A Community-Based Participatory Diabetes Prevention and Management Intervention in Rural India Using Community Health Workers

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Purpose

The purpose of this study was to test the effectiveness of a 6-month community-based diabetes prevention and management program in rural Gujarat, India.

Methods

A community-based participatory research method was used to plan and tailor the intervention by engaging trained community health workers as change agents to provide lifestyle education, serve as community advocates, and collect data from 1638 rural Indians (81.9% response rate). Ten culturally and linguistically appropriate health education messages were provided in face-to-face individual and group sessions (demonstrations of model meals and cooking techniques).

Results

Mean age was 41.9 ± 15.9 years. Overall point prevalence of diabetes, prediabetes, obesity, and hypertension were 7.2%, 19.3%, 16.7%, and 28%, respectively, with significant differences between the low socioeconomic status (SES) participants (agricultural workers) and the high SES participants (business community) due to differing diet and activity levels. The intervention significantly reduced blood glucose levels by 5.7 and 14.9 mg/dL for individuals

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with prediabetes and diabetes, respectively, and systolic and diastolic blood pressure by 8 mm Hg and 4 mm Hg, respectively, in the overall population. Knowledge of diabetes and cardiovascular disease improved by 50% in the high SES group and doubled in the low SES group; general and abdominal obesity also decreased by ≤ 1%. High rates of undiagnosed hypertension (26.1%) were surprising. Among individuals with diabetes, metabolic complications such as diabetic nephropathy and chronic kidney disease were noted.

Conclusions

Through collective engagement of the community, participatory programs can serve as a prototype for future prevention and management efforts, which are rare and underutilized in India.

Southeast Asian countries are facing a socioeconomic and epidemiological transition. But as with many of the industrialized countries, there is also a concomitant significant emergence of noncommunicable diseases, particularly diabetes mellitus. The World Health Organization predicts that such diseases will account for two-thirds of all deaths within the next 25 years in Southeast Asian countries.[1] Type 2 diabetes is progressing rapidly, and it has been predicted that the number of individuals with diabetes mellitus in India will be the highest in the world (79.4 million) in 2030,[2] with the incidence of cases manifesting at younger ages.[2-5] With 70% of India's population living in resource-poor rural areas,[3,5] populations afflicted with this disease can quickly deteriorate into a crisis due to low awareness, poor access to quality care, and increased diabetes-related complications.[6] It has been shown that application of population-based interventions to tackle preventable risk factors could avert at least 80% of noncommunicable diseases such as type 2 diabetes,[7] making primary prevention a valuable cost-effective strategy to prevent type 2 diabetes mellitus.[8]

To date, the Diabetes Prevention Program in India has had only a moderate effect on reducing the risk factors for diabetes through lifestyle intervention.[9] Studies suggest that using community-based participatory research (CBPR) will enhance the effectiveness of such programs by engaging the participants in the planning and intervention processes.[10,11] However, CBPR interventions to stem chronic diseases are not often used in rural India. Hence, this study was designed as a collaborative approach to equitably involve the community stakeholders (key formal and informal community leaders, village elders, local school staff, health professionals, and community members) in the planning, implementation, education, and review process. It was expected that involvement of the community in all aspects of the research process would help to identify the challenges, successes, and lessons learned and to better understand the socioeconomic factors that affect the burden of diabetes. Hence, the purpose of this nonpharmacological intervention was to evaluate the effectiveness of a CBPR approach to diabetes prevention and management program in rural Gujarat in India. The study duration was from December 2007 to May 2008.

Methods

Design: CBPR Approach

The CBPR method as described by Israel and her colleagues[12] was used to plan the project using a "top-down and grounds-up" approach. CBPR is defined as a collaborative approach to research that equitably involves community members, organizational representatives, and researchers in all aspects of the research process, whereby partners contribute unique strengths and shared responsibilities to enhance understanding of a given phenomenon and the social and cultural dynamics of the community and to integrate the knowledge gained with action to improve the health and well-being of community members.[13] The guideposts of the CBPR partnership[14] with the rural Indian community included the following: (1) recognizing the characteristics of the community as a unit; (2) determining needs, assets, and geographical mapping to build on strengths and resources within the community; (3) facilitating collaborative partnerships in all phases of the research; (4) integrating knowledge and action for mutual benefit of all partners; (5) promoting a colearning and empowering process that attended to the socioeconomic disparities in the community; (6) involving a cyclical and iterative process; (7) addressing benefits and barriers of noncommunicable disease prevention and management; and (8) sharing the findings and knowledge gained to all partners. These guiding principles were fundamental to the success of this community-based endeavor.

The entire rural community was inducted into this partnership where the village elders, the research team, and the elected community health workers (CHWs) discussed and obtained a clear understanding of the purpose of the study, its usefulness to the community, and the anticipated outcomes. Eight preplanning community meetings were conducted before launching the program, to build trust, confidence, and rapport with the stakeholders and academic partners. Community representatives identified chronic diseases, especially diabetes, as a major area of concern. The village matrix was mapped and divided into pockets comprising of 4 to 6 street blocks (50 houses per block); block spokespersons were identified to work with the team. The participatory process provided guidance for data collection and solved challenges to engage participants in the educational intervention. Furthermore, understanding the profile of the community helped to tailor scientific content and materials into appropriate intervention strategies. Effort was made to ensure collaborative participation,[15] which was rewarded by a visible positivism in the community toward the study. The elected block spokespersons were able to motivate and support villagers who were resistant to the acceptance of the program idea.

