

Research Article

Health interventions and its impact on outcomes among diabetic patients: A systematic review

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ABSTRACT

Studies related to the prevention of diabetes mellitus have developed rapidly, from effectiveness research to implementation research. However, effective implementation of diabetes programs and evidence of their impact on the population should be produced by means other than measuring the effectiveness of the program. We reviewed the results of systematic reviews focused on diabetes prevention programs and the outcomes of those programs in a real-world setting. A systematic review of the program aimed at assessing or measuring the outcome of preventive programs in individual prediabetes, moderate or high-risk diabetes. In September 2021, an article search was performed on PubMed, Science Direct, and SAGE Journal databases. We have reviewed all the articles published in the last ten years. The exclusion criteria were studies published before 2011. The number of diabetic participants is unknown and the method is incomplete. Eight studies were included in the review. All information about participation and programs. Most of all studies were cohort and RCT studies. All interventions showed positive changes (efficacy) based on weight loss, HbA1C, blood glucose levels, and BMI. Rapid studies have shown that the risk of diabetes is reduced. Our results show that the strength of the program plays an important role in the outcome of weight loss. Programs with different variations (education, Community Health worker, diet, physical activity) have had a positive effect on reducing the risk of diabetes in the population.

Keywords:

Intervention, Diabetes mellitus, Outcomes, Prevention program

1. INTRODUCTION

The prevalence of DM increased from 108 million (4.7%) in 1980 to 425 million (8.5%) in 2017, and is predicted to be 629 million in 2045¹. All types of diabetes especially type 2 diabetes are a common chronic disease, which is a major public health problem and affects almost every country in the world. An estimated 9.3% of the US population has diabetes. Diabetes is a major risk factor for cardiovascular disease and stroke and is a major cause of chronic renal failure, non-traumatic lower extremities, and blindness¹⁻⁴. In some cases, T2D can be achieved by changes in lifestyle, diet, and physical activity, all of which result in weight loss. Lifestyle interventions in the Diabetes Prevention Program (DPP) have shown a

reduction in T2D incidence in obese adults of various races/ethnicities at high risk of developing T2D and long-term intervention showed good impact⁵⁻⁷. In 6-month weight loss in 57% of areas achieved with DPP lifestyle intervention^{2,5,8}.

The systematic review by Whittemore R.A (2011), assessing diabetes prevention programs focuses on the reach, acceptance, implementation, and behavior of the community towards the program. That review focuses on these implementation settings, such as a) community, b) primary health care, and c) work⁹. The same review by Laws R.A (2012) showed efficacy intervention by external validity and behaviors related to preventive programs. The results can generalized from external validity¹⁰. In this systematic review, the authors evaluate

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in terms of program description, outcomes, adoption, and implementation. This review had more space for an explanation about interventions and outcomes the goal of this systematization was to 1) explain a particular diabetes program, 2) explain the choice of intervention, and 3) explain the overall effect of all interventions.

2. METHODS

2.1. Study selection

We reviewed all articles published in the last 10 years (ie 2011-2021) reporting on evaluations or measuring outcomes of preventive programs aimed at individuals at pre-diabetes, moderate or high diabetes risk. The reason for choosing this coverage is to see how the diabetes prevention measures are up to date and in the last 10 years. This review is based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)¹¹.

2.2. Data sources and searches

An article search was performed on the PubMed, Science Direct, SAGE Journal database in September 2021. The search terms were ‘diabetes mellitus’ and

‘prevention’ or health promotion or ‘program’ or ‘intervention’ and ‘implementation’. The search was repeated using Science Direct and SAGE Journal. We were used references manager Zotero for seen articles duplication.

2.3. Search strategy and extraction

The process in selected articles was by reading the abstract and then reading the full version of the article to determine the eligibility of the article. We inclusion articles based on english language publications; original articles, full text and the articles were included a diabetes prevention program focused aim to individual pre-diabetes, moderate or high risk of diabetes; program outcomes (such as impaired glucose tolerance (IGT), elevated hemoglobin A1c (HbA1c), high body mass index (BMI) or being overweight/weight loss. Exclusion criteria were studies published before 2011; the number of participants with diabetes is unclear and methods are incomplete. Studies were also excluded if they were exclusively not concerned with efforts in the prevention of patients with diabetes. The team research also discussed the process of searching articles and extracting article data. In this review, we also used a checklist critical appraisal for the observed validity of published research.

