BMJ Open

Diabetes Prevention Education Program in a population with pre-diabetes in Nepal: a study protocol of a cluster randomised controlled trial (DiPEP)

Pushpanjali Shakya ,[1] Archana Shrestha,[2,3] Biraj Man Karmacharya,[1,2] Abha Shrestha,[2] Bård Eirik Kulseng,[4] Eva Skovlund,[1] Abhijit Sen [1,5]

To cite: Shakya P, Shrestha A, Karmacharya BM, *et al*. Diabetes Prevention Education Program in a population with pre-diabetes in Nepal: a study protocol of a cluster randomised controlled trial (DiPEP). *BMJ Open* 2021;**11**:e047067. doi:10.1136/bmjopen-2020-047067

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-047067).

Received 17 November 2020
Accepted 20 October 2021

For numbered affiliations see end of article.

Correspondence to
Pushpanjali Shakya;
pushan.ali@gmail.com

ABSTRACT

Introduction Evidence suggests that diabetes burden can be reduced by implementing early lifestyle intervention programmes in population with pre-diabetes in high-income countries. However, little is known in developing nations like Nepal. This study aims to assess effectiveness of community-based Diabetes Prevention Education Program (DiPEP) on haemoglobin A1c (HbA1c) level, proportion of pre-diabetes reverting to normoglycaemia, diet, physical activity, weight reduction, diabetes knowledge and health literacy after 6 months of follow-up. Furthermore, we will also conduct qualitative studies to explore experiences of participants of intervention sessions and perception of healthcare workers/volunteers about DiPEP.

Methods and analyses This is a community-based two-arm, open-label, cluster randomised controlled trial. We will randomise 14 clusters into intervention arm and control arm. Estimated total sample size is 448. We will screen individuals without diabetes, aged 18–64 years, and permanent residents of study sites. HbA1c test will be only performed if both Indian Diabetes Risk Score and random blood sugar value are ≥60 and 140–250 mg/dL, respectively. At baseline, participants in intervention arm will receive DiPEP package (including intensive intervention classes, diabetes prevention brochure, exercise calendar and food record booklet), and participants in control arm will be provided only with diabetes prevention brochure. The change in outcome measures will be compared between intervention to control arm after 6 months of follow-up by linear mixed models. Also, we will conduct individual interviews among participants and healthcare workers as part of a qualitative study. We will use thematic analysis to analyse qualitative data.

Ethics and dissemination Regional Committee for Medical and Health Research Ethics, Norway; Nepal Health Research Council, Nepal and Institutional Review Committee, Kathmandu University School of Medical Sciences have approved the study. The DiPEP package can be implemented in other communities of Nepal if it is effective in preventing diabetes.

Trial registration number NCT04074148, 2019/783.

Strengths and limitations of this study

- Use of cluster randomisation allows identification of effects when randomisation at the individual level is not suitable.
- Cluster randomisation helps to prevent contamination due to sharing of information between participants in intervention and control arm.
- In-depth perception of both participants with pre-diabetes and community healthcare workers/volunteers about this intervention programme will be obtained.
- Participation of interested candidates in the screening camps might lead to selection bias.
- A limitation concerning the qualitative part is the purposive selection of participants based on availability for an online interview.

INTRODUCTION

The prevalence of diabetes is increasing globally [1] and is expected to increase from 463 million to 700 million by the year 2045.[2] Among the existing number, 79% occurs in low and middle-income countries (LMIC) while the South East Asia (SEA) had 87.6 million of them in 2019.[2] The national prevalence of diabetes in India, Sri Lanka, Bhutan, Bangladesh was 8.9%, 8.7%, 8.7% and 8.1%, respectively, whereas it was 4% in Nepal according to the International Diabetes Federation (IDF) atlas 2019.[2] However, a meta-analysis and systematic review showed that the pooled prevalence of diabetes in Nepal from 2000 to 2014 was 8.5%,[3] which is not very different from the national prevalence of diabetes in other countries of SEA.[2] Diabetes is associated with an increased risk of myocardial infarction, stroke, peripheral arterial disease, diabetic nephropathy, diabetic retinopathy[4] and all-cause mortality.[5–7] Diabetes causes 4.2 million deaths[8] and 760 billion dollars expenditure in 2019, which is 10% of global health expenditure.[9]

The population with pre-diabetes is a high risk group for developing diabetes. Around 5%–10% and 15%–30% of individuals with

pre-diabetes develop diabetes annually[10 11] and within 5 years,[12] respectively. According to the American Diabetes Association (ADA), a fasting blood glucose level of 100–125 mg/dL, oral glucose tolerance test 2-hour plasma glucose level of 140–199 mg/dL and/or glycated haemoglobin (HbA1c) levels of 5.7%–6.4% suggests pre-diabetes—an intermediate state of hyperlycaemia.[5] The prevalence of pre-diabetes is also increasing rapidly.[13] About 347 million adults between the ages of 20 and 79 (7.5% of the population) have pre-diabetes according to the IDF atlas 2019.[2] In Nepal, the prevalence of pre-diabetes was 10.3%.[3] Pre-diabetes is associated with complications like cardiovascular disease, coronary artery disease and stroke.[14 15] Therefore, early identification of individuals with pre-diabetes, thereby allowing an earlier cost-effective intervention, may potentially prevent diabetes manifestation either by reverting into normoglycaemia or stabilising blood glucose levels.[16] Evidence suggests that pre-diabetes can be reversed by the implementation of lifestyle modification programmes by increasing the level of physical activity, following a healthy diet, and reducing weight, which is efficacious, safe and cost-effective.[11 17]

