analysed the period of November 2016 to June 2017 (Pre-
243 intervention phase) and October 2017 to March 2018 (early post-intervention phase). During
244 these period, the intervention group were more likely to have HbA1c test and foot examination
245 performed within the past three months. Additionally, for intermediate clinical outcomes, there
246 was no significant difference on the proportion of T2DM patients who achieved the target for
247 HbA1c, BP and LDL.

248

249

250 **Table 2: Difference-in-difference (DID) analysis of EnPHC interventions on process of care**
251 **in Type 2 Diabetes patients**

252

253 **Table 3: Difference-in-difference (DID) analysis of EnPHC interventions on intermediate**
254 **clinical outcomes in Type 2 Diabetes patients**

255

256

257

258

259 *Discussion*

260 This is the first study in Malaysia where a large scale, complex intervention package targeting
261 improvement in chronic disease management in primary care facilities was evaluated in a real-
262 world setting displaying outcomes which were adjusted for patient- and clinic-characteristics. We
263 found that the EnPHC interventions improved process of care but did not show overall
264 improvements in intermediate clinical outcomes.

265 Process of care that were evaluated can be categorised into three areas, namely, laboratory
266 investigations, clinical assessment and counselling and prescription. Eight out of 14 indicators
267 showed change after the intervention. The improvements in process of care were most evident for
268 laboratory investigations, which may be attributed to several reinforcing elements of the EnPHC
269 intervention package including physician reminders, standardized documentation with the use of
270 NCD care form and adequate resource allocation in terms of availability of reagents. Although
271 the majority of laboratory investigations improved, there was no change in LFT compared to
272 indicators like HbA1c and UMA tests. Of interest, there was a decrease in blood glucose testing
273 on the clinic visit day. Taken together with the observed increase in three-monthly HbA1c tests,
274 we may be witnessing an appropriate shift to more efficient use of manpower and resources,
275 since HbA1c is a more reliable marker of glycemetic control.

276 In the area of clinical assessments, we saw an increase in the proportion of BMI measured in the
277 past six month and marked increase in CVD risk assessments completed in the past year while
278 other indicators showed no significant changes. BMI is a method to quantify obesity reflected by
279 excess in body fat mass. Frequent monitoring allows prediction of coronary heart disease [31],
280 stroke [32], and cardiovascular death [33] and can be managed in a timely manner. Similar to the

281 increase in CVD risk assessments, although early detection is important, they were neither
282 routinely assessed nor well-documented previously. By making BMI and the CVD risk score a
283 required field in patients' medical records, the interventions managed to reinforce this guideline-
284 adherent practice. Compared to laboratory investigations, clinical assessments are more provider-
285 , resource- and patient-dependent. Improved performance of these assessments is more
286 commonly observed following intervention in high-income countries [34] compared to low- and
287 middle-income countries [13,14]. In addition, CVD risk assessment was not well documented or
288 offered at baseline hence there was a significant improvement in the process, contributing the
289 OR and 95% CI. On the other hand, the lack of improvement in fundus and foot examinations
290 may be due to insufficient manpower and equipment. The fundamental objectives of the EnPHC
291 included task-shifting and staff empowerment with minimal increase in staffing or resources. As
292 a result, a complex intervention such as this may have increased workload and required trickle-
293 down training in an environment where staff turnover is high. Indeed, an accompanying survey
294 of health care providers revealed low job satisfaction in the EnPHC clinics [35]. Inadequate
295 equipment may be another reason for lack of improvement in fundus examination, where about
296 40% of the clinics have fundus camera (unpublished result from facility survey). Finally, our
297 study may underestimate improvement in foot examination as our definition required
298 documentation of all three examinations (ulcer, neurological and vascular) to be considered a
299 complete foot assessment.

300 In the area of counselling and prescription, only one of three indicators showed significant
301 improvement. We examined the areas of providing lifestyle advice through exercise and diet
302 counselling and use of lipid-lowering medication as proxies for preventive actions by health care
303 providers and attempt to improve patient self-management. Measures of exercise and diet

304 counselling both moved in a positive direction in the intervention group; the change was not
305 significant for diet counselling. These improvements may also be due to the reinforcing elements
306 of the EnPHC intervention mentioned above. Prescribing of lipid lowering medication did not
307 show improvement following the intervention, primarily due to high baseline prescription rates in
308 both study groups which left little room for improvement.