Community Health Workers

CHWs were used as the change agents to provide health education, serve as community advocates, and collect data for this study. The CHWs and all project personnel were selected by a formal process that included an application and interview. The recruiting committee consisted of the principal investigator, 2 local village elders, and the project coordinator. The committee also finalized the selection criteria and qualifications as well as the training requirements of the CHWs. The stipend and the prospect of working in a Diabetes Prevention Program proved to be attractive drawing cards. Qualification included at least a high school diploma, with 60% CHWs having a college degree. Desired qualities included an interest in health care and community, willingness to learn, leadership qualities, bilingual (English and Gujarati), and previous health care or community experience. A strong commitment to work in the community was identified as an important criterion for recruiting a CHW. The project coordinator and the 16 CHWs were recruited from local areas and represented the target population's multireligious demographics. Training was provided by an expert and multidisciplinary team, which comprised a registered dietitian, a certified health educator, a public health practitioner, an endocrinologist, a sanitation specialist, a general practitioner, and an internal medicine specialist. CHWs and the project coordinator underwent 4 weeks of structured training on an existing diabetes prevention and management curriculum.[16] The training used didactic sessions, one-on-one mentored learning, and role-playing to improve (1) skill-based knowledge using hands-on training on vital signs, dietary intake, anthropometrics, and health screening; (2) knowledge of diabetes and its risk factors/complications; and (3) ethics and confidentiality of dealing with human subjects and survey administration. Key diabetes prevention and management intervention features included basic nutrition and dietary modification with attention to fiber content, quality and quantity of fat and portion control, knowledge of diabetes and its risk factors and complications, lifestyle modifications for diabetes prevention, meditational breathing practices to help with stress and relaxation, physical activity improvement, nonconfrontational interviewing, problem solving, and effective teaching methods.

Participants

Participants included all adults, 18 years and older, from a rural community, 25 km from Vadodara, Gujarat. Of the 2100 village residents, approximately one-fifth were migrant workers and hence excluded. In sum, 1681 villagers participated in the baseline survey, but only 1638 completed the postintervention measurements (response rate, 81.9%). Recruitment of respondents and data collection were completed via door-to-door visits by the CHWs. A participatory, situational analysis of the village helped delineate 2 predominantly different target areas—a poor agrarian community and a wealthier business community—with differing population characteristics. The "business community" (ie, higher socioeconomic status; SES) reported a below-poverty level of 24% and illiteracy level of 9.7%, whereas the economically stressed agrarian farmworkers (low SES) reported 51% and 50.5%, respectively. No monetary compensation was provided, but health appraisal data were disseminated to the participants. Institutional review board approval was obtained from Texas A&M University.

Measures

Demographic data included personal/family health history, educational level, income, dietary pattern, and tobacco use. Dietary recall revealed participants' eating practices and macronutrient/calorie intake. Knowledge of diabetes risk factors was determined based on the American Diabetes Association's 7-item diabetes risk test (age, family history, overweight, sedentary activity, gestational diabetes, high blood pressure, and high-fat/high-calorie diet). Knowledge of CVD risk factors was determined on the basis of an 11-item American Heart Association risk calculator (age, sex, smoker, family history, overweight, high cholesterol, diabetes, hypertension, menopause, sedentary activity, and high-fat/high-calorie diet). Physical activity was assessed using a modified version used in the Indian Diabetes Prevention Programme study,[17] taking into account occupation (farmworkers, manual labor, desk work or office jobs, domestic); duration of household chores, fetching water, and brisk walking (minutes per day: < 45 minutes, 45-240, and 240-480); duration of vigorous or manual physical activity per day (15-60 minutes, 60-240, 240-600); mode of transport to work (walking, cycling, bus); and leisure time and enhanced physical activities (jogging, gardening, recreational sports). The physical activity score ranged from 1 to 70, and participants were categorized as sedentary (1-17), light (18-34), moderate (35-51), and heavy (> 51). Dietary intake of fruits, vegetables, bread/rice, and milk/milk products was assessed (intake of meat, fish, and poultry was deemed unnecessary because the majority were vegetarians).

Given a marked resistance among village inhabitants toward venous blood drawing, fasting capillary blood glucose was used to assess glycemic status (Accu-Chek glucometer, Roche Laboratories), as used in a rural Indian study by Chow.[18] However, high correlation was noted between capillary and venous plasma glucose tested for 120 participants ($r = 0.92$, $P < .001$). Participants were informed by the CHWs to fast 8 to 10 hours. Each household was visited in the early hours of dawn, and fasting status was confirmed prior to data collection. Individuals were categorized to normoglycemic (≤ 100 mg/dL), impaired fasting glucose (IFG; 100-125 mg/dL), and diabetes levels (≥ 126 mg/dL) using the current American Diabetes Association standards of care[19]; individuals with abnormal glucose levels were reconfirmed. Three blood pressure measurements were averaged; participants were seated with feet on the floor and arm supported at heart level. Hypertension and prehypertension were categorized according to definitions of the Seventh Joint National Committee on Hypertension.[20] Height, weight, waist circumference, and hip circumference were measured by standard procedures. Reference guidelines for Asian Indians were used for all obesity measures (body mass index, waist circumference, and waist:hip ratio).[19] Individuals with diabetes provided venous blood samples for assessment of clinical parameters, as they were familiar with the importance of these tests (A1C, serum lipids, urine albumin, and creatinine).

Lifestyle Intervention

Ten face-to-face encounters (5 one-on-one and 5 group based) were provided to all respondents. Linguistically appropriate (Gujarati language) health education was tailored for sex, age, lifestyles, and socioeconomic differences. Lifestyle intervention included advice on healthy diet and regular physical activity. Agricultural farmworkers, manual laborers, or those who were physically active (walked or bicycled for > 30 minutes/day or participated in recreational sports or brisk walking) were requested to continue their routine, while those engaged in sedentary to light physical activity were advised (and regularly motivated) to be physically active (eg, walk, perform household chores, garden, dance/exercise) for at least 30 minutes per day. All participants received personalized advice about their risk for developing diabetes, and those with diabetes and prediabetes were provided education and counseling for blood glucose management by a certified diabetes educator in one-on-one sessions. For overweight/obese (27%) individuals, weight loss education was provided in group sessions. To demonstrate healthier dietary approaches, for example, the prevailing custom of inadequate fiber intake among the more affluent respondents was highlighted through cooking competitions and model meals, the latter of which demonstrated how to improve the taste of high-fiber substitute millets such as bajra (*Pennisetum typhoideum*) and jowar (*Sorghum vulgare*), sprouted legumes, and vegetables. Dietary education focused on the benefits of fiber and protein intake from local, low-cost resources, such as the nutritionally rich and ubiquitous drumstick leaves and locally grown millets, legumes/lentils, and whole grains. Educational materials included handouts in Gujarati downloaded from National Diabetes Education Program. However, the majority of participants preferred discussions and demonstrations.