Most interventions related to 'lifestyle modification programmes' have been conducted and implemented in Western nations.[11] To our knowledge, so far, no community-based intervention study to prevent diabetes has been conducted in Nepal among individuals with pre-diabetes. Therefore, in our study we developed a lifestyle modification-based educational package-Diabetes Prevention Education Program (DiPEP) in order to prevent diabetes. If the DiPEP study turns out to be successful in reducing the incidence of diabetes, it could be implemented within a community-based healthcare system throughout the country. The trial results may potentially be extrapolated to fill a knowledge gap in other LMICs. Therefore, the primary objective of the study is to evaluate the effect of a Diabetes Prevention Education Program (DiPEP) on HbA1c level, and secondary objectives are to assess the effectiveness of DiPEP on reversion to normoglycaemia, weight reduction, improvement in diet, physical activity among the Nepalese population with pre-diabetes. In addition, we will assess diabetes knowledge and health literacy. A qualitative approach will be used to explore the acceptability and usability of the DiPEP among the participants with pre-diabetes and also to explore the perception of healthcare workers/volunteers about DiPEP.

METHODS/DESIGN

Study design and setting

This is a community-based open-label two-armed cluster randomised controlled trial (RCT), where the intervention group will follow the lifestyle modification-based educational package—DiPEP and the control group will just receive an educational brochure on diabetes prevention. Two populations in urban regions of Nepal will be screened for participation; Dhulikhel municipality, located 30 km southeast from Kathmandu with a population of 32 026 and a literacy rate of 75.26%,[18] and Patan, which is the core part of Lalitpur Metropolitan City (LMC, 5 km southeast of Kathmandu with a population of 284 922 and a literacy rate of 80.35%).[19] Both study sites have similar healthcare services as found in general urban areas of Nepal. Four out of 12 administrative units, also known as wards in Dhulikhel,[18] and 10 out of 29 administrative units in Patan[19] will be operationalised as clusters for data collection. Details are presented in online supplemental tables S1 and S2.

Study population

The inclusion and exclusion criteria of the study population are presented in table 1.

Outcomes

The primary outcome is the HbA1c level (%) after 6 months of intervention, and secondary outcomes are proportion of pre-diabetes reverting to normoglycaemia; change in weight, diet, physical activity, improvement in diabetes knowledge and health literacy after 6 months of follow-up.

Sample size

It has been estimated that a total of 448 pre-diabetes individuals (224 in each arm; 32 per cluster) are needed to detect a minimum detectable difference in HbA1c of 0.12%, as shown in a previous study[20] between the intervention and control arm with 80% power, 5% significance level, assuming an intracluster correlation coefficient of 0.01,[21] SD=0.36[20] and 30% loss to follow-up. This study is powered to detect the minimum detectable

Table 1 Inclusion and exclusion criteria of the study

Inclusion criteria	Exclusion criteria
► Adult aged 18–64 years; permanent residents of Dhulikhel municipality and Patan ► Indian Diabetes Risk Score ≥60 ► Random blood sugar test ≥140 to 250 mg/dL ► Pre-diabetes: participants with HbA1c from 5.7% to 6.4%	► People with type 1 diabetes (self-reported) ► Type 2 diabetes ► Under medication ► HbA1c criteria (≥6.5 %) ► Currently pregnant ► Critically ill patients

HbA1c, haemoglobin A1c.

difference in HbA1c of 0.12%, which was considered from a local worksite study in the Nepalese population of pre-diabetes.[20] Powering the study for a small difference ensures a very high probability of detecting larger differences. We admit that 0.12% may seem small, however, the study will have high power to detect larger differences between groups with the same sample size. We consider that the change in 0.12% in 6 months might be relevant if the change can be sustained over time with the behavioural intervention. Whatever the actual benefit of the intervention, any clinical relevance will be assessed by the estimated difference and its 95% CI once the study is finalised.

In the qualitative study, 10–16 interviews with participants with pre-diabetes of the intervention group and 10–11 interviews with community healthcare workers/volunteers appointed for each cluster in the intervention arm will be conducted. The participants attending at least one of four intervention classes will be selected for the interview. Participants who do not attend any class are not eligible for the interview, which is meant to explore experiences of participants taking part in DiPEP intervention. There will be a purposive selection of participants considering variation in gender, cluster, ethnic group and attendance of the class. Consent of the participants is important to enrol the participants in the interview. The interviews will be conducted until we reach data saturation. Data saturation is defined as the point where no new information or themes are observed in the data.[22] The consort diagram with estimated numbers of participants is shown in figure 1.

Randomisation

Out of four clusters in Dhulikhel Municipality, two will be randomised to the intervention arm and other two to the control arm. Similarly, out of 10 clusters in Patan, five will be randomised to the intervention arm and five to the control arm. Hence, there will be 14 clusters (seven in the intervention arm and seven in the control arm), and for each cluster, 32 participants will be enrolled. The randomisation will be performed using STATA software (runiform).

