Journal Pre-proofs

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Please cite this article as: S.H. Ali, S. Misra, N. Parekh, B. Murphy, R.J. DiClemente, Preventing Type 2 Diabetes among South Asian Americans through community-based lifestyle interventions: a systematic review, *Preventive Medicine Reports* (2020), doi: https://doi.org/10.1016/j.pmedr.2020.101182

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Preventing Type 2 Diabetes among South Asian Americans through community-based lifestyle interventions: a systematic review

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Word count (abstract): 232
Word count (main text): 4495

1   **Abstract**

2   Ethnic South Asians Americans (SAAs) have the highest relative risk of type 2 diabetes

3   mellitus (T2DM) in the United States (US). Culturally tailored lifestyle interventions have the

4   potential to promote South Asian diabetes prevention; however, the extent of their use and

5   evaluation in US settings remains limited. This systematic review characterizes and evaluates

6   outcomes of community-based lifestyle interventions targeted towards T2DM indicators among

7   South Asians living in the US. A PRISMA-informed search of Pubmed, Embase, Cochrane, Web

8   of Science, and clinical trial registry databases using key words pertaining to South Asians

9   migrants and diabetes indicators (glucose and insulin outcomes) was conducted of community-

10   based lifestyle interventions published up until October, 31 2019. Of the eight studies included in

11   the final synthesis, four interventions focused on cultural and linguistic adaptations of past chronic

12   disease prevention curricula using group-based modalities to deliver the intervention. Hemoglobin

13   A1c (A1c) was the most common outcome indicator measured across the interventions. Three of

14   the five studies observed improvements in indicators post-intervention. Based on these findings,

15   this review recommends 1) greater exploration of community-based lifestyle interventions with

16   high quality diabetes indicators (such as fasting blood glucose) in ethnic South Asian American

17   communities, 2) expanding beyond traditional modalities of group-based lifestyle interventions

18   and exploring the use of technology and interventions integrated with passive, active, and

19   individualized components, and 3) development of research on diabetes prevention among second

20   generation South Asians Americans.

21

22   **Key words**: diabetes, insulin, glucose, lifestyle, South Asian, migrants, community health

23

24   **Background**

25

26   *Diabetes among South Asians in the US*

27   In 2017 approximately 30.3 million people in the US were living with diabetes, creating

28   an epidemic cost of 327 billion [1, 2]. Ethnic SAAs have a disproportionately high burden of

29   T2DM; ethnic Asian Indians for instance have a 2.8 times greater relative risk of T2DM as

30   compared to whites and 1.3 greater risk compared to the Asian aggregate [3]. In clinical and

31   research settings, the primary outcome indicators used to measure and screen for T2DM include

32   measures of blood glucose, such as A1c, fasting plasma glucose (FPG), the oral glucose tolerance

33   test (OGTT), and measures of insulin resistance, such as the Homeostasis Model Assessment

34   (HOMA) and the Quantitative Insulin Sensitivity Check Index (QUICKI) [4, 5]. Lifestyle factors

35   (such as poor diet and exercise) have been recognized as key contributors to the sharp rise in T2DM

36   [6]. Among ethnic South Asians, factors such as migration and cultural values pertaining to diet

37   and exercise have been observed to further compound the rising prevalence of T2DM [7].

38

39   Much of the existing literature and reviews on interventions targeting T2DM among South

40   Asian migrants have targeted diabetes management and focused on populations living in the

41   United Kingdom and Europe [8-10]. Yet, compared to the United Kingdom and Europe, the United

42   States attracts a significantly greater population of highly educated, first-generation South Asian

43   migrants [11-13]. The significant differences in socio-demographics, relevant to intervention

44   design between South Asian migrants living in the US versus those in the UK and Europe, suggests

45   the need for region-based intervention analysis. Likewise, given the rise of pre-diabetes in the

46   United States, preventing diabetes incidence is also of paramount importance [2].

47

48   *Diabetes prevention interventions*

49   Although diabetes management remains a concern among many ethnic South Asians in the

50   United States, there has been a growing impetus to focus attention on diabetes prevention among

51   individuals with pre-diabetes and patients who have not yet developed diabetes but may be at-risk

52   [14]. Diabetes prevention programs focus on promoting health-protective lifestyle changes;

53   however, these programs must be tailored in a culturally sensitive way to optimize programmatic

54   effectiveness [14].

55

56   In the United States, the large, multi-ethnic, multi-center Diabetes Prevention Program

57 (DPP) has provided robust evidence for diabetes prevention [15]. However, the program lacks a

58 separate analysis of ethnic South Asian community outcomes. Its generalizability for the Asian

59 American migrant community has also been criticized, in part, due to limited cultural relevance in

60 the diet, exercise, and behavior change components of the program [16]. Indeed, with the observed

61 need for cultural precision in diabetes prevention campaigns, there is a gap in understanding the

62 impact that existing diabetes prevention interventions (with varying levels of cultural sensitivity

63 in design) have had on at-risk subpopulations such as ethnic SAAs.