Statistical Analysis

Point prevalence of diabetes and prediabetes, hypertension, and obesity was calculated from the baseline survey. Analysis of variance examined differences by SES, diabetes, and gender. Diabetic complications—diabetic nephropathy and chronic kidney disease stages—were calculated for individuals with diabetes using eGFR, or estimated glomerular filtration rate, as calculated by the MDRD (modification of diet in renal disease) formula. Multivariate regression analysis was used to examine effectiveness of the program (change in body mass index, waist circumference, physical activity, fruit and vegetable intake, knowledge of diabetes and CVD risk factors, systolic and diastolic blood pressure, and fasting blood glucose) by SES groups and individuals with normoglycemic, IFG, and diabetes levels. To minimize potential bias, the model was adjusted for baseline values, and sex and age were added as covariates to each regression model. Data entry and analysis were performed with SPSS 19.

Results

Baseline Characteristics

The mean age of the respondents was 41.9 ± 15.9 years (Table 1). The majority had less than high school education; 77% reported no family history of chronic diseases; 44.2% used tobacco regularly or occasionally in various forms (cigarettes, beedis, hookah, snuff, chewing tobacco [beetle leaves, *zarda*, and *gutka*]); 63.5% reported sedentary or light physical activity; 98% did not meet the recommended intake of fruits, and 35% did not meet the recommended intake of vegetables per day.

Prevalence of Diabetes, Hypertension, and Obesity

The point prevalence of IFG and diabetes was 19.3% and 7.1%, respectively (3.0% self-reported and 4.2% undiagnosed cases; Table 1). The prevalence of diabetes was similar by sex, correlated with age and physical activity, and was higher among the higher SES group. The majority of participants were unaware of diabetes risk factors, and individuals with diabetes did not have a clear understanding of self-management of the disease. While diagnosed hypertension was 4.3%, elevated levels were noted in 21.8% of respondents; 37% were prehypertensive. Despite a low prevalence of diabetes among the low SES respondents, elevated systolic (28%) and diastolic (19%) hypertension levels were noted in this group. Tobacco use and sedentary activity was positively associated with elevated blood pressure ($P = .001$). According to the Asian criteria, 13% and 26% of high SES rural Indians and 7% and 6% of the low SES rural Indians were found to be overweight and obese, respectively. Females and high SES participants had central obesity and higher elevated waist:hip ratio than did the male and low SES respondents (Table 1).

Glycemic Control and Diabetic Nephropathy Among Individuals With Diabetes

Patients with A1C > 6.5% had statistically higher levels of microalbumin ($P = .001$), total cholesterol ($P = .053$), triglycerides ($P = .050$), and LDL ($P = .045$), suggesting metabolic complications of diabetes. Among individuals with diabetes, the point prevalence of diabetic nephropathy as defined as microalbumin > 30 mg/dL was 15.3% (very few were in chronic kidney disease stages 3 and 4; data not shown). Furthermore, individuals with poor control (A1C > 6.5%; 45% cases) had higher serum cholesterol, triglyceride level, and creatinine than those with A1C ≤ 6.5. Approximately two-thirds of females (61.4%) and 48.9% males had low levels of HDL and 15% had an HDL:LDL ratio over 4.0.

Differing Dietary Patterns and Physical Activity

The distinctly differing lifestyles of the 2 SES groups involved diverse dietary patterns and physical activity (Tables 2 and 3). In general, 62% reported a lactovegetarian diet. This was higher (84%) in the high SES respondents, but they had higher levels of obesity, type 2 diabetes mellitus, and hypertension. Dietary intake of participants in the lower SES group shows a simple diet of coarsely ground cereals and unleavened bread (*rotis, rotlas*, or *chappathis*) made from bajra (*P typhoideum*) or sorghum (*S vulgare*), some converted (or parboiled) rice for at least one of the meals, and some gravy or a little vegetable, onion, or green chilies. While the bajra and sorghum millets have high fiber content, they have low glycemic index, ranging 55% to 77%, as indicated by Mani and colleagues.[21] Dietary analysis among the low SES participants indicated that crude fiber intake was ~18 g per day

Table 1

Baseline Participant Characteristics[a]