309
310 The majority of process of care in the EnPHC clinics showed improved performance with the
311 exceptions of those that required substantially more time from health care providers and use of
312 equipments (e.g. fundus). This findings was further supported by the EnPHC process evaluation
313 that showed there was initial readiness , however sustainability of the intervention was
314 challenging. Some barriers identified were poor clinic infrastructure, staff shortages and
315 inadequate training [36].

316
317 Although the odds of achieving recommended targets were higher for three out of four
318 intermediate clinical outcomes (HbA1c, LDL and HDL) in the intervention group, the
319 improvements were not statistically significant. Our study does not have enough power to detect
320 the change in intermediate clinical outcomes as it is our secondary objective. Despite that, this
321 result is in line with a study which posit that process of care contribute less to patient outcome
322 than patient factors [37]. Improving the intermediate clinical outcomes would require not only
323 identification of patients with elevated clinical biomarkers, but also health care providers'
324 responding with appropriate medications and self-management support followed by patients'
325 adherence to the recommended therapies and lifestyle changes. A system and health care provider
326 targeted intervention such as EnPHC may may need longer duration of implementation and
327 greater patient engagement to bring about the more distal changes in patient outcomes.

328 Otherwise, the details of counseling given by Integrated Specialized Services and Cardiovascular
329 Care Bundle Medication Therapy Adherence Clinic could be improvised as a systematic review
330 on empowerment-based diabetes education showed that it could reduce HbA1c levels, improve
331 psychosocial self-efficacy and diabetes knowledge [38] whereas conventional education that
332 focused on compliance was not found to be effective [39]. This is an area for potential
333 improvement in the EnPHC package, given that low level of self-management support and low
334 health literacy level was reported in the Malaysian primary care setting [37,40–42].

335
336 The strength of our study is the use of difference-in-differences analysis which take into account
337 the counterfactual effect. It measures the changes contributed by the intervention by comparing
338 the changes in intervention group and control group, taking into consideration the differences at
339 baseline. Another strength is that selection bias was controlled through several steps. Important
340 clinic characteristics were matched to limit between-group differences in resource availability
341 and capacity. Probability sampling of medical records ensured representativeness of the sample
342 with inclusion of all type 2 diabetes patients who were compliant with their clinic follow-up. We
343 ensured continuous monitoring for the presence of other health programs in the clinics throughout
344 the duration of the evaluation which could have contaminated the effects of the EnPHC
345 intervention. In addition, the evaluation was carried out by investigators who were independent
346 from the implementation team to minimize biases. Moreover, in addition to process of care, we
347 also measured patient intermediate outcomes for a more comprehensive assessment of quality of
348 care.

349 Nevertheless, there are several limitations in this study. Four indicators did not meet the parallel
350 trends assumption as shown in Additional file 1; these results should be interpreted with caution.

351 Missing records and incomplete documentation in patient records may have introduced selection
352 bias. The data collected were based on documentation in medical records and thus may
353 underestimate the frequencies of care process that were carried out but not documented.

354 Conclusion

355 The EnPHC interventions were able to change health care providers' behaviours which are the
356 first step towards improved quality of care. Eight processes of care indicators have shown
357 improvement (HbA1c test, blood glucose test, lipid test, LDL test, UMA, BMI, CVD risk
358 assessment and exercise counseling). Patient behavior change is challenging and may require
359 greater engagement to translate into improved intermediate clinical outcomes. Hence, health
360 system and health care provider level interventions may take longer to have an effect on
361 intermediate clinical outcomes. Adding components to EnPHC interventions that can further
362 improve patient engagement and facilitate self-management should be considered before
363 nationwide scale-up. Future research should assess the implementation and cost-effectiveness of
364 the EnPHC interventions, as well as consistency across settings in its content, intensity and
365 effects.

366 Declarations

367 Ethical approval

368 This study was approved by the Medical Research and Ethics Committee, Ministry of Health
369 Malaysia (NMRR-17-267-34768).