Screening and recruitment process

Participants will be recruited by organising screening campaigns in the allocated clusters of Dhulikhel and Patan. For this, a temporary place will be set up with all required equipment in the open visible space in the community, where the interested eligible participants could come to have their blood sugar test for the screening purpose. Banners and speakers will be used to make public announcements in the Nepali language to provide awareness about conducting the screening campaigns. The recruitment process will continue until the required sample size in each cluster is attained. Participation in the screening will be voluntary. However, the

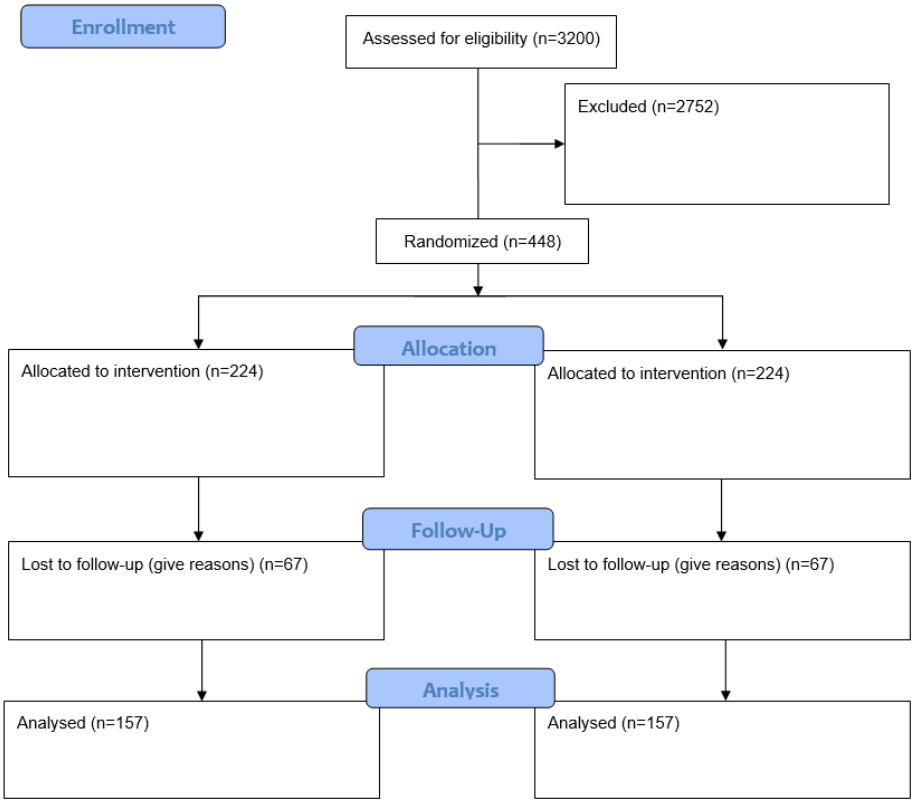

Figure 1 Consort diagram. This figure illustrates the study design (RCT). A total of 448 participants with pre-diabetes will be randomised to an intervention arm and a control arm. RCT, randomised controlled trial.

COVID-19 pandemic will complicate the recruitment process, and the final number of participants is expected to be smaller than originally planned.

The purpose of the screening will be explained to the interested participants in their local language. After obtaining verbal consent, the screening process will be initiated following Indian Diabetes Risk Score (IDRS),[23] which takes into account parameters such as age, abdominal obesity, self-reported physical activity and family history of diabetes.[23] Random blood sugar (RBS) tests will also be performed via glucometer for the screening process. If a participant meets both the criteria of IDRS ≥60 and RBS between 140 mg/dL and 250 mg/dL, then HbA1c via point-of-care test (POCT) will be performed. The use of different methods and reagents in POCT and lab tests makes some variability in the result.[24] However, we will use only one HbA1c analyser called DCA Vantage 2000 throughout the study to minimise the variability in the results. DCA vantage is certified by National Glycohemoglobin Standardization Program/Diabetes Control and Complications Trial and International Federation of Clinical Chemistry and Laboratory Medicine) with coefficient of variance consistently below 3% in internal quality evaluation.[25] If the percentage of HbA1c is 5.7%–6.4%,[26] participants will be operationalised as pre-diabetes and detailed information about the research project will be provided. Written informed consent will be obtained from all individuals with pre-diabetes and who want to participate in this study. A thumb impression will be obtained in case a participant who is illiterate.

Data collection and assessment

At inclusion as well as at the 6-month follow-up, data on sociodemographic factors such as age (years), gender (male/female/other), marital status (married/unmarried/widow), residency (rural/urban), level of education (highest education), occupation (business/housewife/agriculture/office/others), income (annual household per capita income) will be registered using a standardised questionnaire. Furthermore, data on smoking (cigarettes per day and duration of smoking), alcohol intake (drinks per week), assessment of the quality of diet using two 24-hour dietary recalls, physical activity (metabolic equivalents (METs) mins per week) assessment using a Global Physical Activity Questionnaire,[27] information on family history of diabetes and hypertension will be collected. Diabetes knowledge will be assessed by using a standardised questionnaire[28], and literacy in diabetes will be assessed by measuring functional, communicative and critical health literacy among patients with diabetes.[29] Details are shown in online supplemental table S3. Telephone calls will be used in case physical presence is not possible due to the COVID-19 pandemic.