	Total	High SES[b]			Low SES[b]		
	n = 1638	Male; n = 404, 46%	Female; n = 470, 53%	Total; n = 874, 53.4%	Male; n = 362, 47%	Female; n = 402, 53%	Total; n = 764, 46.6%
Age, y	41.9 ± 15.9	40.1 ± 15.5	40.4 ± 15.9	43.4 ± 15.9	43.3 ± 16.1	43.3 ± 15.8	40.2 ± 15.7
Body mass index,[c] kg/m^2	20.8 ± 4.6	21.5 ± 4.3	22.7 ± 4.9	22.2 ± 4.7	18.7 ± 3.3	19.7 ± 4.6	19.2 ± 4.1
Underweight	35.6	28.2	20.2	23.9	54.4	44.0	49.0
Normal	35.0	37.1	33.8	35.4	32.6	36.6	34.7
Overweight	10.1	11.9	14.3	13.2	5.0	8.0	6.5
Obese	16.7	20.5	30.0	25.6	4.7	8.0	6.4
Waist circumference, in.	29.6 ± 4.7	32.2 ± 4.8	29.8 ± 4.7	30.9 ± 4.9	28.7 ± 4.4	27.7 ± 4.0	28.2 ± 4.2
Normal	74.7	85.5	79.2	64.4	94.4	89.0	83.4
Abnormal, M > 35; F > 31 in.	25.3	13.5	20.4	34.1	3.9	10.3	14.3
Hip circumference, in.	35.2 ± 4.1	33.4 ± 3.5	33.8 ± 3.3	33.6 ± 3.4	36.4 ± 3.7	36.7 ± 4.8	36.6 ± 4.3
Waist-hip ratio	0.84 ± 0.08	0.86 ± 0.07	0.82 ± 0.07	0.84 ± 0.08	0.88 ± 0.07	0.81 ± 0.07	0.83 ± 0.07
Normal	54.3	46.3	45.7	46.0	34.3	44.3	39.5
Abnormal, M > 0.89; F > 0.81	43.0	50.2	52.8	51.6	61.0	54.2	57.5
Capillary glucose,[d] mg/dL	95.5 ± 30.3	100.6 ± 35.2	99.2 ± 37.6	99.9 ± 36.5	90.3 ± 15.9	90.8 ± 22.7	90.5 ± 19.8
Prevalence of diabetes	7.1	10.1	10.2	10.4	3.3	3.2	3.4
Prevalence of IFG	19.3	24.3	19.6	21.6	17.1	15.9	16.6
Blood pressure, mm/Hg							
Systolic blood pressure	136.6 ± 23.5	140.5 ± 22.4	140.0 ± 26.8	140.2 ± 24.9	133.6 ± 19.5	131.4 ± 22.4	132.5 ± 21.1
Prehypertension	43.3	44.3	39.1	41.5	44.5	46.0	45.3
Hypertension	34.7	42.6	38.9	40.6	32.3	24.1	28.0
Diastolic blood pressure	83.2 ± 14.1	86.6 ± 13.6	85.4 ± 14.0	88.0 ± 13.8	80.0 ± 13.7	79.9 ± 13.5	80.0 ± 13.6
Prehypertension	30.8	30.2	32.8	31.6	27.6	31.8	29.8
Hypertension	27.8	39.1	32.6	35.6	22.7	15.7	19.0
Education							
Illiterate	28.8	4.5	14.3	9.7	30.9	68.2	50.5
Up to high school	54.7	61.1	68.3	65.0	57.7	29.6	42.9
Some college/graduate	16.5	34.4	17.4	25.3	11.0	2.2	6.4
Income, rupees							
< 1500	36.7	24.3	24.0	24.1	47.0	54.7	51.0
1500-3500	37.3	37.9	38.7	38.3	39.8	32.8	36.1
> 3500	25.8	37.9	37.2	37.5	12.7	11.9	12.3
Knowledge of diabetes[e]	0.94 ± 1.92	1.58 ± 2.4	1.28 ± 2.2	1.42 ± 2.3	0.55 ± 1.36	0.25 ± 0.92	0.39 ± 1.2
Knowledge of CVD[f]	1.72 ± 3.50	2.97 ± 4.4	2.34 ± 4.0	2.6 ± 4.2	0.95 ± 2.26	0.44 ± 1.65	0.68 ± 1.9
Fruit intake[g]	0.16 ± 0.25	0.20 ± 0.26	0.21 ± 0.26	0.20 ± 0.25	0.13 ± 0.25	0.12 ± 0.23	0.12 ± 0.24
Vegetable intake[h]	1.67 ± 0.51	1.66 ± 0.48	1.64 ± 0.48	1.65 ± 0.48	1.72 ± 0.54	1.68 ± 0.56	1.70 ± 0.55
Physical activity[i]							
Sedentary	25.8	58.9	9.4	32.2	31.5	6.7	18.5
Light	37.7	6.4	75.1	43.4	17.4	43.8	31.3
Moderate	11.7	5.7	10.0	8.0	16.0	15.9	16.0
Heavy	24.7	29.0	5.5	16.4	35.1	33.6	34.3

(continued)

Table 1

(continued)

	Total	High SES[b]			Low SES[b]		
	n = 1638	Male; n = 404, 46%	Female; n = 470, 53%	Total; n = 874, 53.4%	Male; n = 362, 47%	Female; n = 402, 53%	Total; n = 764, 46.6%
Tobacco users							
Smoking, beedis/cigarettes	15.4	23.3	0.2	10.9	35.6	7.2	20.7
Chewing tobacco	21.3	30.7	5.5	17.2	34.8	18.2	26.0
Inhaled tobacco, hookah/snuff	4.4	0.0	3.2	1.7	1.1	13.2	7.5
Multiple categories	3.1	6.2	0.9	3.3	4.4	1.2	2.7

[a]Data presented as mean ± SD or percentage. Total column includes individuals with normal, IFG (impaired fasting blood glucose), and diabetes levels.
[b]The high SES (socioeconomic status) or the richer "Patel" community comprised higher-income and higher-education participants. The low SES group was economically stressed agrarian farmworkers with higher levels of poverty and illiteracy.
[c]Underweight, < 18.5; normal, 18.5-22.9; overweight, 23-24.99; obese ≥ 25.0.
[d]In the fasting state.
[e]Knowledge of diabetes was calculated as the sum of 7-item American Diabetes Association risk factor test: age, family history, overweight, sedentary activity, gestational diabetes, high blood pressure, and high-fat/high-calorie diet.
[f]Knowledge of CVD (cardiovascular disease) was calculated as the sum of 11-item American Heart Association risk calculator: age, sex, smoker, family history, overweight, high cholesterol, diabetes, hypertension, menopause, sedentary activity, and high-fat/high-calorie diet.
[g]Fruit intake was evaluated by the daily consumption (servings) of fresh fruits or fruit juice.
[h]Vegetable intake was expressed as servings per day and assessed by the daily consumption of vegetables.
[i]Physical activity score ranged from 1 to 70 and was evaluated by daily work involving standing or walking, occupation (manual work, agriculture, desk job, housewives), recreational physical activity, and household work. Physical activity was categorized as light (1-17), light (18-34), moderate (35-51), and heavy (> 51).