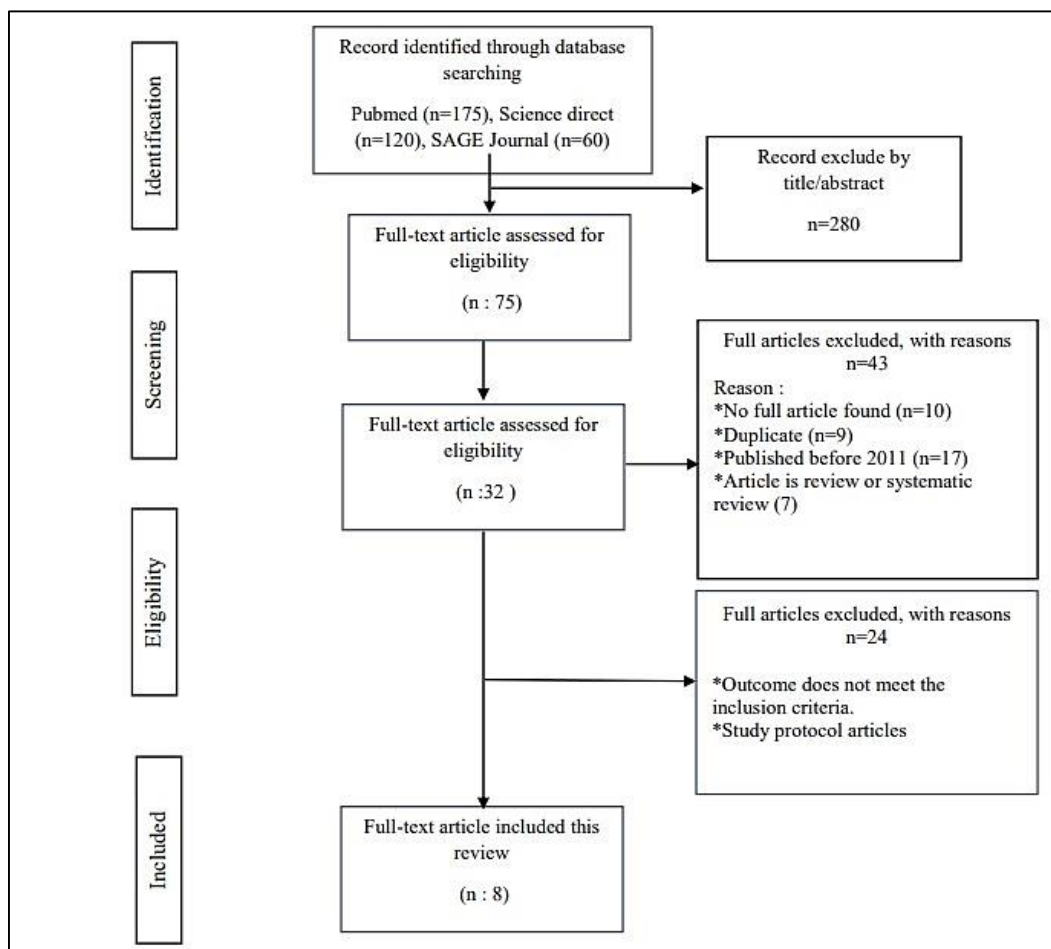


Figure 1. Prisma Flow Diagram.

3. RESULTS

3.1. Study selection

Total articles were found in the database, (Figure 1). n=175 journals from PubMed, n=120 journals from Science Direct, and n=60 from SAGE Journal. Extraction articles were by reading the title of the article, abstract and result. From the screening process, articles will be decided according to the purpose of a systematic review. At the screening stage, 75 articles were obtained and entered the eligibility stage. At this stage 75 articles were read in full text to assess their suitability with the inclusion and exclusion criteria. Of the 75 articles, several articles were excluded for the following reasons, no full article found (n=10), Duplicate (n=9), Published prior to 2010 (n=17), Article is a review or systematic review (n=17), and (n=24) excluded because the outcome does not meet the inclusion criteria and study protocol. The number of articles synthesized was 8 articles.