370

371 Consent for publication

372 Not applicable

373

374 Availability of data and materials

375 The data that support the findings of this study are available from the corresponding author, upon
376 reasonable request.

377

378 Competing interests

379 The authors declare that they have no competing interests.

380

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385

386 Author contributions

387 MH, SSivasampu, XRT, CLC, SMO and YMFL conceived the idea for the manuscript. RA, DK,
388 DRD, AW ,NHN and NII contributed to the design of the study. RA, DK, DRD supervised the
389 study. With contributions by DRD and AKW,MH, XRT, SHA, and CLC carried out the data
390 analysis. XRT, SHA, MH, CLC, MTL, SShanmugam, FSAJ, NK, YMFL, NHN, NII contributed
391 to the coordination of the study. MH, SSivasampu, XRT, CLC and SMO drafted the manuscript.
392 XRT, CLC, NK, SHA, MH, MTL, SShanmugam, FSAJ, NK and YMFL made substantial
393 contributions to the acquisition of the data. All authors critically revised the manuscript. All

394 authors read and approved the final manuscript. SSivasampu takes full responsibility for the
395 contents of the article.

396

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516

517

THEORETICAL MODEL

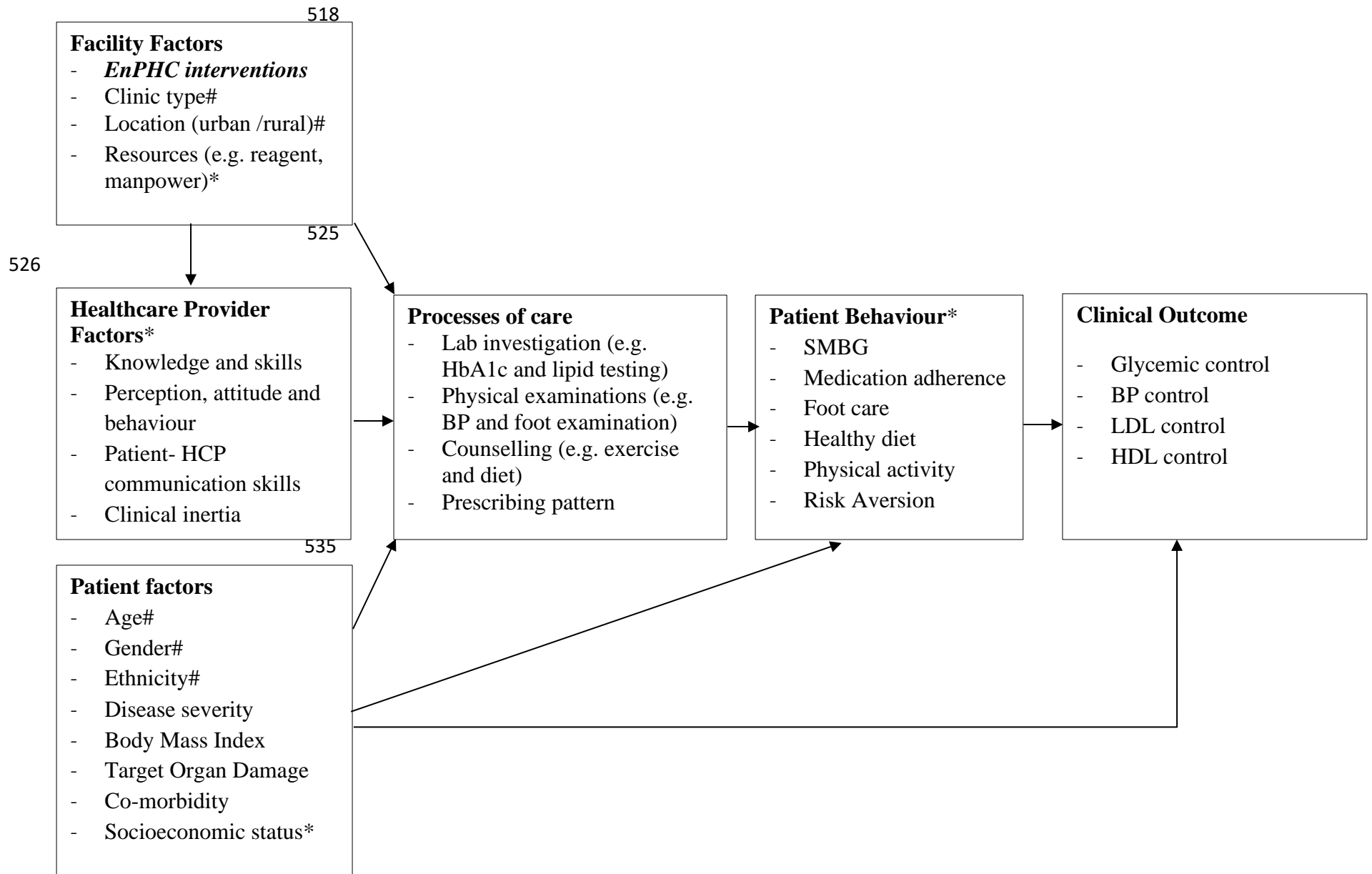


Figure 1 – Theoretical model of the study.

*= unmeasured outcomes, #=non-modifiable factors, *SMBG*: self-monitoring of blood glucose, *BP*: blood pressure

Table 1: Pre-intervention patient characteristics