with 73%, 10%, and 17% of total calorie intake from carbohydrate, protein, and fat, respectively. In contrast, among the high SES respondents, the main staple was whole wheat flour or converted rice with vegetables, potatoes, lentils or legumes, fried snacks (almost every day), fruits of the season, and dessert. Crude fiber intake of this group was ~13 g per day, with 65%, 9%, and 26% of total calorie intake from carbohydrate, protein, and fat, respectively. The fat intake was more saturated fat from the use of buffalo milk, *ghee*, and the use of hydrogenated vegetable oil (*dalda* and *vanaspati*) used in the preparation of snacks. Postintervention dietary pattern of fruits and vegetables intake showed some significant improvement, although it still did not meet the recommended intake.

Program Outcomes at 6-Month Follow-Up

Lifestyle intervention significantly reduced fasting blood glucose levels by 1.3 mg/dL in general and normoglycemic individuals and by 6.02 mg/dL and 19.08 mg/dL among individuals with IFG and diabetes, respectively ($P < .001$; Table 4). This equated to a reduction in fasting glucose levels by 1.3%, 5.6%, and 11.5% for normoglycemic, IFG, and diabetes individuals, respectively. Lifestyle intervention successfully lowered systolic and diastolic blood pressure by 7 mm Hg and 3 mm Hg, respectively, in both groups. As compared to baseline levels, general and central obesity decreased by 0.5% and 1% among all participants as well as among individuals with diabetes and IFG in both groups (Table 3). There was a significant and meaningful improvement in the knowledge of diabetes and CVD risk factors in both groups (0.78 and 1.64 points, respectively; $P < .001$); this equated to > 50% increase of knowledge in the high SES group, and awareness doubled among the lower SES group participants. Prior to the intervention, participants were unaware that lack of physical activity was a risk factor for type 2 diabetes mellitus and CVD. Community awareness and lifestyle intervention raised knowledge regarding the benefits of moderate physical activity by 12%, with greater improvement among the high SES group, especially when culturally

Table 2

Dietary Patterns of Groups in the Village: High vs Low Socioeconomic Status

Eating Pattern	High	Low
Morning	Dry-roasted or pan-fried *chappathis* or *rotis* flatbreads, 1-3, made from atta or semolina *khichdi* (from semolina and mung bean lentils) with *ghee*	Dry-roasted *bajre ki roti* (flatbreads made from bajra), 2-3; sauteed vegetables or green chillies or fresh onion slivers
Midmorning	*Chaas* or diluted, salted buttermilk	Sweetened tea with milk
Lunch	*Chappathis* or *rotis* (flatbreads) or *khichdi* (from semolina) with *ghee*, 1-3; sauteed vegetables; milk- or starch-based dessert (on occasion)	Dry-roasted *bajre ki roti* (flatbreads made from bajra), 2-3; green chillies or fresh onion slivers
Tea time	Sweetened tea with fried snacks	Usually nothing; sometimes sweetened tea
PM (dinner)	Dry-roasted or pan-fried *chappathis* or rice; lentils and vegetable gravy; *chaas* or diluted, salted buttermilk; milk- or starch-based dessert (on occasion)	Bajra or *jowar* (sorghum) or *rotis* (flatbreads), 2-3; *khichdi* (rice-mung bean dish) or plain rice; a gravy with vegetables or chicken or goat; *chaas* or diluted buttermilk or sweetened tea
Milk	Usually buffalo milk	Cow's milk or buffalo milk
Cereal/starch	Atta (semolina); parboiled or polished rice; occasionally, millets	Bajra millet (*Penniseteum typhoideum*) or jowar millet (*Sorghum vulgare*); parboiled or converted rice
Vegetables	Potatoes and seasonal vegetables, 0.5-1 cup/day	Potatoes and seasonal vegetables, 0.25-0.75 cup/day
Fats/oils	Vegetable, sesame, peanut oils; hydrogenated fats for frying; clarified butter or *ghee*	Vegetable, sesame, mustard, peanut oils
Sweetener	Refined white sugar or *jaggery*	Refined white sugar or *jaggery*

Table 3

Nutrient Composition of Diet in Groups: High vs Low Socioeconomic Status[a]

Total	High	Low
Kcal/day	2932	2136
Protein, g	81 (9)	54 (10)
Fats, g	85 (26)	39.6 (17)
Carbohydrates, g	476 (65)	391 (73)
Crude fiber, g	13	18

[a]Percentage of total kcal in parentheses.

appropriate activities were highlighted, such as community dances (*garba*), walking, dance/exercise, and yoga (deep breathing, *pranayama*). Yoga was favorably received when postyoga blood pressure measurements showed a significant drop in systolic/diastolic values among a select subgroup of participants who participated in the activity.

