Achievement of guideline recommended diabetes treatment targets and health habits in people with self-reported diabetes in India (ICMR-INDIAB-13): a national cross-sectional study

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Summary

Background There is little information on comprehensive diabetes care comprising glycaemic, lipid, and blood pressure control in India; therefore, we aimed to assess the achievement of treatment targets among adults with self-reported diabetes.

Methods The Indian Council of Medical Research (ICMR)-India Diabetes (INDIAB) study is a cross-sectional, population-based survey of adults aged 20 years or older in all 30 states and union territories of India. We used a stratified multistage sampling design, sampling states in a phased manner, and selected villages in rural areas and census enumeration blocks in urban areas. We used a three-level stratification method on the basis of geography, population size, and socioeconomic status for each state. For the outcome assessment, good glycaemic control was defined as HbA_{1c} of less than 7·0% (A), blood pressure control was defined as less than 140/90 mm Hg (B), and the LDL cholesterol target was defined as less than 100 mg/dL (C). ABC control was defined as the proportion of individuals meeting glycaemic, blood pressure, and LDL cholesterol targets together. We also performed multiple logistic regression to assess the factors influencing achievement of diabetes treatment targets.

Findings Between Oct 18, 2008, and Dec 17, 2020, 113 043 individuals (33 537 from urban areas and 79 506 from rural areas) participated in the ICMR-INDIAB study. For this analysis, 5789 adults (2633 in urban areas and 3156 in rural areas) with self-reported diabetes were included in the study population. The median age was 56·1 years (IQR 55·7–56·5). Overall, 1748 (weighted proportion 36·3%, 95% CI 34·7–37·9) of 4834 people with diabetes achieved good glycaemic control, 2819 (weighted proportion 48·8%, 47·2–50·3) of 5698 achieved blood pressure control, and 2043 (weighted proportion 41·5%, 39·9–43·1) of 4886 achieved good LDL cholesterol control. Only 419 (weighted proportion 7·7%) of 5297 individuals with self-reported diabetes achieved all three ABC targets, with significant heterogeneity between regions and states. Higher education, male sex, rural residence, and shorter duration of diabetes (<10 years) were associated with better achievement of combined ABC targets. Only 951 (weighted proportion 16·7%) of the study population and 227 (weighted proportion 36·9%) of those on insulin reported using self-monitoring of blood glucose.

Interpretation Achievement of treatment targets and adoption of healthy behaviours remains suboptimal in India. Our results can help governments to adopt policies that prioritise improvement of diabetes care delivery and surveillance in India.

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Introduction

Diabetes affects more than 537 million individuals across the globe and is one of the leading causes of death worldwide.[1,2] It has been unequivocally shown that maintaining good glycaemic control can prevent or delay the onset of complications;[3,4] however, comprehensive cardiovascular risk reduction in diabetes also requires attainment of lipid and blood pressure treatment targets, avoidance of smoking and adoption of other healthy behaviours such as increased physical activity.

Although reports[5,6] from high-income countries have shown reductions in complications and mortality resulting from diabetes, probably due to better control of risk factors, the situation is far from satisfactory in low-income and middle-income countries. India has the second largest number of people with diabetes in the world[1] and only a quarter achieve glycaemic targets, and even less achieve blood pressure control targets.[7,8] However, these studies have been mostly clinic based and within an urban setting;[9] therefore, the results

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Research in context

Evidence before this study

Comprehensive risk factor control, focusing on attainment of glycaemic, lipid, and blood pressure targets has been shown to be associated with a reduction in complications and mortality in people with diabetes. Evidence from high-income countries shows that there have been substantial improvements in glycaemic control and other cardiometabolic risk factor control in people with diabetes in the past decade. However, scarce data are available in low-income and middle-income countries, such as India, which has the second largest number of people with diabetes in the world.