Standardised techniques and calibrated equipment will be used for anthropometric measurements. Weight (in kg) will be taken in light indoor clothing without shoes using a digital weighing scale. Height (in cm) will be measured using a height scale using a metal scale; hip circumference will be measured using a plastic tape around the widest portion of the buttocks, with the tape parallel to the floor; and waist circumference (in cm) will be measured by placing a plastic tape horizontally, passing the umbilicus (midway between the 12th rib and the iliac crest on the midaxillary line).

Blood pressure will be measured in resting position using the 'Omron' digital blood pressure measurement instrument. Three blood pressure measurements will be taken at least 5 min apart[30] and the average for the first three measurements will be used for the study. RBS test via glucometer and POCT HbA1c[26] via DCA Vantage 2000 HbA1c analyser will be measured. All quantitative data will be collected in an electronic version in a tablet with an Android Operating System using Commcare software.

Intervention arm-DiPEP

Theoretical framework

DiPEP incorporates a behavioural framework that includes components of the health belief model,[31] social cognitive theory[32] and the transtheoretical model[33] to tailor the intervention to each participant. We will consider perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action and self-efficacy as described by the health belief model[31] and will emphasise social influence and its emphasis on external and internal social reinforcement as described by social cognitive theory.[32] We will recognise different levels of willingness of participants to change behaviour and different barriers to behaviour change, as described by the transtheoretical model.[33]

Operational framework

The intervention will be conducted following all the components of DiPEP as described in box 1 considering the cultural values of the study population. A four-session DiPEP curriculum will be derived from the Diabetes Prevention Program.[34]

The development of a four-session intervention was based on the researcher's experience in diabetes counselling where Nepali people focus more on symptoms and treatment from the doctor and less on holistic healthcare with preventive approach. Multiple classes and follow-up sessions are challenging in Nepal in terms of both interest of the participants and also the resource for intensive interventions, and the number of sessions was, therefore, restricted to four. Furthermore, the curriculum will be tailored to the Nepalese population by considering the availability and acceptability of foods and the feasibility and acceptability of exercises. Collaboration with local stakeholders; training to study nurses and community healthcare workers/volunteers; orientation to peer group leaders; conduction of group sessions in a community using Nepali language; provision of motivational materials in the Nepali language; involvement of family members and maintenance sessions by community healthcare workers/volunteers will be essential components of this DiPEP intervention. The digital intervention

Box 1 Components of Diabetes Prevention Education Program (DiPEP) intervention

DiPEP curriculum
- It includes four sessions
  1. Introduction to diabetes and pre-diabetes.
  2. Healthy eating and physical activity.
  3. Stress management.
  4. Management of social cues.
- Each session will last for 1 hour (30 min theory and 30 min practical).
- It is tailored to the Nepalese population-based on US-based National Diabetes Education Program and Diabetes Prevention Program.
- Community-based or digital-based media will be used for delivery.

Collaboration with healthcare centres
- The main aim of the collaboration with healthcare centres is to work efficiently and to sustain the programme.
- Community healthcare workers/volunteers will be appointed by healthcare centres for this programme.

Training and orientation

Training to study nurses
- The 1-day training will be provided to study nurses followed by 1 week of practice in the delivery of the contents.
- The training will cover the purpose, objectives and implications of the research, ethical issues of the intervention study and core contents of the curriculum.

Training to community healthcare workers/volunteers
- One-day workshop on the DiPEP curriculum will be provided to community healthcare workers/volunteers.
- Two community healthcare workers/volunteers will be appointed from each cluster.
- Terms of reference will be provided to each trainee at the beginning of the training.
- The main responsibilities of community healthcare workers/volunteers are to coordinate to conduct DiPEP in the community setup and to be in contact with participants via running weekly maintenance classes or biweekly phone calls.

Orientation to peer leaders
- Two peer leaders will be appointed from each intervention group.
- They will be oriented to help trained community healthcare workers/volunteers to run maintenance classes and to encourage fellow participants to change their lifestyle.

Orientation to local stakeholders
- Orientation about DiPEP will be provided to local stakeholders (ward chairman, ward officials, ward health coordinators, community leaders, community health volunteers) for their support.

Group education session
- It will be a group-based education session comprising 60 min.
- The first half will be interactive theory and the next half will be supervised exercise training.
- The goal of group session is to encourage each other to change their lifestyle to prevent diabetes.
- Empathetic listening will be implemented if participants want to share their queries and experiences.

Involvement of family members
- Interested family members of the participants with pre-diabetes will also be invited in a group education session.

Continued

Box 1 Continued
- The aim of inviting family members is to support participants with pre-diabetes to adopt changes in their lifestyle to prevent diabetes.

Brochure on diabetes prevention, exercise calendar and food logbook
- The pictorial brochure on diabetes prevention education, exercise calendar and food logbook will be provided in the Nepali language to all enrolled participants with pre-diabetes in the intervention arm.
- The pictorial brochure is a summary of the education session.
- The exercise calendar consists of a box for each date, where participants write the duration of exercise they perform each day. There is an eighth column in the calendar, which is meant to write total minutes of exercise in a week.
- A food logbook is meant to keep records of food intake on a daily basis.
- The aim of providing these materials is to track them for their lifestyle and motivate them to change accordingly to prevent diabetes.