Patient Characteristics	N (%)		N (%)		P-value
	Intervention group		Control group		
		3283		3436	
Age (years) ^a	60.0	(11.0)	59.8	(10.8)	0.526
Male	1183	(36.0)	1302	(37.9)	0.115
Ethnicity					
Chinese	561	(17.1)	637	(18.5)	<0.001
Indian	364	(11.1)	469	(13.6)	
Malay	2343	(71.4)	2303	(67.0)	
Others	15	(0.5)	27	(0.8)	
Weigh (kg) ^a	69.6	(15.3)	69.9	(15.6)	0.499
BMI (kg/m ²) ^a	28.1	(5.6)	28.3	(5.9)	0.175
BMI					0.685
<18.5	46	(1.6)	46	(1.5)	
18.5-22.9	385	(13.3)	386	(12.8)	
23-27.4	1046	(36.1)	1058	(35.1)	
>27.4	1421	(49.0)	1527	(50.6)	
No target organ damage	2317	(70.6)	2430	(70.7)	0.895
Smoking Status					<0.001
Current	201	(6.1)	209	(6.1)	
Ex-smoker	39	(1.2)	56	(1.6)	
Non-smoker	1111	(33.8)	1615	(47.0)	
unknown	1932	(58.8)	1556	(45.3)	
Comorbidities					
Dyslipidaemia	1539	(46.9)	1733	(50.4)	0.004
Hypertension	2562	(78.0)	2693	(78.4)	0.738
Newly diagnosed diabetes	294	(9.0)	379	(11.0)	0.005
Diabetes duration (years)*	5	(2.6,9.8)	5	(2.4,9.9)	0.644
Hypertension duration (years) *	7	(3.5,11.2)	7	(3.3,11.3)	0.306
Dyslipidaemia duration (years) *	5	(2.9,8.0)	5	(2.7,8.0)	0.531
Systolic blood pressure (mmHg) ^a	137	(18.9)	138	(18.8)	0.750
Diastolic blood pressure (mmHg) ^a	77	(11.2)	78	(10.7)	0.144
LDL (mmol/l) ^a	3.0	(1.0)	3.0	(1.1)	0.760
HbA1c (%)*	7.7	(6.6,9.6)	8.0	(6.7, 9.7)	0.021

Data are presented as n (%) unless otherwise indicated, ^a mean (standard deviation) , * median (interquartile range)

Table 2: Difference-in-difference (DID) analysis of EnPHC interventions on process of care in Type 2 Diabetes patients