We searched PubMed, Google Scholar, IndMED, and the Cochrane Database of Systematic Reviews, and relevant reference lists and review articles published in English between database inception and May 31, 2021, on the achievement of type 2 diabetes treatment targets in Asian Indian people. We used the search terms "diabetes", "self-reported diabetes", "diagnosed diabetes", "known diabetes", "treatment goals", "care goals", "glycaemic targets", "blood pressure targets", "lipid targets", "target goals", "achievement", "urban", "rural", "India", "Asian Indians", and "South Asians". We used a combination of Medical Subject Headings and free terms for the search, with no study design restrictions. The key inclusion criteria were original studies in participants aged 20 years or older and Asian Indian people with diabetes.

Added value of this study

We report for the first time, to our knowledge, results from the largest epidemiological study done in India in the field of diabetes. In this population-based study we showed that achievement of treatment targets remain suboptimal in the Asian Indian population with self-reported diabetes. Alarmingly, fewer than 8% of individuals with diabetes achieved their glycaemic, blood pressure, and lipid targets. Only a small proportion of individuals with diabetes in India perform self-monitoring of blood glucose, and even fewer meet the global recommendations for physical activity and fruit and vegetable intake. There is substantial heterogeneity in attainment of treatment targets between Indian regions and states.

Implications of all the available evidence

Our findings emphasise the need for better control of glycemic, blood pressure, and lipid targets to reduce microvascular and cardiovascular risk in the Asian Indian population. Such results could serve as a basis for Government policy decisions to strengthen diabetes care at the primary, secondary, and tertiary settings in India. Because health care is the primary responsibility of the Indian Government, our region and state-level findings could assist the Indian Governments to identify gaps in care and formulate policies for improving diabetes care in their respective states. These results could also be valuable to other countries in South Asia.

cannot be considered representative of India, especially because 70% of the population lives in rural areas.

We aimed to assess the achievement of guideline-recommended health habits and treatment targets for glycemia HbA_{1c} (A), blood pressure (B), and lipids (C) defined as ABC targets among individuals with known diabetes in India.

Methods

Sampling and study population

The Indian Council of Medical Research (ICMR)-India Diabetes (INDIAB) study is a cross-sectional, population-based survey conducted in 30 states and union territories of India.[10–16] Adults aged 20 years or older who consented to participate were included in the study. Those who had acute conditions, such as febrile illness, breathlessness, or paralysis, that would limit their ability to participate or refused to provide informed consent were excluded from the study. In phase 1, four regions representing the south (Tamil Nadu), north (Chandigarh), east (Jharkhand), and west (Maharashtra) of the country were studied from 2008 to 2010. Between 2011 and 2020, the remaining states were surveyed as follows: phase 2 consisted of undivided Andhra Pradesh (subsequently divided into Andhra Pradesh and Telangana), Bihar, Gujarat, Karnataka, and Punjab (survey period, 2012–2013), phase 3 included Delhi, Madhya Pradesh, Rajasthan and Uttar Pradesh (survey period, 2017–2018), phase 4 included Kerala, Goa, Puducherry, Haryana and Chhattisgarh (survey period, 2018–2019), North East Phase included Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (survey period, 2011–2017) and Phase 5 included Himachal Pradesh, Uttarakhand, Odisha and West Bengal (survey period, 2019–2020). Using systematic sampling, we selected villages in rural areas and used census enumeration blocks in urban areas. To obtain a representative sample, we used a stratified multistage sampling design based on geography, population size, and female literacy rate (as a surrogate of socioeconomic status). The primary sampling units were villages in rural areas and census enumeration blocks in urban areas. Using a systematic sampling method, we selected 24 households from urban areas and 56 households from rural areas. Door-to-door assessment was conducted and one individual was selected at random from each household, in accordance with the WHO Kish method,[17] thereby avoiding selection bias with respect to sex and age. The full methodology has been published elsewhere.[10]

Written informed consent was obtained from all study participants. The study was approved by an institutional ethics committee of the Madras Diabetes Research Foundation. More details on the sampling strategy and phases are shown in the appendix (pp 2–8) and have been published earlier.[10,11,15]