Maintenance classes
- Trained community healthcare workers/volunteers will conduct maintenance classes weekly to their respective groups with help of the peer group leaders.
- They have the following responsibilities:
  - Arranging premises for the class.
  - Calling and motivating participants to attend the sessions.
  - Conducting a 45 min group session.
  - Encouraging participants in discussion related to the benefits and challenges of lifestyle modification.
  - Keeping records on attendance, track of weight, diet and physical activity.
  - A biweekly phone call to participants if there are no physical sessions.
  - Monthly meeting with study nurses and participants.

will be performed if physical presence is not possible due to the COVID-19 pandemic.

Control arm

After randomisation, participants allocated to the control group will receive pictorial brochures in Nepali illustrating instructions for physical activity and a healthy diet to prevent diabetes. Thereafter, follow-up on the same participants will take place after 6 months. Later, all sessions demonstrated to the intervention group will also be conducted for the control group once the study is completed.

Qualitative study

To explore the acceptability and usability of DiPEP intervention, participants from the intervention arm will be invited for interviews after 3 months of DiPEP intervention. Participants belonging to different age groups, with varied educational backgrounds, will be invited for an interview to obtain diverse data. Similarly, all trained community healthcare workers/volunteers will also be invited for interviews. Both interview themes are presented in table 2. There will be one interviewer and one-note-taker for each interview. Each interview session is expected to last approximately 60–90 min, and

Table 2 Themes of a qualitative interview with participants with pre-diabetes and community healthcare workers/volunteers

Themes of qualitative interview with participants with pre-diabetes	Themes of the qualitative interview with community healthcare workers/volunteers
A. Understanding of diabetes and pre-diabetes	A. Perception of DiPEP
B. Level of acceptance for being pre-diabetes	B. Adoption of DiPEP for its sustainability
C. Health information sources, access to them, and interest to know more	C. Recommendation and suggestions
D. DiPEP and its effectiveness	
E. Motivation of participants	
F. Acceptability and sustainability	
G. Effects of COVID-19	

DiPEP, Diabetes Prevention Education Program.

only verbal informed consent will be taken from the potential participants before conducting the interview if the interview will be taken on a digital platform due to the COVID-19 pandemic. The interview will be audio-recorded and significant points will be noted. Recorded interviews will be transcribed (verbatim) and translated into English.

Statistical analysis

Data will be described by mean and SD for normally distributed variables, and median and IQRs for variables with skewed distribution. Frequencies and percentages will be applied for the description of categorical variables. The primary analyses will be performed based on the intention-to-treat principle. Linear mixed models will be used to compare the change in HbA1c in percentage, diet in Kcal, physical activity in terms of change in METs min/week, weight reduction in kilogram, over time between intervention to control groups. Similarly, change in diabetes knowledge and health literacy score will be analysed by linear mixed models.

The effect of DiPEP on proportion reverting to normoglycaemia, quality of diet (poor=0, good=1); physical activity status (inactive=0, active=1, based on a cut-off value of METs minutes/week recommended by WHO); weight loss status (weight loss by less than 5% from baseline=0, weight loss by more than or equal to 5% from baseline=1); on diabetes knowledge and health literacy (not adequate=0, adequate=1), respectively, will be analysed by generalised linear regression with logit and exchangeable correlation coefficient and presented as ORs and 95% CI. Per-protocol analysis will be performed as sensitivity analysis including participants of intervention clusters who have attended all four intervention sessions. In all analyses, standard errors will be estimated by a clustered sandwich estimator. All statistical analyses will be performed using STATA V.16 (IBM, USA).

Thematic analysis

English transcripts of the interviews will be read several times to become familiar with the discussions and obtain manifesting meanings. There will be at least two team members who will review the data. We will consider an 80% consensus process for identification of themes based on intercode reliability and intercode agreement. The meaning units and codes will be condensed to create subcategories and categories depending on their cohering findings. Categories capture the fullness of the experiences and actions studied.[35] Mindjet MindManager (software application for mind mapping) will be used to facilitate organising the meaning units into codes and merge into subcategories and categories.

Ethics and dissemination

This study involves human participants and wasapproved by an Ethics Committee(s) or Institutional Board(s). The study is approved by the Regional Committee for Medical and Health Research Ethics, Norway (registration number 2019/783); Nepal Health Research Council (registration number 324/2019), Nepal and Institutional Review Committee, Kathmandu University School of Medical Sciences (registration number 196/19). Also, written permission from Dhulikhel Municipality and LMC have been obtained to conduct the study. A key output of this project will be to facilitate the implementation of this DiPEP package in other communities of Nepal if this intervention programme is effective in preventing diabetes.

Patient and public involvement

General public were involved during the development stage of the diabetes prevention brochure and were asked to give us the feedback in order to improvise and finalise it. The public was not directly involved in developing research questions, study design, intervention designs and outcome measures. The results of this study will be disseminated to the associated organisations, local committees, etc.