2

Outcome (%)	N ^a	Intervention Group		Control Group		Difference (C=A-B)	OR ^b	95% CI (Lower CI)	95% CI (Upper CI)	Adjusted P-value ^c
		Pre	Change (A) (Post-Pre)	Pre	Change (B) (Post-Pre)					
Lab investigations										
HbA1c test in the past 3 months ^d	10803	38.4	23.2	36.2	-5.6	28.8	3.306	2.131	5.130	<0.001
Blood glucose test at every visit ^d	10821	82.4	-30.2	84.9	-4.5	-25.7	0.323	0.142	0.737	0.018
Lipid test in the past one year ^d	10821	83.3	13.6	78.8	3.5	10.1	4.587	2.640	7.970	<0.001
LDL test in the past one year	10820	70.2	22.4	69	2.6	19.8	4.331	2.157	8.700	<0.001
UMA test in the past one year	10802	65.9	15.9	67.8	2.1	13.8	1.994	1.119	3.553	0.038
Liver function test in the past one year ^d	10821	58.2	3.0	51.3	1.8	1.2	1.084	0.518	2.269	0.894
Clinical assessments										
Blood pressure at every visit	10821	97.4	1.1	98.9	0.4	1.5	3.207	0.794	12.962	0.159
BMI measured in the past six month	11945	29.0	49.5	50.8	-12.5	62.4	15.80	4.78	52.24	<0.001
Fundus examination in the past one year ^d	10479	38.5	-1.3	37.7	-8.9	7.6	1.325	0.778	2.256	0.420
Foot examination in the past one year ^d	10695	42.5	-8.1	52.6	-3.8	-4.3	0.742	0.333	1.655	0.593
CVD risk assessment the past one year ^d	10821	0.6	86.3	0.1	0.8	85.5	174.654	16.840	1810.800	<0.001
Counselling and prescription										
Exercise counselling ^d	10821	44.9	21.8	44.9	4.7	17.1	1.18	1.044	1.330	0.018
Diet counselling ^d	10821	67.6	14	63.0	3.5	10.5	1.862	1.026	3.377	0.071
Lipid lowering drug prescription ^d	8835	98.0	0.3	98.4	-0.3	0.6	0.969	0.218	4.308	0.968

3

4 OR, Odds ratio, UMA, Urine microalbumin, CVD, Cardiovascular disease

5 ^a Complete case analyses were performed

6 ^b Adjusted for covariates (age, sex, ethnicity, duration of Type 2 Diabetes, body mass index, presence of Hypertension, presence of Hyperlipidemia, presence of target organ

7 damage, state, urban/rural, clinic type)

8 ^c Adjusted for covariates (age, sex, ethnicity, duration of Type 2 Diabetes, presence of Hypertension, presence of Hyperlipidemia, presence of target organ damage, state,
 9 urban/rural, clinic type)

10 ^d Parallel assumption met

11 ^e P-value adjustment using Benjamin & Hochberg (1995) method

12 A = Post - pre value (intervention group)

13 B = Post - pre value (control group)

14

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18 **Table 3: Difference-in-difference (DID) analysis of EnPHC interventions on intermediate clinical outcomes in Type 2 Diabetes patients**

19

Outcome (%)	N ^a	Intervention Group		Control Group		Difference (C=A-B)	OR ^b	95% C (Lower CI)	95% CI (Upper CI)	P-value ^d
		Pre	Change (A) (Post-Pre)	Pre	Change (B) (Post-Pre)					
HbA1c ≤ 7% ^c	9195	35.1	3.2	33.0	0.8	2.4	1.056	0.8394	1.328	0.672
BP ≤ 135/75mmHg ^c	10821	27.0	-2.9	27.0	-0.8	-2.1	0.900	0.705	1.253	0.672
LDL ≤ 2.6mmol/L ^c	8050	39.2	5.5	40.1	1.9	3.6	1.168	0.8698	1.57	0.603
HDL within control	10821	47.9	7.6	44.1	-2.6	10.2	1.445	1.003	2.083	0.192

21 OR, Odds ratio, BP, Blood pressure

22

23 ^a Complete case analyses were performed

24

25 ^b Adjusted for covariates (age, sex, race, duration of Type 2 Diabetes, body mass index, presence of Hypertension, presence of Hyperlipidemia, presence of Target organ damage,
 26 state, urban/rural, clinic type)

27 ^c Parallel assumption met

28 ^d P-value adjustment using Benjamin & Hochberg (1995) method

29 A = Post - pre value (intervention group)

30 B = Post - pre value (control group)

31