Procedures

For the demographic and behavioural assessment, a standardised structured questionnaire was used to collect information on demographic and socioeconomic characteristics, dietary habits, physical activity, smoking, alcohol, medical history, and family history of diabetes. Smoking and alcohol use were self-reported (current or in the past 6 months). Daily consumption of fruit and vegetables was also self-reported and adequate intake was defined as consumption of 3 or more servings per day. Physical activity was assessed using the validated Madras Diabetes Research Foundation Physical Activity Questionnaire.[18] The physical activity level was calculated as total energy expenditure divided by basal metabolic rate for 24 h and individuals were allocated into three categories: sedentary (range 1·40–1·69), moderately active (1·70–1·99), and vigorously active (2·00–2·40). Moderate and vigorous physical activity were grouped for analysis. Additionally, in those with self-reported diabetes, information was collected on the duration of diabetes, medication use, whether or not blood glucose was self-monitored, choice of health facility (government or private), and the system of treatment (allopathic medicine, ayurveda, unani, siddha, or homeopathy).

For an anthropometric and clinical assessment, we measured weight, height, waist circumference, and blood pressure using standardised techniques.[19] BMI was calculated by dividing bodyweight by the square of height. Generalised obesity was defined as BMI of $25 kg/m^2$ or higher and abdominal obesity was defined as waist circumference of 90 cm or more for men and 80 cm or more for women (based on WHO Asia Pacific guidelines).[20] Blood pressure was recorded to the nearest 1 mm Hg using electronic sphygmomanometers (Omron HEM-7101; Omron Corporation, Tokyo, Japan). The final reading was recorded as the average of two readings taken 5 min apart. Interobserver and intraobserver coefficients of variation between the field technicians were less than 5% across all regions.

For the biochemical assessment, capillary blood glucose measurements were taken using a glucose meter (LifeScan One Touch Ultra; Johnson and Johnson, Milpitas, CA, USA) after ensuring an overnight fast of at least 8 h. Equipment with same specifications was used throughout the study as a measure of quality assurance. A venous sample was drawn for assessment of HbA_{1c} and lipids in all individuals with diabetes. Samples were centrifuged within 1 h at the survey site, and serum was transferred to separate labelled vials and temporarily stored in –20°C freezers until they were transferred to the central laboratory in Chennai, India. All biochemical assays were carried out by laboratory technicians using standardised methods. HbA_{1c} was estimated by high-performance liquid chromatography using the Variant II Turbo machine (Bio-Rad; Hercules, CA, USA), which is certified by the National Glycohemoglobin Standardization Program and was used in the Diabetes Control and Complications trial as a reference method.[21] Serum cholesterol (cholesterol esterase oxidase–peroxidase–amidopyrine method), serum triglycerides (glycerol phosphate oxidase–peroxidase–amidopyrine method), and HDL cholesterol (direct method; polyethylene glycol pretreated enzymes) were measured using an autoanalyser (model 2700/480; Beckman Coulter, O'Callaghans Mills, Ireland). Non-HDL cholesterol was derived by subtracting the HDL cholesterol concentration from total cholesterol. The intraassay and interassay coefficients of variation for biochemical assays ranged between 3·1% and 7·6%.

See Online for appendix

Outcomes

Self-reported or known diabetes was defined by the physician or the use of insulin or oral hypoglycaemic drugs for diabetes in the past 6 months. Physician diagnosis was checked against medical reports or patient's prescription for validity. For the outcome assessment, good glycaemic control was defined as HbA_{1c} of less than 7·0% and good blood pressure control was defined as less than 140/90 mm Hg.[22] Good lipid control was defined as total cholesterol of less than 200 mg/dL, triglycerides of less than 150 mg/dL, LDL cholesterol of less than 100 mg/dL, and non-HDL cholesterol of less than 160 mg/dL.[22] ABC control was defined as the proportion of individuals meeting glycaemic, blood pressure, and LDL cholesterol targets together.