DISCUSSION

Diabetes is a serious global health concern and imposes an economic burden on the healthcare system particularly in resource-limited countries like Nepal. Evidence suggests that individuals originating from Asian countries develop type 2 diabetes at a higher rate than Caucasians counterparts.[36] The prevalence of individuals with pre-diabetes is also increasing worldwide, and those with pre-diabetes are at an increased risk of developing diabetes and its associated complications. Therefore,

the selection of an appropriate target population and cost-effective diabetes prevention lifestyle intervention strategies are much needed.

This community-based cluster RCT (DiPEP) is remarkable in terms of its novelty and potential impact on the country's policy. Moreover, as this trial is conducted in a resource-constrained country like Nepal, the results of this study might influence activities in other LMIC. Nepal has a federal government, and each municipality has its independence to plan and conduct programmes required for its population. Hence, these kinds of community-based prevention programmes would be resourceful in preventing diabetes.

The main strength of this study is that it is a randomised trial making it possible to evaluate the effectiveness of the lifestyle intervention programme DiPEP to prevent diabetes. The use of cluster randomisation allows identification of effects when randomisation at the individual level is not suitable. Second, as all cluster participants will be offered the same intervention, this may ease the recruitment process, simplify administrative tasks and enhance compliance due to interaction among cluster participants in the intervention arm.[37 38] Moreover, it provides an environment to motivate each other following social cognitive behaviour theory. Third, cluster randomisation may help to prevent contamination due to sharing of information between intervention and control participants.[39] Furthermore, we will obtain an in-depth perception of both participants of pre-diabetes and community healthcare workers/volunteers about this intervention programme from qualitative part of this study.

There are some limitations in this study. First, in general, a cluster RCT design may require a larger sample size than a trial with randomisation at the individual level because of intracluster correlation.[40 41] We assumed a very small intra-cluster correlation for sample size calculation for this study. Second, there might be a possibility of potential spillover among participants in intervention and control groups due to short geographical distances between clusters and potential contact with participants in other clusters. However, to reduce this risk, we will provide intensive education sessions with follow-up to the specific group participants of the intervention arm. Third, participation of only interested candidates in the screening camps might also lead to selection bias. Fourth, the variability in HbA1c result with POCT and lab test should be considered if the test results from POCT method in this study are to be compared with results from lab test because of the use of different methods and agents in these two methods and also because of discrepancies between capillary, venous and arterial blood sample.[42] Finally, there are some limitations in regards to the qualitative parts such as purposive selection of participants based on availability for online interview and degradation of the meaning of the statements due to translation from Nepali language to English language.

Author affiliations
[1]Department of Public Health and Nursing, Faculty of Medicine and Health Sciences, Trondheim, Trøndelag, Norway
[2]Department of Public Health, Kathmandu University School of Medical Sciences, Dhulikhel, Province 3, Nepal
[3]Institute of Implementation Science and Health, Kathmandu, Province 3, Nepal
[4]Department of Clinical and Molecular Medicine, Norwegian University of Science and Technology, Trondheim, Norway
[5]Center for Oral health Services and Research (TkMidt), Trondheim, Norway

Acknowledgements Authors would like to thank physiotherapist (Nistha Shrestha), research officer (Seema Das), research assistants (Smriti Shrestha, Suruchi Lama, Krishnaa Barun Shrestha, Supriya Kharel), intern (Ishwori Byanju Shrestha) who contributed to the development this project. Authors would like to remember the contribution of the Late Dr. Kedar Manandhar, who guided in the initial phase of project design.

Contributors PS, ArS, AbSh, AbSe, BMK, BEK conceived the study, designed the final study protocol and provided the domain knowledge expertise. PS and ArS sampled the study participants. ArS and ES contributed to the technical design and provided biostatistical and epidemiological support. PS and AbSe drafted the manuscript. All authors critically revised the manuscript for important intellectual content and approved the final version.

Funding The grant was obtained by BEK. This work was supported by the Department of Public Health and Nursing, Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology (NTNU), Trondheim, Norway (project number: 81850087)

Competing interests None declared.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

ORCID iDs
Pushpanjali Shakya http://orcid.org/0000-0002-1073-4812
Abhijit Sen http://orcid.org/0000-0001-9560-4226

REFERENCES

1 Diabetes [online]. Available: https://www.who.int/news-room/fact-sheets/detail/diabetes [Accessed 6 Aug 2020].
2 Facts & figures [online]. Available: https://www.idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html [Accessed 6 Apr 2021].
3 Gyawali B, Sharma R, Neupane D, *et al*. Prevalence of type 2 diabetes in Nepal: a systematic review and meta-analysis from 2000 to 2014. *Glob Health Action* 2015;8. doi:10.3402/gha.v8.29088. [Epub ahead of print: Available from].
4 Zhang X, Saaddine JB, Chou C-F, *et al*. Prevalence of diabetic retinopathy in the United States, 2005-2008. *JAMA* 2010;304:649. doi:10.1001/jama.2010.1111
5 ADA. Standards of medical care in diabetes-2020. *J Clin Appl Res Educat Diabet Care* 2020;43 https://care.diabetesjournals.org/content/diacare/suppl/2019/12/20/43.Supplement_1.DC1/Standards_of_Care_2020.pdf
6 Huang D, Refaat M, Mohammedi K, *et al*. Macrovascular complications in patients with diabetes and prediabetes. *Biomed Res Int* 2017;2017:7839101

