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ORIGINAL ARTICLE

Convergence of Prevalence Rates of Diabetes and Cardiometabolic Risk Factors in Middle and Low Income Groups in Urban India: 10-Year Follow-Up of the Chennai Urban Population Study

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Abstract

Aim:

The aim of this study was to look for temporal changes in the prevalence of diabetes and cardiometabolic risk factors in two residential colonies in Chennai.

Methods:

Chennai Urban Population Study (CUPS) was carried out between 1996–1998 in Chennai in two residential colonies representing the middle income group (MIG) and lower income group (LIG), respectively. The MIG had twice the prevalence rate of diabetes as the LIG and higher prevalence rates of hypertension, obesity, and dyslipidemia. They were motivated to increase their physical activity, which led to the building of a park. The LIG was given standard lifestyle advice. Follow-up surveys of both colonies were performed after a period of 10 years.

Results:

In the MIG, the prevalence of diabetes increased from 12.4 to 15.4% (24% increase), while in the LIG, it increased from 6.5 to 15.3% (135% increase, $p < .001$). In the LIG, the prevalence rates of central obesity (baseline vs follow-up, male: 30.8 vs 50.9%, $p < .001$; female: 16.9 vs 49.8%, $p < .001$), hypertension (8.4 vs 20.1%, $p < .001$), hypercholesterolemia (14.2 vs. 20.4%, $p < .05$), and hypertriglyceridemia (8.0 vs 23.5%, $p < .001$) significantly increased and became similar to that seen in the MIG.

Conclusion:

There is a rapid reversal of socioeconomic gradient for diabetes and cardiometabolic risk factors in urban India with a convergence of prevalence rates among people in the MIG and LIG. This could have a serious economic impact on poor people in developing countries such as India.

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Abbreviations: (BMI) body mass index, (CUPS) Chennai Urban Population Study, (HDL) high-density lipoprotein, (IDPP) Indian Diabetes Prevention Programme, (LIG) lower income group, (MIG) middle income group, (NCD) noncommunicable disease, (SES) socioeconomic status, (WHR) waist-to-hip ratio

Keywords: Asian Indians, cardiometabolic risk factors, community empowerment, diabetes, physical activity, socioeconomic gradient

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Introduction

Prevalence rates of noncommunicable diseases (NCDs) such as diabetes, hypertension, obesity, dyslipidemia, and cardiovascular disease are increasing dramatically worldwide in developing countries such as India.[1] Significant differences in the prevalence of cardiometabolic risk factors have been reported in people of different socioeconomic status (SES) but the relationship with SES is different in developing and developed nations as they are in different stages of epidemiological transition. Thus, while in developing countries, prevalence rates of diabetes and cardiometabolic risk factors are higher among the more affluent,[2–4] in developed countries, the converse is true and prevalence rates are higher in the less affluent.[5,6]

The Chennai Urban Population Study (CUPS) was carried out in two urban residential colonies in Chennai (formerly Madras) city in southern India. This study showed a significantly higher prevalence of all cardiometabolic risk factors including diabetes in a middle income group (MIG) (Asiad colony in Tirumangalam) as compared to a lower income group (LIG) (Bharathi Nagar in T.Nagar).[7] The present study was undertaken after a decade to look for temporal changes in prevalence of diabetes and cardiometabolic risk factors in the same two colonies, in one of which (MIG) a community-based intervention was carried out.

Methods

Baseline Study

The baseline population was drawn from CUPS, an epidemiological study conducted in two residential colonies representing the MIG and LIG in Chennai, the details of which are published elsewhere.[4,7] In brief, the two residential colonies were purposively selected to represent the two socioeconomic groups (MIG and LIG), which represent over 95% of the population of Chennai. Definitions of MIG and LIG were based on the Housing and Urban Development Corporation classification. In this classification, LIG is defined as a household monthly income between Rs. 2500–5500 and MIG is defined as a household monthly income between Rs. 5501–10,000.[8] The aim was to look at differences in the prevalence of cardiometabolic risk factors in people of different socioeconomic strata within an urban environment. The baseline study was conducted from 1996 to 1998 and all individuals aged 20 years and above residing in these two colonies were invited to participate in a baseline screening program for diabetes and other cardiometabolic risk factors. Of the 1262 subjects recruited at baseline, 479 were from the MIG (response rate 91.4%) and 783 were from the LIG (response rate 89.4%).[4]

The baseline study included anthropometry (weight, height, and waist) and blood pressure measurements using standard methods.[7] A fasting venous sample was obtained (after ensuring 8 hours of overnight fast) for estimation of glucose and lipids. Following this, an oral glucose tolerance test (75 g) was conducted in individuals excluding known diabetic subjects.