Statistical analysis

To assess whether the power required to report on treatment goals, the proportion of individuals with HbA_{1c} control (ie, HbA_{1c} <7%) of 36·3% was used. Allowing for a margin of error of 3% and a significance level of 5%, the sample size was estimated to be 986. Estimates for continuous variables are shown as mean (95% CI) and for categorical variables are shown as proportions (95% CI). Sampling weights were calculated to account for sampling at different levels within each state (appendix pp 8–10). All statistical analyses accounted for the complex survey design by applying appropriate survey weights and error estimation techniques.[23] The primary sampling unit was accounted for as the cluster, the normalised weight was accounted for as the final study weight, and the state was accounted for as the stratum to estimate population means, variance, and proportions. To compare the mean or percentage of variables between two groups (urban and rural, and male and female), survey-adjusted linear regression and Wald χ^2 was applied. For sub-group analysis, the Indian states were divided into six geographical zones: north (Chandigarh, Delhi, Haryana, Himachal Pradesh, Punjab, and Rajasthan), south (Andhra Pradesh, Karnataka, Kerala, Puducherry, and Tamil Nadu), East (Bihar, Jharkhand, Odisha, and West Bengal), west (Goa, Gujarat, and Maharashtra), central (Chhattisgarh, Madhya Pradesh, Uttar Pradesh, and Uttaranchal), and the north east (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura). Multiple logistic regression analysis was used to examine the various factors such as age, sex, area of residence, duration of diabetes, education, smoking and alcohol usage, fruit and vegetable consumption, physical activity, and medication use influencing the achievement of treatment goals. α was set at 0·05 to determine statistical significance. To analyse data, we used Statistical Data Analysis Software (version 9.4; SAS Institute, Cary, NC, USA).

Role of the funding source

The funder of the study had a role in the study design, data interpretation, and writing of the report.

Results

Between Oct 18, 2008, and Dec 17, 2020, 119 022 participants were assessed for eligibility in the ICMR-INDIAB