64

65   Community-based lifestyle interventions are particularly promising for diabetes prevention

66 among ethnic SAAs. The strength of this approach lies in a number of key aspects [17]. First,

67 targeting an intervention at the population level among individuals with varying levels of risk

68 allows for maximum reach and access to intervention materials, especially relevant for

69 communities such as ethnic SAAs who may not be able to afford or seek clinical services [18].

70 Second, since diabetes progression involves complex dynamics between behavioral and

71 environmental factors, community-based approaches can be designed to affect social or

72 environmental conditions in ways that clinical services cannot. Finally, community-based

73 prevention can be culturally tailored to populations' unique barriers to disease prevention, such as

74 ethnic SAAs.

75

76   The aims of this systematic review are twofold: 1) describe characteristics of community-

77 based lifestyle interventions which have assessed changes in T2DM glucose and insulin indicators

78 among ethnic South Asians in the US, and 2) evaluate the effectiveness of these interventions in

79 improving T2DM glucose and insulin indicators. In doing so, this review will identify components

80 associated with successful community-based lifestyle interventions among ethnic South Asians

81 Americans as well as opportunities for further research.

82

83   **Methods**

84

85   *Search Strategy*

86   A systematic search of literature published up through October 31, 2019 was performed

87   adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

88   guidelines [19]. Database search included PubMed, Web of Sciences, Embase, Cochrane, and

89   SCOPUS. A manual search was conducted for further peer-reviewed studies, grey literature, and

90   registered clinical trials from WHO International Clinical Trials Registry Platform,

91   Clinicaltrial.gov, and Google Scholar. Authors of protocols, registered trials, and studies with

92   only baseline data were individually contacted to assess if post-intervention data was available for

93   inclusion (three contact attempts were made of each author).

94

95   The detailed search strategy employed in the formal database search is displayed in Table

96   1. Key words used included community-based lifestyle intervention related terms informed from

97   past systematic reviews along with terms focused on South Asian immigrant populations (those

98   ethnically identifying as Indian, Pakistani, Bangladeshi, Sri Lankan, Nepalese, Bhutanese, or

99   Maldivian), and terms relating to diabetes, including glucose or insulin indicators (A1C, plasma

100   blood glucose, 2h post load glucose, insulin sensitivity, among others) [20].

101

102   *Eligibility of studies*

103   A screening reliability test was conducted by two independent reviewers (SA and BM) of

104   60 abstracts within the full screening sample, followed by complete abstract and title screening.

105   Studies conducted on ethnic SAA populations above the age of 18 were within the scope of the

106   study. A study was included if it satisfied the following criteria. First, the study had to focus, at

107   least partly, on a specific South Asian population (including the seven identified South Asian

108   nationalities) that were residing in the US at the time of study. Second, the study must discuss a

109   community-based intervention defined as an "approach directed to a population rather than

110   individuals, implemented in community settings rather than hospital or health care settings, and

111   approaches coordinated through friends, family, neighbors, community members, worksites,

112   schools or primary health care centers" [20]. Third, the study had to include at least baseline data.

113   Fourth, the study had to include biomarkers commonly used to assess diabetes risk: blood glucose

114   or insulin related indicators. A study was excluded if it was a review, lacked an ethnic SAA sample,

115   focused exclusively on diabetes management among individuals with T2DM, or lacked a

116   community-based component (e.g., exclusively structural or clinic/hospital-based).

117

118   *Data Extraction*

119   A data extraction form was developed by the study authors and pilot tested before being

120 implemented for the final study sample. Data extracted included study participant characteristics,

121 intervention characteristics, and outcome variable data. Full-text assessment and data extraction

122 were conducted by two independent reviewers (SA and SM), and the senior author (RD) served as

123 a tiebreaker when a consensus could not be reached. If demographic information for control and

124 intervention group was presented separately, a weighted average was calculated for the variables

125 of interest.

126   *Quality Assessment of included studies*

127   The National Heart, Lung, and Blood Institute (NHLBI) study quality assessment tool was

128 applied to all included studies by two independent reviewers (SA and SM). One of two NHLBI

129 checklists were used, depending on study design: controlled intervention studies or before-after

130 (pre-post) studies with no control group [21]. Given the heterogeneity in the study designs, the

131 checklists were supplemented by a brief narrative quality assessment focused on aspects of

132 feasibility, acceptability, retention, and the meaningful role of cultural and community-based

133 design and adaptation measures.

134

135   **Results**

136

137   The search strategy retrieved 1,571 individual articles, of which 44 passed through title and

138 abstract screening. Another 36 studies were excluded through the full text assessment process

139 specified in Figure 1. Of the one protocol and two registered trials that passed through screening,

140 study authors of only one registered trial [22] were able to provide an unpublished manuscript with

141 both baseline and post-intervention data [23].

142

143   *Included Studies*

144   Eight studies were included in the final qualitative synthesis, including two randomized

145 controlled trials [24, 25], two two-group pre-post studies [26, 27], three one-group pre-post studies

146 [23, 28, 29], and one experimental study with only baseline data [30] (Table 2). While the number

147 of participants analyzed in intervention or control groups across most studies was between 20-54,

148   one single-group pilot study had only 9 participants [23], while another large intervention trial had

149   2726 participants [30].