Discussion

Satterfield et al emphasized the critical need to conduct and publish reports on well-designed community-based diabetes prevention research despite low response rates or lack of information on nonresponders.[22] Our study is the first population study using CBPR and CHWs who effectively engaged the community to reduce the prevalence of type 2 diabetes mellitus and hypertension in rural Gujarat, India. Intervention successfully resulted in a 2-mg/dL drop in fasting blood glucose values among the high SES group, bringing down the mean from impaired to acceptable levels, similar to results of the Indian Diabetes Prevention Programme study.[17] While the beneficial effects of lifestyle modification in

Table 4

Main Outcome Effects After Diabetes Prevention and Management Program Intervention: 6 Months[a]

Outcome	Total	Normal	IFG	Diabetes	*P*
Percentage change in BMI, kg/m^2	–0.46	–0.41	–0.45	–1.02	< .001
Baseline	20.73 ± 4.3	20.20 ± 4.1	21.61 ± 4.4	24.409 ± 4.7	
Follow-up	20.64 ± 4.2	20.13 ± 4.1	21.49 ± 4.3	23.88 ± 4.7	
Percentage change in WC, in.	–1.25	–1.12	–1.64	–1.55	.001
Baseline	29.66 ± 4.8	28.99 ± 4.5	30.66 ± 4.7	34.04 ± 5.0	
Follow-up	29.44 ± 4.8	28.84 ± 4.5	30.28 ± 4.7	33.51 ± 5.1	
Change in systolic blood pressure, mmHg	–7.37	–7.21	–8.57	–6.21	< .001
Baseline	136.62 ± 23.5	134.11 ± 23.0	141.29 ± 22.6	150.94 ± 23.9	
Follow-up	129.25 ± 20.6	127.18 ± 19.4	132.2 ± 21.1	143.58 ± 24.1	
Change in diastolic blood pressure, mmHg	–3.24	–3.08	–4.17	–0.167	< .001
Baseline	83.22 ± 14.1	81.81 ± 14.0	86.51 ± 13.6	89.15 ± 13.0	
Follow-up	80.00 ± 12.9	78.81 ± 12.7	82.11 ± 12.5	11.7 ± 86.77	
Change in FBG,[b] mg/dL	–1.28	1.32	–6.02	–19.08	< .001
Baseline	96.26 ± 27.3	86.47 ± 8.2	107.65 ± 6.5	165.57 ± 59.2	
Follow-up	94.94 ± 25.5	87.60 ± 10.6	101.89 ± 11.3	151.53 ± 61.5	
Changes in diabetes knowledge score[c]	0.78	0.81	0.86	0.47	< .001
Baseline	.94 ± 1.9	0.86 ± 1.8	0.91 ± 1.8	1.90 ± 2.5	
Follow-up	1.72 ± 2.1	1.69 ± 2.1	1.72 ± 2.1	3.90 ± 3.6	
Change in CVD knowledge score[d]	1.64	1.69	1.86	1.27	< .001
Baseline	1.72 ± 3.5	1.60 ± 3.3	1.69 ± 3.4	3.22 ± 4.7	
Follow-up	3.32 ± 3.6	3.29 ± 3.6	3.27 ± 3.5	3.90 ± 3.6	
Change in fruit intake[e]	.04	.04	.02	.02	< .001
Baseline	0.17 ± 0.25	0.16 ± 0.24	0.18 ± 0.29	0.19 ± 0.29	
Follow-up	0.19 ± 0.26	0.20 ± 0.26	0.20 ± 0.24	0.21 ± 0.22	
Change in vegetable intake[f]	0.19	0.18	0.22	0.19	< .001
Baseline	1.67 ± 0.51	1.68 ± 0.52	1.65 ± 0.50	1.71 ± 0.47	
Follow-up	1.86 ± 0.57	1.86 ± 0.58	1.87 ± 0.59	1.90 ± 0.46	
Percentage change in moderate/vigorous physical activity[g]	11.6	11.6	14.2	4.2	< .001
Baseline	36.4	36.3	39.6	30.8	
Follow-up	48.0	47.9	53.8	35.0	
High SES[h]; n = 874, 53.4%					
Percentage change in BMI, kg/m^2	–0.71	–0.23	0.06	–1.26	.007
Baseline	22.11 ± 4.6	21.5 ± 4.42	22.75 ± 4.4	24.9 ± 4.5	
Follow-up	21.97 ± 4.5	21.38 ± 4.35	22.54 ± 4.3	24.75 ± 4.5	
Percentage change in WC, in.	–1.00	–0.54	–1.93	–1.74	< .001
Baseline	30.94 ± 4.9	30.0 ± 4.53	31.73 ± 4.8	35.33 ± 4.5	
Follow-up	30.76 ± 5.0	30.02 ± 4.79	31.27 ± 4.9	34.68 ± 4.5	
Change in systolic blood pressure, mmHg	–7.69	–6.98	–8.53	–6.38	.001
Baseline	140.27 ± 24.9	137 ± 24.76	144.22 ± 22.7	153.71 ± 24.5	
Follow-up	132.55 ± 21.9	129.71 ± 20.26	135.11 ± 23.0	146.22 ± 24.6	
Change in diastolic blood pressure, mmHg	–3.23	–2.85	–4.73	–2.46	.001
Baseline	86.01 ± 13.9	84.35 ± 14.10	88.99 ± 12.3	90.64 ± 13.3	
Follow-up	82.82 ± 13.1	81.63 ± 13.27	84.07 ± 12.5	87.86 ± 11.6	
Change in FBG,[b] mg/dL	–1.61	–1.03	–6.35	–13.39	.001
Baseline	100.23 ± 33.8	86.77 ± 8.12	107.78 ± 6.4	172.33 ± 63.6	
Follow-up	98.56 ± 31.9	87.98 ± 10.79	101.84 ± 10.5	161.25 ± 65.2	
Changes in diabetes knowledge score[c]	0.82	0.93	0.69	1.05	< .001
Baseline	1.42 ± 2.3	1.34 ± 2.2	1.32 ± 2.1	2.25 ± 2.7	
Follow-up	2.22 ± 2.3	2.29 ± 2.2	1.98 ± 2.3	2.35 ± 2.1	
Change in CVD knowledge score[d]	1.47	1.64	1.19	–13.39	< .001
Baseline	2.63 ± 4.2	2.53 ± 4.1	2.45 ± 4.0	3.80 ± 5.03	
Follow-up	4.01 ± 3.9	4.15 ± 3.9	3.50 ± 3.8	4.30 ± 3.7	

(continued)

Table 4

(continued)