Intervention: Community Empowerment

The baseline study showed that 12.4% of the MIG had diabetes, while in the LIG the prevalence rate was 6.5%.[4] Results of the survey were shared with both colonies. In the LIG, standard lifestyle advice was given as the prevalence rates of diabetes were low and, at that time, these individuals had sufficient physical activity. As the MIG colony residents had a two-fold higher prevalence of diabetes and low physical activity levels, the need for prevention was strongly emphasized to this group. The process of empowerment of colony residents is described in detail elsewhere.[9] In brief, to promote health in the community, awareness was created among colony residents by community-based education programs, which focused on adopting a healthier lifestyle with healthier food choices and increasing physical activity. Awareness programs included lectures, video clips, and short skits that emphasized the importance of physical activity in preventing diabetes and other NCDs. Various pamphlets and other educational material were also distributed to residents of this colony. Having been thus motivated, colony residents realized the need for increasing physical activity. Mobilizing funds from various sources, but primarily from donations from residents themselves and without any formal governmental funding, residents built a beautiful park just adjacent to their colony.[10] Furthermore, they motivated one another to increase physical activity, a result of which the percentage of exercisers in the colony increased from 14.2 to 58.7%.[9] Thus, our awareness programs resulted in the colony taking control of their need for physical activity.

Follow-Up Study

A follow-up examination of residents in the two colonies was performed from 2006 to 2008 after a mean period of 10 years. All individuals aged 20 years and above were invited to participate in the follow-up study. Chennai, like other cities in India, faces a lot of migration in and out of the city, particularly among the youth. We found that. overall, 604 (47.8%) individuals had moved out of the two colonies, 233 (48.6%) in Asiad colony and 371 (47.3%) in Bharathi Nagar. Meanwhile, 531 new residents had moved into the two colonies, 302 in the Asiad colony and 229 in the Bharathi Nagar colony. Sixty-eight individuals, 22 (4.6%) in Asiad colony and 46 (5.9%) in Bharathi Nagar, died during this period. For the purpose of this study, only those individuals residing in the respective colonies at the time of the follow-up study were examined, which comprised a total of 1122 individuals, 526 individuals from the MIG (response rate 73.9%) and 596 from the LIG (response rate 72.2%). Approval of the institutional ethical committee of the Madras Diabetes Research Foundation was obtained, and written informed consent was obtained from all study subjects.

All screening procedures employed and diagnostic criteria used were similar to the baseline study. All biochemical assays (plasma glucose and lipids) were done using Hitachi 912 Autoanalyzer (Roche Diagnostics GmbH, Mannheim, Germany) utilizing kits supplied by Roche Diagnostics GmbH. A structured questionnaire was used to elicit information, which included details on demographic and socioeconomic characteristics, health behavior, health status, medical history, and physical activity.

Study subjects were classified according to their job title: professionals (such as doctors, lawyers, businessmen, and executives), clerical (accountants and clerks), manual laborers, and others (housewives, elderly, and disabled). Educational status was graded as none, high school, graduate, and postgraduate. Monthly family income was graded as 1 (<Rs. 1000), 2 (Rs. 1001 ± 5000), 3 (Rs. 5001 ± 10,000), and 4 (>Rs. 10,000). Individuals were classified as nonsmokers, exsmokers, and current smokers (habitual smokers regardless of quantity smoked). Alcohol intake was categorized as none, social (if occasional drinkers), and regular (individuals who admitted to take alcohol everyday regardless of quantity consumed). Individuals were also categorized based on a physical activity questionnaire. The questionnaire included job-related activities, leisure-time activities, and questions on exercise. Physical activity was then graded as light, moderate, and heavy, using a scoring system that was validated in another study.[4]

Anthropometric measurements, including weight, height, waist, and hip measurements, were obtained using standardized techniques.