3.2. Study characteristics

The characteristics of the included studies were described in Table 1. Of the eight studies included, they were conducted in, USA, Japan, and India. The number of respondents included in the studies ranged from 17 to 8,556 patients. Different study designs were used, namely cohort study design (n=5)¹²⁻¹⁶ and RCT study design

(n=3)¹⁷⁻¹⁹. The duration of these studies ranged from 6 month-10 years.

3.3. Preventive program in dealing with diabetes mellitus

3.3.1. Education and counseling

Six articles provide education and counseling for diabetic patients, such as in the article^{12,13,15-16,19}. Education is provided by experts and in this review articles do so with the help of health professionals^{12,15,17,19}. Education-based programs are carried out in various ways, starting from providing material, group discussions, or face to face with patients.

3.3.2. Monitoring and lifestyle modification

Six articles do intervention in a lifestyle modification. These lifestyle modifications include physical activity and diet. In the articles intervention there are differences from each other, this is also related to the results to be achieved^{12,14-18}. The article provides an intervention in which participants are asked to complete household tasks including self-monitoring of eating and physical activity. The physical activities provided will be in the form of safety training, stretching, basic strength training, and increasing activity levels with each predetermined schedule and usually within one week.

Table 1. Characteristics of the included articles.

Author	Country	Setting	Participants	Duration	Study population	Study design	Intervention
Kramer et al. (2014)	US	Community setting	81	12 months	Overweight/obese adults with prediabetes	Cohort	Physical activity and dietary
Weber et al. (2020)	US	Community setting (South Asians)	17	6 month	South Asians indicative of overweight/obesity in Asians and pre-diabetes	Cohort	Focus group discussion and modification lifestyle
Matsushita et al. (2020)	Japan	From a database of 23 medical insurers	792	2 years	Diabetes or were at a high risk of diabetes	Cohort	(SLS program) The components of the intervention were lecture, nutritional intervention, exercise and follow up
Prezio et al. (2013)	US	Community clinic	156	12 month	Adult diagnosed with (T2DM)	RCT	Education by Community Healthworker (CHW)
Katula et al. (2013)		Community setting	261	2 years	Prediabetes	RCT	Lifestyle weight-loss program (LWL) and CHW education
Balagopal et al. (2012)	India	Rural Community	1638	6 month	Prediabetes and diabetes	Cohort	Education and lifestyle modification by Community Health worker
Marrero et al. (2016)	India	Community setting	225	12 month	Prediabetes persons of Asian descent BMI \geq 23	RCT	Self-monitoring of weight, intake, and activity; dietary modification; physical activity.
Jiang et al. (2018)	India	American Indian and Alaska Native (AI/AN) communities	8,556	From 2006-2016	Prediabetes	Cohort	Special Diabetes Program for Indians Diabetes Prevention Program lifestyle intervention

*SLS (Smart Life Stay), CHW (Community Healthworkers), LWL (Lifestyle weight-loss), AI/AN (American Indian and Alaska Native)

Table 2. Components of diabetes preventive program.