150

151   The sample characteristics of the studies varied (Table 3). All studies were conducted in

152   large, urban centers across different regions of the US. While many studies targeted ethnic South

153   Asians Americans broadly, others were more specifically focused on categories of ethnicity [25],

154   religion [26], occupation [28], or motherhood status [29]. Most studies were primarily based on

155   populations at risk for a chronic illness. Three studies focused on populations at risk for T2DM

156   through the American Diabetes Association risk assessment tool [26, 27] or the Madras Diabetes

157   Research Foundation's Indian Diabetes Risk Score [25]. One study focused on overweight (using

158   the $\geq$22kg/m2 cut-off identified for Asian populations [31]) participants with pre-diabetes (FPG

159   100-125 mg/dl and/or 2-hour post-load glucose of 140-199 mg/dl) [23]. Other at-risk factors used

160   for participant eligibility included BMI of $\geq$25kg/m2 [29], family history of diabetes [29], or at

161   least one cardiovascular disease risk factor (BMI$\geq$25kg/m2, total cholesterol $\geq$200, LDL

162   cholesterol $\geq$130, prediabetes using FPG>100 or A1c 5.7-6.4, diabetes using FPG>126 or A1c>6.4,

163   systolic blood pressure $\geq$140, or diastolic blood pressure $\geq$90) [24].

164

165   While two studies exclusively studied men [28] or women [29], four predominantly

166   included men [30] or women [24, 26, 27], and only one study showed a relatively balanced gender

167   profile [25]. Five studies focused only on first-generation South Asian immigrants (born outside

168   of the US), and among the two studies with US-born participants, these individuals represented

169   only 2% and 4% of the total study sample, respectively [25, 30]. The average age of participants

170   ranged from 43 to 53.1 years; however, education status varied markedly. While 87% and 96% of

171   two studies, respectively, had participants with bachelor's degree or higher [25, 30], other studies

172   had significant (or majority) of participants with high school (or below) levels of educational

173   attainment [28, 29].

174

175   The quality of the studies was generally good for their study design, with all but two studies

176   scoring in the ("Good") category on the three-option ("Good, Fair, Poor") NHLBI assessment tool.

177   Most studies were pilot studies and did not include a control group. Among controlled studies, a

178   few used randomizations but others, such as Islam et al., did not due to negative community

179   perceptions toward randomization [26]. Most studies compared the characteristics of those who

180   dropped out of the study with those who stayed in the study (with issues of time-commitment being

181   a salient reason for attrition across the interventions); however, only one study included a full

182   qualitative process evaluation through participant interviews to understand barriers and facilitators

183   of the intervention [29]. Community-based participatory research (CBPR) approaches were also

184   widely employed to enhance study quality; Kandula et al. (2015) credited their 100% participant

185   retention to integrating CBPR tenets throughout the study [24]. Although only baseline data was

186   provided in Sathe et al.'s health coaching intervention, of the 2726 individuals analyzed during

187   baseline, only 50% (1359) completed full participation, with authors citing lack of time and not

188   understanding the program or its benefits among the reasons for attrition [30].

189

190   *Characteristics of Interventions*

191   The structure of the community-based lifestyle interventions varied considerably (Table 4).

192   Group-class formats of positive lifestyle behavior promotion were most popular [23-27]. Most

193   interventions were between 12-16 weeks in duration, while some lasted 6 months [26, 27] or 1

194   year [30]. Community settings, such as religious institutions, non-profit organization venues, local

195   fitness facilities, and other convenient community spaces were common for intervention settings.

196   Other studies had non-specific venues; Ganey et al. provided participants with pedometers to use

197   throughout daily activities [28], while Sathe et al.'s health coaching intervention was largely phone

198   or email based [30].

199

200   Most (seven) studies incorporated some form of cultural and linguistic tailoring to the

201   intervention design. Formative, qualitative research with South Asian communities was explored

202   by some studies to directly inform curriculum design and adaptation [23, 26]. Others involved

203   community partners [29]; Islam et al. for instance recruited a Sikh nutrition expert to help create

204   healthy recipes [26]. Lim et al. expanded on the successes of Islam et al.'s pilot study and included

205   many of the same cultural adaptions [26, 27]. The adaptation of existing chronic disease prevention

206   curriculum was common, including the materials from the United States DPP [23, 26, 27], the

207   National Diabetes Education Program's Power to Prevent curriculum (P2P) [25-27], and the

208   NHLBI Healthy Heart, Healthy Family curriculum [26, 27]. Linguistic tailoring was included in

209   four of the five group-class based interventions through some form of oral or written translation

210   of study materials [24-27]. Likewise, Gany et al.'s pedometer-based intervention had

211   questionnaires administered in participants' preferred language [28], and Kandula et al.'s exercise-

212   based intervention had Hindi-speaking study staff participating in fitness classes for translation

213   [29].

214

215   While technology was not a significant component included in the interventions,

216   pedometers were used in multiple interventions. Three studies incorporated pedometers as an

217   explicit component of the intervention [24, 28, 29] while one primarily used the technology to

218   track daily step counts [25]. Patel et al. employed a smartphone app messaging software to allow

219   participants to receive weekly reminders about mailing weekly logs and coming to weekly group

220   sessions [25]. Moreover, Sathe et al.'s health coaching intervention was largely phone and email

221   based [30], Islam et al. and Lim et al. incorporated telephone-based follow ups with participants

222   after sessions [26, 27], and Kandula et al. (2015) included a telephone-based motivational

223   interviewing component in their intervention [24].