Body mass index (BMI): BMI was calculated using the formula: weight (kg)/height (m)^2.

Waist circumference: Waist was measured using a non-stretchable fiber measuring tape. The subjects were asked to stand erect in a relaxed position with both feet together on a flat surface; one layer of clothing was accepted. Waist girth was measured at the smallest horizontal girth between the costal margins and the iliac crests at minimal respiration.

Hip circumference: Hip measurement was taken at the greatest circumference at the level of greater trochanters (the widest portion of the hip) on both sides. Measurements were made to the nearest 0.1 cm.

Waist-hip ratio (WHR): WHR was calculated by dividing waist circumference (cm) by hip circumference (cm).

Blood pressure: Blood pressure was recorded in the sitting position in the right arm to the nearest 1 mm Hg using a mercury sphygmomanometer (Diamond Deluxe, Pune, India). Two readings were taken 5 minutes apart and their mean was taken as the blood pressure.

Definitions

Diabetes: Diabetes was diagnosed if the subjects were on drug treatment for diabetes or if the fasting plasma glucose was ≥126 mg/dl (≥7 mmol/liter) or 2-hour postglucose was ≥200 mg/dl (≥11.1 mmol/liter).[11]

Prediabetes: Prediabetes was diagnosed if fasting plasma glucose was ≥110 and <126 mg/dl (≥6.1 and <7 mmol/liter) (impaired fasting glycemia) or 2-hour postglucose was ≥140 and <200 mg/dl (≥7.8 and <11.1 mmol/liter) (impaired glucose tolerance).[12]

Hypertension: Hypertension was diagnosed based on drug treatment for hypertension or if blood pressure was ≥140/90 mm Hg.[13]

Obesity: Generalized obesity was defined using World Health Organization Asia-Pacific guidelines,[15] i.e., BMI ≥25 kg/m^2, and central obesity as WHR >0.9 for men and >0.85 for women.[14]

Dyslipidemia: National Cholesterol Education Program guidelines[15] were used for the definition of dyslipidemia.

Hypercholesterolemia: Hypercholesterolemia was diagnosed if serum cholesterol levels were ≥200 mg/dl (≥5.2 mmol/liter) or if subjects were under drug treatment for hypercholesterolemia.

Hypertriglyceridemia: Hypertriglyceridemia was diagnosed if serum triglyceride levels were ≥150 mg/dl (≥1.7 mmol/liter) or if subjects were under drug treatment for hypertriglyceridemia.

Low high-density lipoprotein (HDL) cholesterol: Low HDL cholesterol was diagnosed if HDL cholesterol levels were <40 mg/dl (<1.04 mmol/liter) for men and <50 mg/dl (<1.3 mmol/liter) for women.

Statistical Analysis

Statistical analyses were performed using SPSS for Windows version 10.0 software (SPSS Inc., Chicago, IL). Student's *t*-tests were used for continuous variable and Chi square test for proportions, and all comparisons were only between groups. Log-transformation of triglyceride values was performed to account for the skewness of the data and these values are presented as geometric means. The prevalence rates at baseline and follow-up were age-standardized to the 1991 census for Chennai. *P* values of <.05 were considered significant.

Results

Table 1 shows the demographic details of the study subjects at baseline and during follow-up. Compared to baseline, the mean income level of subjects at follow-up had almost doubled ($p < .001$) both in the MIG and LIG. Percentage of subjects who completed post graduation (at least 17 years of education) increased significantly (MIG, baseline vs follow-up: 12 vs 30%, $p < .001$; LIG, 0.3 vs 1.4%, $p < .05$). In the MIG, the proportion of professionals increased significantly ($p < .001$) whereas the proportion of manual laborers decreased significantly ($p < .001$). However, the occupational status of subjects in the LIG did not change significantly between baseline and follow-up. In both colonies, the proportion of subjects involved in light intensity activity decreased significantly and those involved in moderate intensity activity increased significantly. However, subjects involved in heavy intensity

Table 1.
Demographic Details of Study Population at Baseline and Follow-Up[a,b]