Author	Physical activities	Dietary	Education and Conseling	Community Healthworker (CHW)
Kramer et al. (2014)	Increase physical activity with a weekly schedule Enrolled participants are trained by trained diabetes educators. Participants are asked to complete homework assignments including self-monitoring of physical activity.	Home assignment monitoring of eating.	None	None
Prezio et al. (2013)	None	None	Community Diabetes Education (CoDE). -Three educational modules delivered-Includes self-monitoring of blood glucose, 24-hour memory of diet history and daily lifestyle.	CHW delivered CoDE: full-time physicians, bilingual medical assistants and clerical staff.
Weber et al. (2020)	Follow up month 4 and 6 with completed an exercise treadmill. Identify contraindications to unsupervised exercise	Follow up dietary with blood glucose at 24 hours	Focus group discussion class with trained health educator on weekdays or weeknight	None
Matsushita et al. (2020)	Combination of aerobic exercise based on the Exercise and Physical Activity Guide.	Interventions such as food intake made from local ingredients. The chef gives a lecture on how to cook healthy food.	One-to-one meeting for conseling, education and monitoring. Follow up by telephone and email for motivation participants.	Team of doctors, general nurses, fitness coaches and dietitians provide education to participants
Katula et al. (2013)	Participants meet weekly. Increase in moderate-intensity aerobic physical activity to result in weight loss of approximately 0.3 kg per week.	Reductions in daily caloric intake.	None	CHW facilitated for consultations and delivered HELP PD
Balagopal et al. (2012)	Receive personal advice doing regular physical activity and suggested walk or bicycled.	Diet education focuses on fiber and protein intake from cheap local food ingredients.	Educational materials including leaflets obtained by the National Diabetes Education Program.	Using CHW as a community: (1) Skill-based knowledge with training. (2) Training related to knowledge about diabetes and its risk factors/complications; and (3) Training on ethics and confidentiality dealing with human subjects and survey administration
Marrero et al. (2016)	They were also given access to the Weight Watchers e-tools, which includes digital tools to track weight, intake, and activity as well as tips to facilitate adherence.	Strategies for tracking food intake and calculating fat grams by using the food tracker and calorie fat gram guide provided in the materials	None	None
Jiang et al. (2018)	None	None	Diabetes Prevention Program (DPP) lifestyle community diabetes-prevention activities, guided by the DPP Lifestyle Balance after-core manual and focused on different behavioral/ motivational topics.	None

*DPP (Diabetes Prevention Program), CoDE (Coworkers Delivered Education), HELP PD (Healthy Living Partnership to Prevent Diabetes), CHW (Community Healthworkers)

Table 3. Outcomes of diabetes preventive program.

Author	Intervention/ Name Intervention	Weight (kg)	HbA1C	BMI(kg/m ²)	Blood Glucose (mg/dL)
Kramer et al. (2014)	Physical activity and dietary	Mean weight loss for this group of program completers was 5.5 kg (5.5%, $p<0.001^*$)	None	Mean Change BMI Body Mass Index (2.0 kg/m ² , 5.4%, $p<0.001$)	None
Prezio et al. (2013)	Education and Conseling and Community Healthworker (CHW)	None	The intervention group achieved a greater reduction in HbA1c (1.6%, $p<0.001^*$) than the control group (.9%, $p<0.001$)	The CoDE group achieved a greater increase in BMI (0.4%), than the control group (0.6%)	None
Weber et al. (2020)	Physical activity, dietary, education and conseling	Baseline mean all participant is 78.1, after intervention is 73.9	Baseline mean all participant is 5.8, after intervention is 5.7.	Baseline mean all participant is 28.9 after intervention is 26.2	None
Matsushita et al. (2020)	Physical activity, dietary, education consoling and Community Healthworker (CHW)	Baseline mean before intervention 71.37, after intervention 69.62 ($p=0.001^*$). Meanwhile, baseline control group is 73.02 and after 2 years is 73.07	Baseline HbA1C intervention group is 6.09, after 2 years intervention is 6.05 ($p=0.112$). And the baseline control group is 6.09 and after 2 years is 6.21 ($p=0.001^*$)	BMI Intervention group before intervention is 25.83, after 2 years intervention is 25.23 ($p=0.001^*$). And control group is 25.61, and after 2 years is 25.66.	None
Katula et al. (2013)	Physical activity, dietary, and community Healthworker (CHW)	Baseline LWL group is 94.38, after 2 years intervention is 88.61. Control group (usual care), baseline is 93.01, and after 2 years is 92.80. P value LWL group and control is 0.001*.	None	BMI LWL group before intervention is 32.85, after 2 years is 32.42. And control group baseline is 32.56, after 2 years is 32.42. P value LWL group and control group is <0.001*	Before intervention LWL group glucose is 105.37. And after intervention, glucose LWL group is 103.09. Meanwhile before after control group is 105.71 and 107.44. P value LWL group and control group is <0.001*
Balagopal et al. (2012)	Physical activity, dietary, education conseling and Community Healthworker (CHW)	None	None	BMI mean before intervention is 24.409. And after intervention is 23.88 ($p=0.001^*$)	None
Marrero et al. (2016)	Physical activity and dietary	After intervention, mean of weight loss is -5.51 from baseline $p=0.001^*$	None	After intervention, mean of BMI is reduce -2.06 from baseline $p=0.001^*$	After intervention, mean of glucose is reduce -2.27 from baseline $p=0.001^*$
Jiang et al. (2018)	Education conseling and	Baseline of weight is 221.4 lb. After 10 th intervention 217.4	None	Baseline of BMI is 36.2. After 10 th intervention is 35.6	None

*CHW (Community Healthworker), LWL (Lifestyle weight-loss)

Participants are encouraged to have a balanced diet. In addition, the chef provides education on how to make healthy food from local ingredients^{15,17}. This healthy diet focuses on fiber and protein intake and uses products or ingredients from local and inexpensive sources¹².