224

225   Physical activity was widely explored across the interventions. General promotion of

226   physical activity strategies through group class formats (ranging from 60 minutes to 120 minutes

227   on a weekly or biweekly basis) [24-27] or targeted health coaching [30] was common. However,

228   more active exercise-based interventions were also explored. For example, Kandula et al. (2016)

229   conducted a biweekly, 45-minute moderate-intensity Zumba and aerobics-based exercise

230   intervention [29]. Others incorporated exercise into aspects of the intervention; Kandula et al.

231   (2015) conducted four group melas (a term used in South Asia for a gathering or festival) over the

232   course of the year-long intervention involving yoga and folk-dance-based aerobic exercises [24],

233   Patel et al. incorporated group physical activities and demonstrations in some group classes [25],

234   and Narayan et al. incorporated traditional Indian dancing, work-out videos, and group walks [23].

235

236   Diet and nutrition were similarly explored in different culturally sensitive ways. The

237   promotion of healthy eating practices (mainly focused on reducing unhealthy fats, sugars, and

238   sodium while increasing fruit and vegetable intake) was common across the group-class based

239   interventions [23-27]. Culturally-tailored cooking activities were also explored; Kandula et al.

240   (2015) collaborated with a South Asian chef to teach healthy cooking and have cooking

241 competitions [24], Islam et al. promoted techniques of incorporating healthfulness in traditional

242 Indian cooking [26], and Patel et al. conducted cooking demonstrations, food sampling, grocery

243 store tours, recipe makeovers, and pot-luck parties in some group sessions [25].

244

245   *Effectiveness of Interventions*

246   The most common blood glucose outcome indicators assessed was A1C (measured as %

247 and mmol/mol) [23-25, 29]. Two interventions used random plasma glucose (measured as mg/dL

248 and mmol/L) [28, 30], two used 2h fasting blood glucose (mg/dl) [26, 27], while one used a general

249 fasting plasma glucose test of an unspecified time length (mg/dl) [24]. While most studies assessed

250 blood glucose measures on a continuous scale, Gany et al. conducted a categorical analysis based

251 on subjects with a random plasma blood glucose of <200 mg/dL, 200-399 mg/dL, and ≥400 mg/dL

252 [28]. Unlike other studies, Weber et al. also assessed the number of individuals with

253 normoglycemia, isolated impaired fasting glucose (iIFG), and isolated impaired glucose tolerance

254 (iIGT) [23]. Measures specifically targeting insulin sensitivity and resistance, such as QUICKI or

255 HOMA, were not used.

256

257   Overall, most interventional studies demonstrated effectiveness in improving glucose and

258 insulin indicators among participants. However, only four studies were conducted with the

259 primary objective of diabetes prevention [23, 25, 26, 29], and only two studies conducting data

260 collection included a follow-up period longer than immediately post-intervention, measuring at 2

261 months [23] or 6 months [25] after its completion. Four of the six studies statistically assessing

262 post-intervention efficacy showed statistically significant reductions in blood glucose and A1C

263 [24-27]. Kandula et al. (2015) observed a greater sex-adjusted A1c (%) decrease of 0.43 (p<0.01)

264 in the intervention group compared to the control group at the sixth month of the study period,

265 although fasting glucose showed no statistically significant change [24]. Patel et al.'s 12-week

266 study among participants with prediabetes similarly found the intervention participants reduce A1c

267 from baseline (38.96 mmol/mol) to the 12-week postintervention assessment (37.00 mmol/mol)

268 and to 24-week follow-up (or 12-weeks after the conclusion of the intervention, 36.54 mmol/mol),

269 both of which were significant (p<0.0005) compared to control [25]. However, the small-scale,

270 pilot nature of much of these studies limit the clinical meaningfulness of their observed

271 effectiveness. Among the remaining two studies, Gany et al. observed improvement in individuals

272   with <200 mg/dL glucose readings but it was not statistically significant (p=0.31) [28], while

273   Kandula et al. observed a slight but not clinically meaningful increase in A1c post-intervention

274   [29].

275

276   **Discussion**

277

278   Diabetes prevention among ethnic South Asians Americans is a major public health

279   concern. This review sought to systematically assess characteristics and effectiveness of

280   community-based lifestyle interventions involving T2DM blood glucose and insulin indicators.