	Middle income group (Asiad Colony, Tirumangalam)		Low income group (Bharathi Nagar, T.Nagar)	
	Baseline study (n = 479)	Follow-up study (n = 526)	Baseline study (n = 783)	Follow-up study (n = 596)
Males n (%)	210 (43.8%)	236 (44.9%)	347 (44.3%)	237 (39.8%)
Income				
≤ Rs.1000	36 (7.5%)	4 (0.8%)[d]	268 (34.2%)	90 (15.2%)[d]
Rs.1001–5000	183 (38.2%)	48 (9.7%)[d]	499 (63.7%)	364 (61.5%)
Rs. 5001–10,000	165 (34.5%)	158 (31.9%)	16 (2.0%)	119 (20.1%)[d]
≥ Rs. 10,001	95 (19.8%)	285 (57.6%)[d]	0	19 (3.2%)[d]
Monthly income (Rs.)	8075 ± 3859	14,406 ± 9054[d]	1399 ± 916	4429 ± 2623[d]
Education n (%)				
None	12 (2.5%)	4 (0.8%)[c]	229 (29.5%)	156 (26.5%)
High school	224 (46.8%)	186 (36.0%)[d]	520 (66.4%)	392 (67.0%)
Graduate	186 (38.8%)	171 (33.1%)	30 (3.8%)	30 (5.1%)
Postgraduate	57 (12.0%)	155 (30.0%)[d]	2 (0.3%)	8 (1.4%)[c]
Occupation n (%)				
Professionals	119 (24.8%)	192 (37.9%)[d]	29 (3.7%)	22 (3.9%)
Clerks	108 (22.5%)	95 (18.7%)	73 (9.3%)	45 (8.1%)
Manual laborers	21 (4.4%)	1 (0.2%)[d]	383 (48.9%)	280 (50.2%)
Others	231 (48.2%)	219 (43.2%)	298 (38.1%)	211 (37.8%)
Physical activity n (%)				
Light	311 (64.9%)	175 (33.3%)[d]	280 (35.7%)	127 (21.3%)[d]
Moderate	143 (29.9%)	299 (56.8%)[d]	291 (37.2%)	411 (69.0%)[d]
Heavy	25 (5.2%)	52 (9.9%)[c]	212 (27.1%)	58 (9.7%)[d]

[a] Values are presented as numbers (percentages).
[b] 1 United States dollar is approximately 47 Indian rupees.
[c] $p < .05$ compared to baseline visit.
[d] $p < .001$ compared to baseline visit.

activity increased significantly in the MIG but decreased significantly in the LIG.

Table 2 presents the clinical characteristics of study subjects at baseline and during follow-up. In the MIG, there was no significant difference in the mean age of the subjects at baseline and during follow-up. However, in this group, compared to baseline, subjects at follow-up had significantly higher BMI ($p < .001$), waist circumference ($p < .001$), WHR (females) ($p < .001$), and fasting plasma glucose ($p < .001$). In the LIG, compared to baseline, the subjects at follow-up were older (41.1 ± 13.8 vs 39.3 ± 14.9 years, $p < .05$), had higher BMI ($p < .001$), waist circumference ($p < .001$), WHR ($p < .001$), fasting plasma glucose ($p < .001$), 2-hour postglucose plasma glucose ($p < .001$), systolic blood pressure ($p < .05$), diastolic blood pressure ($p < .001$), serum cholesterol ($p < .001$), and serum triglycerides ($p < .05$).

Table 3 shows the age-standardized prevalence rates of various cardiometabolic risk factors in the study population at baseline and follow-up. In the MIG, prevalence of diabetes increased from 12.4% at baseline to 15.4% at follow-up (24% increase, $p = .159$). In the LIG,

Table 2.
Clinical Features of the Study Population[a]