7 Zhang X, Saaddine JB, Chou C-F, *et al*. Prevalence of diabetic retinopathy in the United States, 2005-2008. *JAMA* 2010;304:649–56.
8 International diabetes federation - facts & figures [online]. Available: https://www.idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html [Accessed 12 Mar 2020].
9 International diabetes federation - facts & figures [online]. Available: https://idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html [Accessed 12 Mar 2020].
10 Tabák AG, Herder C, Rathmann W, *et al*. Prediabetes: a high-risk state for diabetes development. *Lancet* 2012;379:2279–90.
11 Glechner A, Keuchel L, Affengruber L, *et al*. Effects of lifestyle changes on adults with prediabetes: a systematic review and meta-analysis. *Prim Care Diabetes* 2018;12:393–408.
12 Department of Health, New York State. Prediabetes [online]. Available: https://www.health.ny.gov/diseases/conditions/diabetes/prediabetes/ [Accessed 29 Apr 2019].
13 Hostalek U. Global epidemiology of prediabetes - present and future perspectives. *Clin Diabetes Endocrinol* 2019;5
14 Huang D, Refaat M, Mohammedi K. Macrovascular complications in patients with diabetes and prediabetes. *Biomed Res Int* 2017;2017:1–9.
15 Kopf S, Groener JB, Kender Z, *et al*. Deep phenotyping neuropathy: an underestimated complication in patients with pre-diabetes and type 2 diabetes associated with albuminuria. *Diabetes Res Clin Pract* 2018;146:201 doi:10.1016/j.diabres.2018.10.020
16 Perreault L, Pan Q, Mather KJ, *et al*. Effect of regression from prediabetes to normal glucose regulation on long-term reduction in diabetes risk: results from the diabetes prevention program outcomes study. *Lancet* 2012;379:2243–51. doi:10.1016/S0140-6736(12)60525-X
17 Ramachandran A, Snehalatha C, Mary S, *et al*. The Indian diabetes prevention programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia* 2006;49:289–97.
18 A glimpse of dhulikhel municipality [online]. Available: http://dhulikhelmun.gov.np/sites/dhulikhelmun.gov.np/files/Profile_Dhulikhel%20municipality.pdf [Accessed 23 Apr 2019].
19 Statistical Information | Lalitpur Metropolitan City [online]. Available: http://lalitpurmun.gov.np/en/node/126 [Accessed 24 Mar 2020].
20 Shrestha A, Tamrakar D, Karmacharya BM, *et al*. Nepal pioneer worksite intervention study to lower cardio-metabolic risk factors: design and protocol. *BMC Cardiovasc Disord* 2019;19:48.
21 Lorenz E, Köpke S, Pfaff H. Cluster-randomized studies: part 25 of a series on evaluating scientific publications. *Deutsches Ärzteblatt International* 2018;115:163.
22 Guest G, Bunce A, Johnson L. How many interviews are enough? *Field Methods* 2006;18:59–82.
23 Mohan V, Deepa R, Deepa M, *et al*. A simplified Indian diabetes risk score for screening for undiagnosed diabetic subjects. *J Assoc Physicians India* 2005;53:53–63.
24 Heinemann L, Freckmann G, Lutz Heinemann GF. Quality of HbA1c measurement in the practice: the German perspective. *J Diabetes Sci Technol* 2015;9:687.
25 Leca V, Ibrahim Z, Lombard-Pontou E, *et al*. Point-of-care measurements of HbA(1c): simplicity does not mean laxity with controls. *Diabetes Care* 2012;35:e85. doi:10.2337/dc12-0751
26 American Diabetes Association. Classification and diagnosis of diabetes: standards of medical care in Diabetes—2019. *Diabetes Care* 2019;42.
27 WHO. Global physical activity questionnaire (GPAQ) analysis guide [online]. Available: https://www.who.int/ncds/surveillance/steps/resources/GPAQ_Analysis_Guide.pdf
28 Eigenmann CA, Skinner T, Colagiuri R. Development and validation of a diabetes knowledge questionnaire. *Practical Diabetes International* 2011;28:166–70. doi:10.1002/pdi.1586
29 Ishikawa H, Takeuchi T, Yano E. Measuring functional, communicative, and critical health literacy among diabetic patients. *Diabetes Care* 2008;31:874–9. doi:10.2337/dc07-1932
30 Pickering TG, Hall JE, Appel LJ, *et al*. Recommendations for blood pressure measurement in humans: an AHA scientific statement from the Council on high blood pressure research professional and public education Subcommittee. *J Clin Hypertens* 2005;7:102–9. doi:10.1111/j.1524-6175.2005.04377.x
31 The health belief model [online]. Available: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories2.html [Accessed 12 Aug 2019].
32 The social cognitive theory [online]. Available: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories5.html [Accessed 12 Aug 2019].
33 Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. *Am J Health Promot*. doi:10.4278/0890-1171-12.1.38
34 Diabetes Prevention Program (DPP) Research Group. The diabetes prevention program (DPP): description of lifestyle intervention. *Diabetes Care* 2002;25:2165–71. doi:10.2337/diacare.25.12.2165
35 Brinkmaan S, Kvale S, eds. *Preparing for interview analysis. In: InterViews*. California: SAGE publications, Inc, 2015.
36 Modesti PA, Galanti G, Cala' P, *et al*. Lifestyle interventions in preventing new type 2 diabetes in Asian populations. *Intern Emerg Med* 2016;11:375–84.
37 Andersen PK. Design and analysis of cluster randomization trials in health research. *Stat Med* 2002;21. doi:10.1002/sim.957
38 Eldridge S, Kerry S, Torgerson DJ. Bias in identifying and recruiting participants in cluster randomised trials: what can be done? *BMJ* 2009;339:b4006. doi:10.1136/bmj.b4006
39 Torgerson DJ. Contamination in trials: is cluster randomisation the answer? *BMJ* 2001;322:355–7. doi:10.1136/bmj.322.7282.355
40 van Breukelen GJP, Candel MJJM. Calculating sample sizes for cluster randomized trials: we can keep it simple and efficient! *J Clin Epidemiol* 2012;65:1212–8. doi:10.1016/j.jclinepi.2012.06.002
41 Campbell MK, Grimshaw JM. Cluster randomised trials: time for improvement. The implications of adopting a cluster design are still largely being ignored. *BMJ* 1998;317:1171–2.
42 Standards of medical care in diabetesd 2019. Available: https://care.diabetesjournals.org/content/diacare/suppl/2018/12/17/42.Supplement_1.DC1/DC_42_S1_2019_UPDATED.pdf [Accessed 21 Apr 2020].