281   We found that community-based lifestyle interventions targeting diabetes prevention remains

282   relatively unexplored in ethnic SAA populations (reflected by the small sample of eight articles

283   included in the review, all published within the last five years). While cultural and linguistic

284   adaption was widely explored across the interventions, most studies employed traditional group-

285   class intervention delivery formats targeting lifestyle behaviors based on standard curricula of

286   chronic disease prevention. Assessing effectiveness of the interventions was largely confined to

287   A1c, 2h fasting blood glucose, and random plasma blood glucose indicators, and while some

288   observed negative or no impact of the interventions in improving blood glucose indicators, the

289   success observed in most studies suggest that community-based lifestyle interventions, indeed,

290   may be a promising strategy to reduce the rising public health burden of T2DM among ethnic

291   South Asians Americans.

292

293   While most studies were derived from evidence-driven approaches and formative research

294   or incorporated standard diabetes prevention curriculums, many tended to focus exclusively on

295   either passive, group-class based formats of lifestyle behavior change promotion or more active,

296   physical-activity based lifestyle behavior change activities. Multiple studies had significant active

297   and passive components to the interventions [23-25], while some intervention components were

298   infrequently implemented and did not occur on a weekly or biweekly basis [24, 25], and some

299   components were simply optional [29]. Different delivery methods of lifestyle interventions play

300   a unique role in tackling the myriad complex barriers to healthy lifestyle behavior change, and the

301   development of past comprehensive lifestyle interventions rely on active, passive, and

302   individualized components to enhance efficacy [32]. Indeed, there are many lessons to be learned

303   from multi-level health promotion intervention research in Europe; Andersen et al. conducted a

304   randomized controlled trial among Pakistani immigrant men living in Norway that observed

305   significant reductions in post-intervention insulin levels directly targeting constructs of Social

306   Cognitive Theory [33, 34]. Notably, this single intervention included components observed across

307   separate interventions in this review, including bi-weekly group exercises similar to Kandula et al.

308   2016 [29], group lectures similar to that employed in multiple studies, individualized counselling

309   similar to Sathe et al. [30], and motivational phone-based contacts similar to Kandula et al. 2015

310   [24]. This is an opportunity for further research in the US to design similar multi-component

311   interventions that incorporate passive (lecture-based), active (activity-based), and individualized

312   (such as targeted counseling) health promotion and behavior change aspects.

313

314   Likewise, past utilization of theoretical lenses to understand the nuances of chronic

315   diseases prevention among ethnic South Asians provides a starting point on behavior change

316   constructs which may be particularly salient for diabetes prevention; Haider et. al for example

317   employed the Social Cognitive Theory to predict exercise behavior among a cohort of largely first-

318   generation South Asian college students in US and observed the construct of self-efficacy to be

319   the only salient predictor of exercise behavior [35]. Such findings suggest that efficacy-building

320   may be particularly suited for this population, although further theory-based analysis on lifestyle

321   behavior change among other SAAs subgroups (e.g. second-generation immigrants, or older adults)

322   is needed to provide more substantial insights to support intervention design.

323

324   The observed lack of studies involving second-generation South Asian migrants in the US

325   reflects a broader gap in research on this subpopulation [36] and represents a significant

326   opportunity for future work. Indeed, while first-generation migrants still constitute a significant

327   proportion of ethnic South Asians Americans, there are approximately 800,000 second generation

328   ethnic Indian Americans in the US, a number that is expected to significantly rise in the similar

329   way as second and third generation South Asian communities have grown in the UK after waves

330   of migration [13, 37]. Second-generation South Asian migrants around the world have been

331   observed to have significantly higher levels of educational attainment and linguistic integration,

332   greater socio-economic advantage, more favorable attitudes towards physical activity, exercise

333   more, and have less pressure to conform to traditional norms of diet and exercise [38-40]. Indeed,

334   the fact that almost all studies in the current sample did not specifically exclude second-generation
335   or US-born ethnic SAAs suggests a need for greater sampling of second-generation South Asians
336   (or potentially interventions specifically targeting the community) to provide a better
337   understanding of the general applicability of community-based lifestyle interventions and provide
338   implications for future work. Specifically, mixed-methods formative research among second-
339   generation ethnic SAAs my identify certain foods or exercise behaviors more salient or culturally
340   acceptable in this sub-population compared to first-generation migrants, which can then directly
341   be integrated into diabetes prevention interventions targeting the community.

342

343   Studies showed mixed but generally positive improvements in blood glucose indicators
344   post-intervention. The quality assessment conducted found that such findings were limited by
345   small sample sizes, lack of comparison groups, and limited post-intervention follow up assessment.
346   Likewise, these mixed results corroborate other community-based diabetes prevention-oriented
347   lifestyle interventions in ethnic South Asian communities living in New Zealand [41] and Norway
348   [33] that similarly showed mixed results in improvements of diabetes indicators. The common
349   utilization of A1c and random plasma glucose measures across the included studies can, at least in
350   part, be explained by the ease and convenience of both tests for participants and researchers. The
351   lack of clinical meaningfulness was also identified as an issue of concern with respect to some
352   results [29], further supporting the need for large-scale, rigorous intervention trials to assess
353   efficacy. Indeed, as multiple studies in this review have shown, the feasibility constraints that
354   variables such as fasting blood glucose which require greater effort on the part of the participant
355   can be successfully overcome to ensure greater quality of the glucose and insulin outcomes. Thus,
356   these mixed, yet generally positive, findings are compelling to support further high-quality
357   intervention research in the field of T2DM prevention.