	Middle income group (Asiad Colony, Tirumangalam)		Low income group (Bharathi Nagar, T.Nagar)	
	Baseline study (n = 479)	Follow-up study (n = 526)	Baseline study (n = 783)	Follow-up study (n = 596)
Age (years)	48.7 ± 13.7	47.8 ± 14.6	39.3 ± 14.9	41.1 ± 13.8[b]
BMI (kg/m^2)	24.3 ± 4.0	25.8 ± 4.6[c]	21.5 ± 4.3	24.1 ± 4.6[c]
Waist circumference (cm)				
Male	86.9 ± 9.3	89.0 ± 9.6[c]	74.7 ± 10.7	81.5 ± 12.1[c]
Female	82.0 ± 11.7	86.2 ± 12.2[c]	72.9 ± 10.4	81.5 ± 11.4[c]
Waist-to-hip ratio				
Male	0.93 ± 0.07	0.92 ± 0.07[b]	0.86 ± 0.08	0.91 ± 0.07[c]
Female	0.84 ± 0.09	0.86 ± 0.09[c]	0.80 ± 0.08	0.86 ± 0.08[c]
Fasting plasma glucose (mmol/liter)	5.5 ± 2.7	6.1 ± 2.1[c]	4.4 ± 1.9	5.8 ± 2.4[c]
2-hour postglucose plasma glucose (mmol/liter)	6.9 ± 3.1	6.6 ± 2.3	5.6 ± 2.9	6.3 ± 3.6[c]
Systolic blood pressure (mm Hg)	126 ± 15	122 ± 20[c]	120 ± 16	123 ± 20[b]
Diastolic blood pressure (mm Hg)	81 ± 10	74 ± 10[c]	78 ± 10	75 ± 12[c]
Serum cholesterol (mmol/liter)	4.9 ± 1.0	4.7 ± 0.9[b]	4.3 ± 1.0	4.5 ± 0.9[c]
Serum triglycerides (mmol/liter)[d]	1.38 (0.06)	1.40 (0.05)	1.14 (0.04)	1.22 (0.03)[b]
Self-reported diabetes n (%)	67 (8.0%)	99 (11.5%)	24 (2.9%)	69 (9.4%)[c]
Self-reported hypertension n (%)	71 (7.9%)	104 (13.5%)[b]	33 (3.9%)	43 (5.9%)
Self-reported myocardial infarction n (%)	9 (0.9%)	20 (1.8%)	5 (0.7%)	11 (1.6%)
Smoking				
Exsmokers n (%)	17 (3.5%)	29 (5.5%)	21 (2.7%)	34 (5.7%)[b]
Current smokers n (%)	27 (5.6%)	16 (3.0%)[b]	140 (17.9%)	75 (12.6%)[b]
Alcohol				
Regular n (%)	23 (4.8%)	21 (4.0%)	108 (13.8%)	113 (19.0%)[b]
Social n (%)	54 (11.3%)	27 (5.1%)[c]	117 (14.9%)	21 (3.5%)[c]

[a] Values are presented as mean ± standard deviation.
[b] $p < .05$ compared to baseline visit.
[c] $p < .001$ compared to baseline visit.
[d] Log-transformed; values are presented as geometric mean (standard error).

the prevalence of diabetes increased from 6.5 to 15.3% (135% increase, $p < .001$). In the MIG, the increases in generalized obesity rates were 22% ($p < .05$) in males and 45% ($p < .001$) in females. In the LIG, the increases in generalized obesity rates were 109% ($p < .001$) in males and 107% ($p < .001$) in females. At follow-up, the prevalence of central obesity showed no significant difference in the MIG; in contrast, in the LIG, there was a 65% increase ($p < .001$) in central obesity rates among males and a 195% increase ($p < .001$) among females. In the LIG, the prevalence of hypertension ($p < .001$), hypercholesterolemia ($p < .05$), and hypertriglyceridemia ($p < .001$) increased markedly.

Discussion

This study makes the following points: (1) In the MIG colony, where physical activity levels increased as a result of community empowerment, there was only a marginal increase in cardiometabolic disease risk factors, including diabetes. (2) In the LIG, where there was no active intervention, prevalence rates of all cardiometabolic disease risk factors, including prevalence of diabetes, increased and the figures became similar to that seen in the MIG. Thus, two messages emerge from the study. First, there is a rapid transition of the socioeconomic gradient in urban India, and the prevalence of cardiometabolic risk factors and diabetes is now high even among the urban poor. Second, it is possible to slow down the increase in cardiometabolic disease risk factors, including diabetes, through community empowerment as shown in the MIG.