Supplementary files

Table S1: Characteristics of wards of Dhulikhel Municipality

Index: Blue colour: Intervention cluster, Grey colour: Control cluster

S.N	Health care centers	Ward No	Location of ward offices	Total Population	Intervention/ Control
1	Urban Health Center	03	Dhulikhel	2220	Intervention
2	Urban Health Center	05	Shreekhandapur	3937	Control
3	Dhulikhel Hospital	06	Bhagawatisthan	1923	Control
4	PHC and Urban Health Center	08	Bhattedanda	3102	Intervention

Table S2: Characteristics of wards of Patan, Lalitpur Metropolitan City

Index: Blue colour: Intervention cluster, Grey colour: Control cluster

S.N	Ward	Location of ward offices	Population (2068 B.S data)	Intervention/ Control
1	03	Pulchowk	14,082	Intervention
2	06	Kanibahal	6,780	Control
3	07	Tyagal	6,849	Intervention
4	08	Guitol	11,400	Control
5	09	Bholdhoka	13,908	Intervention
6	11	Alukohiti	10,109	Control
7	12	Lagankhel	14,867	Intervention
8	16	Dhaugalbazaar	10,349	Control
9	19	Agnishal	7,385	Control
10	20	Na:bahal	12,380	Intervention

Table S3: Details of the variables

Variables (Unit of measurement)	Methods and tool	Baseline	Endline
Socio-demographic characteristics ● Age (years) ● Gender (Male / Female/ Others) ● Education (Completed grades (in years) ● Ethnicity (Brahmin / Newars / Others) ● Residency (Rural / Urban) ● Occupation (Housewife / Business / Agriculture / Office (Professional) / Unemployed) ● Annual Household per capita Income (Nepali Rupees per year)	Interview method and Tool questionnaire	Yes	No
Clinical History ● History of prediabetes (Yes/ No) ● Duration of prediabetes (Years / Months) ● Intake of prediabetes medicines (Yes / No) ● Duration of prediabetes medication intake (Years / Months) ● Types of prediabetes medication (Oral Hypoglycemic Agents/ Insulin / Both) ● Immediate family members with diabetes (Yes / No) ● History of Hypertension: Yes / No) ● History of current antihypertensive medication (Self report: Yes / No) ● Diabetes counseling (defined diabetes counseling)	Interview method and Tool questionnaire	Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes	Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes
Behavioral Factors ● Smoking History (Yes/ No) ● Type of smoker (Non-smoker/ Current smoker/ Former smoker) ● Number of cigarettes per day ● History alcohol intake (Drinks per week) ● Exercise (Global Physical activity questionnaire) (METs Minutes per week) ● 24 hour diet recall (Total calorie intake per day) ● Self reported regular sleep – (Yes / No) ● Self reported sleep duration (Yes / No)	Interview method and Tool questionnaire	Yes Yes Yes Yes Yes Yes Yes Yes	Yes Yes Yes Yes Yes Yes Yes Yes
Anthropometric measurements ● Weight [Kilogram (kg)] ● Height [Centimeter (cm)] ● Hip circumference [Centimeter (cm)] ● Waist circumference [Centimeter (cm)] ● Blood Pressure (mmHg)	Measurements	Yes Yes Yes Yes Yes	Yes No Yes Yes Yes
Blood test - ● RBS (mg/dl) ● HbA1c test (%)	Tests	Yes Yes	No Yes

Diabetes Knowledge Questionnaire (DKQ)	Interview method and Tool questionnaire	Yes	Yes
Diabetes Literacy Assessment (Measuring functional, communicative, and critical health literacy among diabetes patients)	Interview method and Tool questionnaire	Yes	Yes