358

359   This study identified areas for further exploration of high-quality glucose and insulin
360   outcome indicators in community-based lifestyle interventions. Most studies only employed a
361   single blood glucose indicator, and evidence from included studies involving multiple indicators
362   suggest that significant trends may not be reflected across all diabetes prevention outcomes [24].
363   Indeed, there is evidence highlighting the extent to which different blood glucose or insulin
364   resistance outcomes may have uniquely salient roles in explaining diabetes prevalence across

365 racial groups, including among ethnic South Asians [42, 43]. Kananya et al.'s study on ethnic

366 SAA diabetes prevalence observed that low β-cell function and insulin resistance was particularly

367 high among South Asians and called for further research to identify the biological pathways and

368 mechanisms behind diabetes progression among ethnic South Asians [43]. Similarly, the

369 measurement of A1c in distinguishing between individuals with pre-diabetes and those without

370 diabetes (the main focus of diabetes prevention interventions) has been shown to be lower than its

371 ability for distinguishing individuals with diabetes and individuals with pre-diabetes, compelling

372 scholars to advocate the use of FPG or OGTT verification for individuals diagnosed as without

373 diabetes or with pre-diabetes [44]. Insulin resistance indicators (such as HOMA) were not assessed,

374 and FPG and the Oral Glucose Tolerance Test (OGTT) – the traditional gold standards for diabetes

375 diagnosis – were not employed [42]. Thus, there is a need for the incorporation of multiple, high-

376 quality blood glucose and insulin indicators in further community-based diabetes prevention

377 research in the US. To meet future aims, intervention studies in other settings provide insights on

378 opportunities worthy of exploration in US settings; Rush et al.'s community-based lifestyle

379 intervention among Asian Indians in New Zealand, for instance, assessed glucose (mmol/L),

380 insulin (pmol/L), HOMA-B (%), and HOMA-S (%) [41].

381

382   *Limitations*

383   This review has some key limitations. First, this study relied on the precedent set by

384 selected past literature to define 'lifestyle interventions' and operationalize the community-based

385 lens in the search strategy [20]. Second, this study excluded research focusing on the broader sub-

386 group, 'Asian Americans,' a group which may have included significant numbers of South Asians,

387 given the heterogeneity observed in Asian American subgroups and issues in generalizability

388 between culturally targeted interventions among different Asian American communities. Finally,

389 the review's broad scope on general diabetes prevention meant that some studies did not explicitly

390 exclude individuals with pre-existing diabetes which limits the interpretability of the findings

391 (although among such studies, the percentage of individuals with diabetes was consistently small)

392 – further research may focus more specifically on populations who exclusively do not meet criteria

393 for diabetes or pre-diabetes.

394

395   **Conclusion**

396

397   Preventing T2DM among ethnic SAA communities remains a pressing public health

398   concern in the US, and community-based lifestyle interventions present a promising opportunity

399   to address this challenge. This review provides information on the potential efficacy and gaps

400   pertaining to community-based lifestyle intervention design to inform further research and health

401   promotion activities in this field. Based on the findings of this study, we have the following

402   recommendations. First, there is a need for greater exploration of community-based lifestyle

403   interventions with high quality diabetes indicators (such as fasting plasma glucose) in ethnic SAA

404   communities. Second, further interventions should expand beyond traditional formats of group-

405   class based lifestyle interventions and exploring the use of innovative technologies and

406   interventions integrated with passive, active, and individualized components. For example, the

407   examination of telehealth and mhealth components (e.g. phone based or smartphone application

408   based interventions) was limited, and the potential importance of such platforms has been further

409   highlighted after the COVID-19 pandemic; further formative and interventional research using

410   these technologies should be explored, and may provide insights on whether certain subsets of the

411   population (e.g. second generation or young ethnic SAAs) may particularly benefit from

412   interventions with these technologies. Likewise, expanding standard curricula for diabetes

413   prevention by integrating group-based education, interactive activities (e.g. exercise sessions), and

414   individualized one-on-one consultations with other culturally adaptive components (such as group

415   melas or festivals) may enhance the applicability and effectiveness of interventions. Finally, there

416   is a strong need to explore diabetes prevention among second generation SAAs through crucial

417   phases of formative research and greater inclusion in diabetes prevention interventions. Indeed,

418   fundamentally addressing diabetes prevention among ethnic SAAs requires both effective and

419   sustainable interventions; to this extent, community-based lifestyle interventions culturally

420   adapted to the preferences and norms of the ethnic SAA community have the strong potential to

421   meet these needs.

422

423   **Author Contributions**

424

425   **Shahmir H. Ali**: Conceptualization, Methodology, Investigation, Writing - Original Draft.