There are very few studies that have reported on the changing prevalence of cardiometabolic risk factors in urban poor people in India. A study in an urban slum population of Haryana reported that the prevalence rates of many NCD risk factors were higher in the slum population than in the urban population.[16] High prevalence rates of diabetes, obesity, and dyslipidemia were also reported in an urban slum in south Delhi.[17] Studies in other developing countries also show that NCDs such as diabetes and obesity may be equally prevalent in poor people.[18–20] However, all these studies are cross-sectional in nature and there is no study to

Table 3.
Age-Standardized Prevalence Rates of Various Cardiometabolic Risk Factors[a,b]

Cardiometabolic risk factors	Middle income group (Asiad Colony, Tirumangalam)				Low income group (Bharathi Nagar, T.Nagar)			
	Baseline study (*n* = 479)	Follow-up study (*n* = 526)	% change	*p* value[c]	Baseline study (*n* = 783)	Follow-up study (*n* = 596)	% change	*p* value[c]
Diabetes (self-reported + newly diagnosed) *n* (%)	99 (12.4%)	119 (15.4%)	h 24%	.159	53 (6.5%)	105 (15.3%)	h 135%	<.001
Impaired glucose tolerance *n* (%)	50 (7.5%)	49 (6.4%)	i -15%	.513	24 (2.9%)	15 (2.3%)	i -21%	.503
Hypertension (self-reported + newly diagnosed) *n* (%)	153 (14.9%)	159 (21.8%)	h 46%	<.05	126 (8.4%)	131 (20.1%)	h 139%	<.001
Generalized obesity *n* (%)								
Male	83 (38.0%)	109 (46.5%)	h 22%	<.05	44 (13.4%)	66 (28.0%)	h 109%	<.001
Female	113 (33.1%)	163 (48.1%)	h 45%	<.001	111 (24.2%)	184 (50.2%)	h 107%	<.001
Central obesity *n* (%)								
Male	137 (53.4%)	142 (51.9%)	i -3%	.625	100 (30.8%)	122 (50.9%)	h 65%	<.001
Female	88 (41.6%)	151 (41.7%)	h 0.2%	.977	82 (16.9%)	183 (49.8%)	h 195%	<.001
Hypercholesterolemia *n* (%)	173 (24.2%)	126 (20.8%)	i -14%	.184	121 (14.2%)	123 (20.4%)	h 44%	<.05
Hypertriglyceridemia *n* (%)	132 (7.6%)	134 (27.2%)	h 258%	<.05	144 (8.0%)	135 (23.5%)	h 194%	<.001

[a] Values are presented as numbers (percentages).
[b] Prevalence rates were age-standardized to the 1991 census of India.
[c] *p* value implies significance between baseline and follow-up visit.

our knowledge that has reported on secular trends in diabetes prevalence in the MIG and LIG in India. This is particularly significant in the context of the growing epidemic of diabetes in developing countries such as India.

The Diabetes Prevention Program and other large randomized trials have demonstrated that lifestyle intervention (structured diet and physical activity) among subjects with prediabetes significantly reduces the progression to diabetes.[21,22] The Indian Diabetes Prevention Programme (IDPP), a 3-year randomized, controlled trial, also showed that lifestyle modification and metformin help to prevent diabetes in subjects with impaired glucose tolerance.[23] The IDPP also suggested that when resources are available for prevention, lifestyle modification should be implemented first as it represents the best use of resources.[24]

There are few studies that have reported on community-based approaches to prevent diabetes. The Haida Gwaii Diabetes Project illustrates how community-based family practice research can be a tool for empowerment for the community.[25] A community-based intervention comparing lifestyle change in two churches in urban New Zealand demonstrated an increase in diabetes knowledge and exercise habits, reduction in waist circumference, weight control, and alteration in dietary fat consumption.[26] We are not aware of such studies from Asia or from developing countries that will bear the brunt of the global diabetes epidemic.[1]

There is evidence to show that increased physical activity can reduce age-related increases in waist circumference[27–29] and weight gain,[27,29,30] and improve lipid profile[29,30–32] and blood pressure.[27] Conversely, a reduction in physical activity level may worsen the cardiovascular disease risk factor profile.[27,30,33] In the present study, in the MIG where the intervention was done, no change in the central obesity rate was seen, whereas in the nonintervention LIG, there was an over 100% increase in prevalence of generalized obesity.