3.3.3. Community health worker intervention

Four articles suggest Community Health worker Intervention (CHW) helps implemented interventions for education and counseling. Community Health worker (CHW) delivered knowledge, about diabetes and its risks factors/complications; and monitored the study

population. The four studies that showed CHW in their intervention such a study by^{12,15,17,19}. Before being given education to the study population, CHW trained first about their knowledge or specific term of intervention^{12,19}.

3.4. Outcome

3.4.1. HbA1C

There is three articles showed result of HbA1C. The CoDE group achieved a greater reduction in HbA1c (1.6%, $p<0.001^*$) than the control group (.9%, $p<0.001$),

this result of education, counseling and CHW¹⁹. And another article, with education and monitoring lifestyle method showed baseline mean all participant is 5.8, after intervention is 5.7¹⁶. And intervention in Japan baseline mean before intervention 71.37, after intervention 69.62 ($p=0.001^*$) and baseline control group is 73.02 and after 2 years is 73.07, with education, monitoring life style and CHW intervention¹⁵.

3.4.2. BMI

All of articles showed result of BMI score. Two articles just with monitoring and lifestyle intervention showed mean change BMI Body Mass Index (2.0 kg/m², 5.4%, $p<0.001$)¹⁴. And second articles, after intervention showed mean of BMI was reduce -2.06 from baseline $p=0.001^*$ ¹⁸. One articles with just education and counseling intervention showed baseline of BMI was 36.2 and after 10th of intervention was 35.6¹³. The CoDE group achieved a greater increase in BMI (0.4%, than the control group (0.6%), CoDE method is include education and CHW intervention¹⁹. One article with education and monitoring lifestyle showed baseline mean all participant was 28.9 after intervention was 26.2¹⁶.

One article showed education and monitoring lifestyle had outcome for BMI intervention group before intervention was 32.85, and after 2 years was 32.42. And control group baseline was 32.56, after 2 years was 32.42, p value intervention group and control group was $<0.001^*$ ¹⁷. Two articles with education, monitoring lifestyle and CHW intervention showed BMI mean before intervention is 24.409. And after intervention is 23.88 ($p=0.001^*$)¹². BMI Intervention group before intervention is 25.83, after 2 years intervention is 25.23 ($p=0.001^*$). And control group in second article showed BMI score was 25.61, and after 2 years is 25.66¹⁵.

3.4.3. Weight Loss

There is seven article which measure weight loss. First articles with monitoring and lifestyle intervention¹⁴, showed mean weight loss for this group of program completers was 5.5 kg (5.5%, $p<0.001^*$). And one article with education and monitoring lifestyle intervention showed baseline mean all participant was 78.1, after intervention was 73.9¹⁶. And intervention in Japan with education, monitoring lifestyle and CHW intervention showed baseline mean before intervention 71.37, after intervention 69.62 ($p=0.001^*$). Meanwhile, baseline control group is 73.02 and after 2 years is 73.07¹⁵.

One article showed monitoring and CHW intervention had baseline intervention group is 94.38, and after 2 years intervention is 88.61. And control group was 93.01, and after 2 years is 92.80, p value intervention group and control was 0.001¹⁷. Other article had mean of weight loss is -5.51 from baseline $p=0.001^*$ ¹⁸, with

just monitoring lifestyle intervention. And the longterm intervention with education and counseling¹³ baseline of weight is 221.4 lb and after 10th intervention 217.4.