426   **Supriya Misra**: Methodology, Investigation, Writing - Review & Editing. **Niyati Parekh**:

427   Writing - Review & Editing. **Bridget Murphy**: Investigation, Writing - Review & Editing.

428   **Ralph J. DiClemente**: Conceptualization, Methodology, Investigation, Writing - Review &

429   Editing, Supervision.

430

431   <div align="center">**Acknowledgements**</div>

432

435   <div align="center">**Conflict of Interest**</div>

436

437   The authors declare there is no conflict of interest.

438

439   <div align="center">**References**</div>

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558   Figure 1: PRISMA flowchart of search strategy and included studies
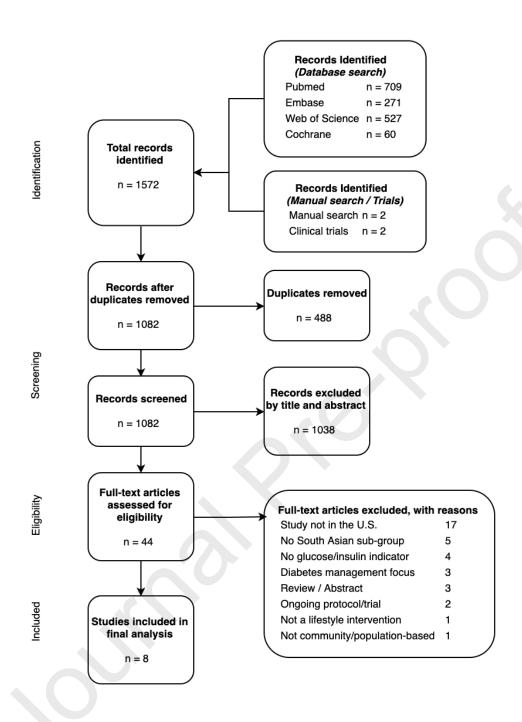
559

Identification

Records Identified (Database search)
Pubmed n = 709
Embase n = 271
Web of Science n = 527
Cochrane n = 60

Records Identified (Manual search / Trials)
Manual search n = 2
Clinical trials n = 2

Total records identified
n = 1572

Screening

Records after duplicates removed
n = 1082

Duplicates removed
n = 488

Records screened
n = 1082

Records excluded by title and abstract
n = 1038

Eligibility

Full-text articles assessed for eligibility
n = 44

Full-text articles excluded, with reasons
Study not in the U.S. 17
No South Asian sub-group 5
No glucose/insulin indicator 4
Diabetes management focus 3
Review / Abstract 3
Ongoing protocol/trial 2
Not a lifestyle intervention 1
Not community/population-based 1

Included

Studies included in final analysis
n = 8

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Table 1: Search Strategy

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Component	Key Words
Population	(South Asia* OR India* OR Sri Lanka* OR Nepal* OR Bangladesh* OR Bhutan* OR Maldiv* OR Pakistan*) AND (Migra* OR Immigra* OR Emigra* OR Minorit*)
Intervention	(implementation OR intervention OR health promotion OR clinical trial OR lay worker OR lay health advisor

	OR lay health educator OR lay health worker OR peer counseling OR peer support OR peer-based OR peer-support OR peers OR peer education OR group education OR group support OR group-based OR peer counseling OR peer support OR peer led intervention OR peer-led intervention OR peer based intervention OR community-led OR community-based OR school based OR work based OR mosque based OR temple based OR gurdwara based OR family based)
Outcome	(diabetes OR T2DM OR tidm OR iddm OR niddm OR diabetes mellitus OR glucose intolerance OR HbA1C OR A1C OR hemoglobin a1c OR blood glucose OR plasma glucose OR fasting glucose OR fasting blood glucose OR postload glucose OR post load glucose OR postprandial glucose OR post prandial glucose OR oral glucose OR insulin OR insulin resistance OR insulin sensitivity OR homeostasis model assessment OR HOMA OR quantitative insulin sensitivity check index OR QUICKI OR Matsuda index OR normoglycemia OR IGT OR impaired glucose tolerance OR IFT OR impaired fasting glucose)

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568   Table 2: List of included studies
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Author (year)	Location of study	Study Design	Description of study population	Study participants analyzed	Glucose/insulin indicators	Effectiveness intervention
Kandula 2015	Chicago, IL	RCT	Asian Indians or Pakistanis with at least one atherosclerotic cardiovascular disease risk factor	Intervention: 31 Control: 32	A1C, Fasting blood glucose (mg/DL)	6-month 0.43% de A1C, no significa in fastin
Patel 2017	Houston, TX	RCT	Gujarati Asian Indians at-risk for T2DM	Intervention: 26 Control: 20	A1C	6-month 1.96 and 12-m mmol/mol decreas
Islam 2014	New York City, NY	2GPP	Sikh Asian Indians at-risk for T2DM	Intervention: 54 Control: 48	2h fasting blood glucose (mg/DL)	6-month 25 decrease in bloo
Lim 2019	New York City, NY	2GPP	Sikh Asian Indians at-risk for T2DM	Intervention: 71 Control: 89	2h fasting blood glucose (mg/DL	6-month 1 decrease in bloo
Gany 2014	New York City, NY	1GPP	Asian Indian, Pakistani, and Bangladeshi taxi drivers	Intervention: 47 Control: N/A	Random glucose test (mg/DL)	No significant bloo
Kandula 2016	Chicago, IL	1GPP	South Asian women with children (age 6-12) who were at-risk for T2DM	Intervention: 30 Control: N/A	A1C	4-month 0.1% in

| Weber + (Narayan 2010) | Atlanta, GA | 1GPP | Overweight, pre-diabetic South Asians | Intervention: 9 Control: N/A | A1C, Normoglycemia, Isolated IGT, Isolated IFT | ^Decrease in A... iIFT, in... normo... |
| Sathe 2013 | Alameda, CA | Baseline | South Asians at-risk for cardiovascular disease | Intervention: 2726 Control: N/A | Random glucose test (mg/DL) | N/A (Base... |