Outcome	Total	Normal	IFG	Diabetes	*P*
Change in fruit intake[e]	0.04	0.04	0.03	0.01	.001
Baseline	0.20 ± 0.25	0.20 ± 0.25	0.20 ± 0.25	0.22 ± 0.32	
Follow-up	0.24 ± 0.26	0.24 ± 0.28	0.23 ± 0.23	0.23 ± 0.23	
Change in vegetable intake[f]	0.24	0.25	0.26	0.19	< .001
Baseline	1.65 ± 0.48	1.68 ± 0.52	1.65 ± 0.50	1.71 ± 0.47	
Follow-up	1.89 ± 0.62	1.86 ± 0.58	1.87 ± 0.59	1.90 ± 0.46	
Percentage change in moderate/vigorous physical activity[g]	13.6	15.0	13.2	4.4	< .001
Baseline	24.4	23.6	27.0	25.3	
Follow-up	38.0	38.6	40.2	29.7	
Low SES[h]; n = 764, 46.6%					
Percentage change in BMI, kg/m^2	–0.19	–0.59	–0.97	–0.78	.01
Baseline	19.16 ± 3.5	18.93 ± 3.3	19.90 ± 3.8	20.94 ± 3.9	
Follow-up	19.13 ± 3.4	18.91 ± 3.2	19.93 ± 3.8	20.69 ± 3.8	
Percentage change in WC, in.	–1.53	–1.72	–.0134	–1.35	.005
Baseline	28.19 ± 4.2	27.98 ± 4.2	29.06 ± 3.9	29.75 ± 4.3	
Follow-up	27.92 ± 3.92	27.69 ± 3.8	28.80 ± 3.7	30.00 ± 4.5	
Change in systolic blood pressure, mmHg	–7.00	–7.43	–8.14	–6.04	< .001
Baseline	132.48 ± 21.1	131.28 ± 20.9	136.94 ± 21.8	141.35 ± 18.9	
Follow-up	125.48 ± 18.3	124.70 ± 18.3	127.88 ± 17.3	134.35 ± 20.0	
Change in diastolic blood pressure, mmHg	–3.25	–3.035	–3.60	–0.89	< .001
Baseline	80.04 ± 13.6	79.34 ± 13.4	82.85 ± 14.5	83.96 ± 10.5	
Follow-up	76.79 ± 11.8	76.07 ± 11.6	79.18 ± 12.0	82.96 ± 11.1	
Change in FBG,[b] mg/dL	–0.90	1.33	–5.69	–14.77	.002
Baseline	91.70 ± 15.9	86.18 ± 8.3	107.46 ± 6.7	142.19 ± 32.0	
Follow-up	90.80 ± 14.0	87.24 ± 10.4	101.98 ± 12.4	117.88 ± 27.7	
Changes in diabetes knowledge score[c]	0.73	0.68	1.02	0.58	< .001
Baseline	0.39 ± 1.2	0.40 ± 1.1	0.29 ± 1.0	0.69 ± 1.4	
Follow-up	1.15 ± 1.7	1.11 ± 1.6	1.31 ± 1.5	1.29 ± 1.9	
Change in CVD knowledge score[d]	1.83	1.73	2.33	1.49	< .001
Baseline	0.68 ± 2.0	0.68 ± 1.9	0.57 ± 1.9	1.19 ± 2.6	
Follow-up	2.53 ± 3.0	2.45 ± 3.06	2.92 ± 2.8	2.70 ± 3.2	
Change in fruit intake[e]	0.03	0.04	0.01	0.05	.006
Baseline	0.12 ± 0.24	0.11 ± 0.21	0.16 ± 0.35	0.11 ± 0.10	
Follow-up	0.15 ± 0.22	0.15 ± 0.22	0.17 ± 0.25	0.16 ± 0.20	
Change in vegetable intake[f]	0.13	0.12	0.17	0.15	< .001
Baseline	1.70 ± 0.55	1.71 ± 0.54	1.65 ± 0.55	1.69 ± 0.54	
Follow-up	1.83 ± 0.50	1.83 ± 0.51	1.82 ± 0.51	1.84 ± 0.39	
Percentage change in moderate/vigorous physical activity[g]	9.3	8.3	15.7	3.8	< .001
Baseline	50.3	48.7	58.3	50.0	
Follow-up	59.6	57.0	74.0	53.8	

[a]Mean or percentage change in study outcome measures; mean ± SD for pre- and postintervention outcome measures. Participants: N = 1638. BMI, body mass index; IFG, impaired fasting blood glucose; FBG, normal fasting blood glucose; WC, waist circumference; CVD, cardiovascular disease.
[b]In the fasting state.
[c]Sum of 7-item American Diabetes Association risk factor test: age, family history, overweight, sedentary activity, gestational diabetes, high blood pressure, and high-fat/high-calorie diet.
[d]Sum of 11-item American Heart Association risk calculator: age, sex, smoker, family history, overweight, high cholesterol, diabetes, hypertension, menopause, sedentary activity, and high-fat/high-calorie diet.
[e]Fruit intake was evaluated by the daily consumption (servings) of fresh fruits or fruit juice.
[f]Vegetable intake was expressed as servings per day and assessed by the daily consumption of vegetables.
[g]Physical activity score ranged from 1-70 and was evaluated by daily work involving standing or walking, occupation (manual work, agriculture, desk job, domestic), recreational physical activity, and household work. Physical activity was categorized as light (1-17), light (18-34), moderate (35-51), and heavy (> 51).
[h]SES, socioeconomic status. The high SES or the richer "Patel" community comprised higher-income and higher-education participants. The low SES group was economically stressed agrarian farmworkers with higher levels poverty and illiteracy.