3.4.4. Blood Glucose

Two article showed result of reduce blood glucose such as, article with monitoring lifestyle intervention showed, before intervention intervention group glucose was 105.37. And after intervention, glucose intervention group was 103.09. Meanwhile before after control group is 105.71 and 107.44. P value LWL group and control group is $<0.001^*$ ¹⁷. And other article showed after intervention, mean of glucose is reduce 2.27 from baseline $p=0.001^*$ ¹⁸.

4. DISCUSSION

Diabetes has increased steadily in recent years and the majority of type 2 diabetes is caused by an unhealthy lifestyle. Diet and modified lifestyle can reduce the risk factor of diabetes²⁰⁻²³. From our systematic review, our findings were that the first intervention can be grouped into several interventions such as, physical activity, diet, providing education and intervention from health workers. The provision of interventions with health workers is usually in collaboration with providing education on research participation. Providing education through co-health workers or CHW is a very comprehensive method because CHWs receive special training before providing intervention and education to participants. Provision of interventions with penetration from health workers shows a fairly good and high impact¹⁷. But not too high in research by Balagopal et al., (2012); Matsushita et al., (2020); Prezio et al., (2013) but this intervention still had a significant effect^{12,15,19}.

Ours evaluation highlights numerous vital findings. First, confirming in reviews, our evaluation demonstrates that lifestyle-targeted diabetes prevention packages which have a 'high' intervention of touch have greater capability to obtain powerful outcomes, in particular, while measured with the aid of using weight reduction. In one study, a diet menu was quite strict but very friendly for people with diabetes, this menu was divided into 2 groups, namely high and low socioeconomic status. The diet pattern formed is breakfast with bread, carbohydrates or vegetables and fruit, then followed by lunch with fruit or milk dessert and a dinner menu with rice or chicken. There is also add additional menu, such as diligently eating fruits and vegetables with the doses that have been determined in the diet menu. In this study dietary patterns were followed up after 6 months by CHW. In addition, CHW also provides education regarding the importance of diet and exercise as a supporter of blood sugar control. With a period of 6 months, this intervention has had a significant effect on reducing BMI¹².

Second, the long-term intervention showed a low effect, due to the lack of follow-up to the participants therefore it was important to include CHWs, to improve outcomes¹³. So it can be said that the importance of follow-up is very influential in the success of the intervention.

This review shows that education and counseling is important thing for the patient. One artikel developed SHAPE intervention for a patient with prediabetic which is a modification of the US DPP intervention¹⁶. The class contains materials with a range that encourage participants to lose weight. The method was discussion, the patient is expected to be able to communicate by involving family and friends in treatment. In the shape intervention model, the material presented in the curriculum is more detailed and specific, adapted to the characteristics of participation in research¹⁵.

Research by Priezio *et al.* (2013) used three modules which will later be delivered by health workers namely, by a team of doctors, nurses, nutritionists and fitness trainers. They provide education to program participants according to their expertise. Nurses provide education related to understanding the results of health checks, how complications can occur due to risk factors for diabetes, then targets for treatment and treatment both pharmacologically and non-pharmacologically (exercise and diet). Adopting new and innovative methods greatly affects the effectiveness of education delivery²⁴. There were article reviews showing that control program management is more effective when given simultaneously and when more than one intervention is given, be it education, reminders or other support²⁵. Consultation for adults is very effective on the quality of the diet that the patient undergoes and this has an impact on the results of the examination (blood glucose) and weight loss. CHWs play many roles to help patients in the success of the diet program²⁶⁻²⁸.

In this review there are some limitations where some articles do not explain in detail the interventions carried out. There are studies with government settings, where the period of 10 years in the use of the intervention, so that many participants drop out and only a few participants remain. Another finding is that some articles do not have a control group in the study, such as in a cohort study. Several articles also assessed the outcome of the incomplete intervention. Most articles point to weight loss as a result. A more specific outcome assessment is needed, especially on HbA1C or blood glucose levels.

5. CONCLUSION

Our findings identify that program intensity plays a major role in weight loss outcomes. Providing education through co-health workers or CHW is a very comprehensive method. Programs that have high variation intervention (education, CHW, dietary and physical activity) had a good impact in lowering diabetes risk in

a population. Outcomes given with high variation intervention are seen significantly in a short time due to high follow-up by CHW.

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Conflict of interest

The authors declare that they have no competing interests.

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