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571 1GPP: One-group pre-test/post-test study; 2GPP: Two-group pre-test/post-test study; RCT: Randomized controlled trial;
572 [1] : NHLBI Controlled Intervention Studies tool
573 [2] : NHLBI Before-After (Pre-Post) Studies With No Control Group tool
574 ^ statistical testing not conducted due to small sample size
575
576

577 Table 3: Characteristics of populations studied (baseline + interventional studies)
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Author (year)	Included sub-groups	Males	Females	Born abroad	Born in US	Average age (range)	Education range
Kandula 2015	Indian, Pakistani	37%	63%	100%	0%	50.0 (30-59)	Below high school: 27%
Patel 2017	Indian	46%	54%	98%	2%	53.1	High school: 13% Bachelor's degree: 46% Graduate degree: 41%
Islam 2014	Indian	19%	81%	100%	0%	46.3 (18-75)	Below high school: 13% High school/some college: 67% College: 17%
Lim 2014	Indian, Bangladeshi	31%	69%	100%	0%	46.5 (18-75)	Below high school: 13% High school/some college: 70% College: 14%
Gany 2014	Indian, Pakistani, Bangladeshi	100%	0%	100%	0%	47.9 (30-79)	Post college/graduate school: 2... College/some college: 34% High school and below: 38%
Kandula 2016	Indian, Pakistani, Other	0%	100%	100%	0%	N/A	High school and below: 57%
Weber + (Narayan 2010)	Self-identified South Asian	77%	23%	N/A	N/A	46.9	Some college and above: 100%
Sathe 2013	Indian, Pakistani, Bangladeshi, Sri Lankan, Nepali	69%	31%	92%	4%	43	Bachelor's degree or higher: 9...

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581 Table 4: Characteristics of interventions

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Author (year)	Length of lifestyle Intervention	Intervention Setting	Physical Activity component	Diet/nutrition component	Other components	Cultural adaptation	Language adaptatio
Kandula 2015	16 weeks	Community-based non-profit organization	1-1.5h weekly group classes: exercise promotion. Group 'Melas': Yoga, aerobic exercise built on folk dances	1-1.5h group classes: reducing fat/salt, increasing healthy fruits/vegetables/ grains. Group 'Melas': healthy cooking with South Asian chef, cooking competition	1-1.5h weekly group classes: heart disease risk factors, weight control, stress and tension control	Sociocultural context and beliefs integrated into curriculum. Festive activities ('Melas') with culturally salient activities to reinforce healthy behaviors	Participan to group based on preference Translatio document communit
Patel 2017	12 weeks	Hindu temple ('mandir')	75-min weekly group session: increasing physical activity Some sessions also included: 20-min group physical activity	75-min group session: increasing fruit/vegetable intake, barriers. Some sessions included: cooking demonstrations, food samples, grocery store tour, recipe makeover, pot-luck party	N/A	Existing curriculum (P2P) adapted and culturally tailored. Inspirational cultural messaging, visuals	Gujarati A facilitator translated personaliz colloquial customs, t
Islam 2014	6 months	Community settings convenient to Sikh Asian Indian community	2h weekly group classes: Physical activity promotion, home-based exercises/activities	2h group classes: Identifying high salt/sugar foods, incorporating healthfulness in traditional Indian cooking, reading food labels	2h group weekly classes: General diabetes awareness, stress and mental health, access to healthcare	Existing curriculum (NHLBI, P2P, DPP, RH) culturally adapted through formative research. Sikh nutritionist created healthy recipes	All curric materials into Punja
Lim 2019	6 months	Community settings (neighborhood gurdwara or education center) convenient to Sikh Asian Indian community	2h weekly group classes: Physical activity promotion	2h weekly group classes: improving nutrition, healthy Indian cooking	2h weekly group classes: General diabetes awareness, stress and mental health, access to healthcare	Culture adaptions further described in pilot paper (Islam, 2014): Existing curriculum (NHLBI, P2P, DPP, RH, other) culturally adapted.	All survey administe Punjabi b communit workers. Interventi bilingual health wo
Gany 2014	12 weeks	Remote	Daily pedometer usage	N/A	N/A	N/A	Multi-ling research p consented participan Questionn administe drivers' p language
Kandula 2016	16 weeks	Community-based non-profit organization, local fitness facility	45 minutes (2+/wk) of moderate intensity exercise (Zumba, aerobics)	Optional group classes: culturally tailored healthy eating, reducing fat and salt intake	N/A	Community partners involved in development of culturally tailored strategies as part of intervention	Study staf participate exercises translation
Weber + (Narayan 2010)	16 weeks	Community locations near city	Group classes: physical activity awareness,	Group classes: diet awareness	N/A	Existing curriculum (DPP) culturally adapted through	N/A

			traditional Indian dance exercises, group walks, work-out videos			focus group research.	
Sathe 2013	1 year	Remote	Health coach recommendations	Health coach recommendations	Health coach recommendations	Health coaches trained to integrated culturally tailored strategies	N/A

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