that study was shown at 6-month intervention, our results showed a greater success in lowering the blood glucose, blood pressure, weight, and waist circumference among the high SES IFG participants, who were comparable to the participants of the Indian diabetes program.[9,17] However, participants in both studies showed similar improvements in adherence to physical activity (15.3% in the program vs 13.2% in our study). The mean fasting blood glucose (total sample) dropped by 1 mg/dL at the end of the study period; systolic and diastolic blood pressure was reduced by 8 mm Hg and 4 mm Hg, respectively, indicating that preventing chronic diseases in rural Indians is possible. It also reinforced (1) the success of CBPR approach, (2) that CHWs can provide advice on lifestyle modifications and improve awareness of diabetes and CVD similar to allied health professionals in earlier studies (eg, social workers, dietitians), and (3) that the collective engagement of the community is a useful model for reducing noncommunicable diseases. The CHWs were able to successfully empower the women to speak up at the meetings and instill them with confidence in their decision-making abilities as related to their health and well-being. Using CHWs strengthened the links among project personnel, the community, and existing community networks. The CHWs interacted with the villagers in the Gujarati language, acting as cultural buffers, providing educational sessions at appropriate health literacy levels, and providing follow-up, outreach, and other community mobilization efforts.

Type 2 diabetes mellitus is manifested at earlier ages in India, and our results concurred.[2-4,23] The disease was prevalent in young adults as early as 24 years of age, with the prevalence significantly higher among the affluent sedentary Indians than among the physically active agrarian workers. Use of fasting capillary glucose values, instead of serum, may have affected the prevalence rates. However, correlation of capillary and serum blood glucose values was high and so increases our confidence in the results. Results also illustrate the demographic transitions taking place in the affluent sections of rural communities.

Although Modi and Jha[24] reported a much higher incidence of chronic kidney disease in the urban population of Bhopal (44%), our results indicate that the majority of type 2 diabetes mellitus patients with diabetic nephropathy were in chronic kidney disease stage 1, suggesting a distinctly present but relatively benign disease process. Furthermore, despite the lack of manifestations of moderate or severe proteinuria, individuals with type 2 diabetes with A1C > 6.5 had metabolic complications of diabetes, and this finding concurs with the study by Raman and colleagues.[25]

The relatively higher prevalence of type 2 diabetes mellitus, obesity, and hypertension in the more affluent SES group highlights contributory lifestyle behaviors. In contrast, use of the heavy, coarse bajra flour among the low SES group contributes to their higher fiber intake. This dietary pattern may play a role in the lower prevalence of type 2 diabetes mellitus, favorable metabolic parameters, and management of hyperglycemia among the agricultural farmworkers.[26] However, the higher physical activity levels of this group cannot be overlooked.

The prevalence of 26.1% hypertension in this rural community confirms the massive burden of this disease in India.[27] Prevalence may be influenced by lack of regular screening, few medical checkups, poor access to health care, and the asymptomatic nature of the disease, which are exacerbated by lifestyle factors such as high stress and poor dietary practices. The finding of high rates of hypertension reinforces the urgent need for educational programs to raise awareness of this silent killer and related comorbidities that disproportionately affect Indians.[27] Rodgers et al[28] have shown that a 2–mm Hg decrease in blood pressure can prevent as many as 151 000 stroke and 153 000 coronary heart disease deaths in India.

Sex disparities were also noted in our study. Females had higher prevalence of obesity and poorer awareness of the risk factors for type 2 diabetes mellitus and CVD compared to their male peers, which calls for a sex-based prevention program. Many of the women perceived weight gain and abdominal adiposity as inevitable corollaries to child bearing, and this concept was addressed during the intervention.[29] Nutritional transition in rural India (defined as the shift away from a diet high in fiber and complex carbohydrates toward a more energy-dense, low-fiber diet) along with sedentary lifestyle has been associated with increased prevalence of noncommunicable diseases.

Several lessons were learned from the educational intervention program. Community buy-in and support during the early phases, particularly the planning stages, were recognized as a crucial part of the success, as it created, inter alia, a forum where the villagers could talk and express their opinion and difficulties freely. For example, one of the areas where community events became strong agents of change was when the recipe contests were judged by the other respondents on the block. Initially, there was a strong resistance to changing the addition of refined sugar to all cooked dishes. Interactive community discussions and competitive recipe contests on every block, as steered by the CHWs, became major motivating factors for this practice to be modified. A similar example that illustrates the effectiveness of a community approach was in the area of physical exercise. Ayurvedic teachings emphasized daily yoga and meditation, but these seem to have fallen into disuse, especially among the younger generations. But through demonstrations, interactive discussions, and community events, CHWs were successful in reviving the interest and participation in physical activity and stress/relaxation exercises.

This study successfully replicated an earlier diabetes prevention and management study in South India,[16] tailored to the local lingo, customs, and traditions. The value and quality of the diabetes prevention and management program were evaluated by the CHWs and the project coordinator as outlined by Stringer: responsive, open inquiry, and audit review evaluation.[30] To illustrate, open inquiry and responses brought up concerns for unanimous rejection of serum blood glucose testing. The comment most often encountered was "I will participate in the study but not if you are going to take blood from my arm"; consequently, the study design had to be altered accordingly. The assessment of the dietary intake showed that most of the respondents from the business community were vegetarians, and their customary, high consumption of refined carbohydrates and fat was addressed in the educational sessions.

Although the cost of primary prevention in India is relatively low, the current health care system falls remarkably short. Our study has shown that the progression of IFG to diabetes can be successfully prevented through lifestyle intervention, even in this high-risk population. This participatory diabetes prevention and management intervention conducted in a community setting and delivered by CHWs was successful in reducing important metabolic parameters and can serve as a prototype for prevention and management of diabetes in India.

Author Contributions

Ranjita Misra: study design, data analysis, statistical measures, draft review/edit; Padmini Balagopal: study design, background, data collection, draft review/edit; Thakor G. Patel: data collection and draft edit; N. Kamalamma: data collection and draft edit.

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