Several features of the environment, including the presence of green spaces, pavements, and cycle paths and the degree of urbanization play an important role in deciding the physical activity level of the population. Studies have reported that people living near green spaces, including parks, playgrounds, and sports fields, are more likely to walk and have higher levels of physical activity.[34–36] Other physical features of the environment such as proper street planning with bicycle lanes or the presence of pavements are also positively associated with various physical activity measures.[34,37,38] Evidence has shown that the absence of exercise and recreational facilities increases the risk of being overweight/obese.[39,40] Living in an attractive or aesthetically pleasing neighborhood seems to encourage walking and overall physical activity,[41–44] whereas living in an unsafe and unpleasant environment discourages walking and overall physical activity.[35,36,42,43,45] In the present study, the LIG environment had no space for walking and, moreover, was unsafe and unpleasant, which discouraged physical activity in their colony. Thus, those aspects of the environment that promote physical activity should be encouraged when planning cities or towns in developing countries.

A 2008 study showed that prevalence rates of diabetes in Chennai had increased to over 18% and that the MIG represented over 80% of Chennai's population.[46] Prevalence rates of diabetes in the MIG increased only marginally to 15.4%. We can therefore speculate that, had the intervention not been done in the MIG colony, the diabetes rates would have been much higher. Indeed, in another MIG colony in Chennai very similar to the Asiad Colony, we found the prevalence rate of diabetes to be 20.3% (unpublished findings). This demonstrates that by making a modest investment of money (building a park) and time (physical activity in the form of walking for about 30 minutes a day), diabetes can be prevented in a substantial proportion of people. If this finding is extrapolated to the whole of India with a population of over a billion people, then development of diabetes could be prevented in millions of people in India.

The present study is of interest because it is the first from a developing country that involves a real-world experience of lifestyle intervention in preventing diabetes. The MIG adopted a lifestyle intervention of increased physical activity levels by building a park utilizing their own resources. This is an example of translational research where prevention of diabetes was achieved in a real-life setting through community empowerment. This underscores the importance of sharing the results of research studies with the community.

Studies from India have also reported a reversal of the socioeconomic gradient.[17,47] As the epidemiological transition matures, the epidemic of diabetes and obesity in India and other developing countries will move to the urban poor and to rural areas as presently seen in developed countries.[48] This could pose a huge socioeconomic burden on developing countries as the poor cannot afford to pay for lifelong treatment that chronic diseases require. This underscores the need for measures to prevent

NCDs such as diabetes and obesity in poor people of developing countries such as India. It is estimated that the poor spend 25–35% of their monthly income toward treatment of diabetes as most patients pay out of pocket for medical expenses.[49]

Stevens and colleagues[50] have suggested an alternative metric, excess gain, which addresses some of the shortcomings of commonly used metrics such as means, incidence, and prevalence. For instance, in an obesity intervention trial, excess gain takes into account two criteria: (1) a body measurement that is greater than the predesignated cut point and (2) a gain of >3% in body measurements compared with baseline. This new concept (prevention of excess gain) is useful as even a slowing down of the increase in obesity and diabetes rates can be considered prevention in a society that is becoming increasingly obesogenic.[51] In this context, the smaller increase in prevalence rates of diabetes in the MIG in this study assumes significance.

The strengths of this study are (1) it is one of the first studies from a developing country that demonstrates activities for preventing diabetes in a real-world setting and (2) the follow-up period is a decade long. However, the findings should be generalized with caution as there are number of limitations. As we have studied only two selected colonies, this limits the generalizability of this study. The self-reported physical activity inevitably involves a certain risk of bias and misclassification. The number of individuals studied is also rather small. Finally, the baseline and follow-up studies report on different sets of individuals living within the two colonies. However, as people of similar socioeconomic status tend to live together, this should not be a matter of concern. Even given these limitations, the strong public health messages that emerge from this article should be of interest to policy makers and administrators in India and other developing countries.

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