	Urban (n=2633)	Rural (n=3156)	p value	Male (n=3010)	Female (n=2779)	p value	Overall (n=5789)
Demographics							
Age, years	55·6 (54·9–56·2)	56·6 (56·1–57·2)	0·0080	56·4 (55·9–56·8)	55·9 (55·3–56·5)	0·21	56·1 (55·7–56·5)
BMI, kg/m²	26·3 (26·0–26·5)	24·9 (24·8–25·1)	<0·0001	24·7 (24·5–24·9)	26·4 (26·2–26·7)	<0·0001	25·6 (25·4–25·7)
Median waist circumference, cm	92·5 (91·8–93·2)	89·6 (89·1–90·1)	<0·0001	91·7 (91·1–92·2)	90·2 (89·6–90·9)	0·0004	91·0 (90·5–91·4)
Generalised obesity	1451 (58·4%, 55·7–61·1)	1435 (45·2%, 43·1–47·2)	<0·0001	1279 (44·0%, 41·7–46·2)	1607 (59·1%, 56·8–61·5)	<0·0001	2886 (51·4%, 49·7–53·1)
Abdominal obesity	1861 (73·4%, 70·9–75·9)	1983 (63·7%, 61·8–65·7)	<0·0001	1663 (55·9%, 53·7–58·1)	2181 (81·4%, 79·6–83·3)	<0·0001	3844 (68·3%, 66·7–69·8)
Median duration of diabetes, years	5·0 (2·5–9·9)	4·9 (2·0–9·5)	..	5·0 (2·5–9·9)	4·9 (2·0–9·5)	..	5·0 (2·0–9·9)
Education							
No formal schooling	392 (16·5%, 14·6–18·4)	750 (23·3%, 21·7–24·9)	<0·0001	246 (8·5%, 7·3–9·6)	896 (32·2%, 30·1–34·3)	<0·0001	1142 (20·1%, 18·9–21·3)
Primary school, high school, or higher secondary school	1693 (63·4%, 61·0–65·8)	2083 (66·5%, 64·7–68·3)	0·054	2099 (69·5%, 67·6–71·5)	1677 (60·4%, 58·2–62·6)	<0·0001	3776 (14·9%, 13·7–16·0)
Technical, undergraduate, or postgraduate education	546 (20·1%, 18·1–22·0)	317 (10·2%, 9·0–11·3)	<0·0001	660 (22·0%, 20·2–23·8)	203 (7·4%, 6·2–8·6)	<0·0001	863 (65·1%, 63·6–66·5)
Health-care use							
Government (public)*	663 (32·0%, 29·3–34·7)	1105 (43·3%, 41·3–45·4)	<0·0001	848 (35·6%, 33·4–37·8)	920 (40·4%, 37·9–42·8)	0·015	1768 (38·0%, 36·3–39·7)
Private†	1552 (68·0%, 65·3–70·7)	1484 (56·7%, 54·6–58·7)	<0·0001	1586 (64·4%, 62·2–66·6)	1450 (59·6%, 57·2–62·1)	0·015	3036 (62·0%, 60·3–63·7)
System of medicine							
Allopathy only	2188 (83·7%, 81·7–85·7)	2555 (82·9%, 81·3–84·5)	0·53	2395 (81·4%, 79·6–83·1)	2348 (85·3%, 83·6–86·9)	0·0008	4743 (83·3%, 82·0–84·6)
Allopathy in combination with other medicine	157 (5·9%, 4·8–7·1)	192 (6·0%, 5·0–7·0)	0·88	203 (6·7%, 5·6–7·9)	146 (5·2%, 4·2–6·2)	0·035	349 (6·0%, 5·2–6·7)
Ayurveda only	41 (1·7%, 1·0–2·5)	61 (1·8%, 1·3–2·3)	0·84	61 (2·0%, 1·4–2·6)	41 (1·6%, 0·9–2·3)	0·37	102 (1·8%, 1·3–2·2)
Others‡	16 (0·6%, 0·3–1·0)	21 (0·6%, 0·3–0·9)	0·99	22 (0·8%, 0·4–1·1)	15 (0·5%, 0·2–0·8)	0·22	37 (0·6%, 0·4–0·9)
Not on any medication	201 (8·0%, 6·5–9·6)	286 (8·7%, 7·4–9·9)	0·54	286 (9·2%, 7·9–10·4)	201 (7·5%, 6·3–8·8)	0·059	487 (8·4%, 7·4–9·3)
Self-monitoring of blood glucose (n=5470)							
Total number of individuals	519 (19·4%, 17·4–21·4)	432 (14·2%, 12·9–15·5)	0·0002	520 (17·5%, 15·9–19·1)	431 (15·8%, 14·1–17·5)	0·15	951 (16·7%, 15·5–17·8)
More than once per day	15 (3·2%, 1·1–5·3)	10 (2·7%, 1·0–4·5)	0·72	14 (3·1%, 1·3–5·0)	11 (2·9%, 0·8–4·9)	0·85	25 (3·0%, 1·6–4·4)
Once per day	26 (4·8%, 2·5–7·2)	27 (6·0%, 3·7–8·3)	0·46	25 (4·7%, 2·5–6·8)	28 (6·2%, 3·6–8·8)	0·40	53 (5·4%, 3·7–7·0)
Once per week	218 (42·8%, 37·2–48·4)	164 (36·1%, 31·4–40·9)	0·092	215 (41·0%, 36·0–45·9)	167 (38·4%, 32·7–44·1)	0·49	382 (39·8%, 36·0–43·5)
Once per month	211 (39·4%, 34·0–44·9)	195 (44·7%, 39·7–49·7)	0·20	210 (39·8%, 34·9–44·8)	196 (44·1%, 38·4–49·8)	0·23	406 (41·8%, 38·1–45·6)
Once per year	14 (2·3%, 1·0–3·6)	10 (2·4%, 0·7–4·2)	0·92	13 (2·7%, 1·0–4·4)	11 (2·0%, 0·7–3·3)	0·55	24 (2·4%, 1·3–3·4)
Very rarely or not at all	38 (7·4%, 3·7–11·0)	33 (8·0%, 5·2–10·7)	0·79	46 (8·7%, 6·0–11·4)	25 (6·4%, 2·5–10·4)	0·35	71 (7·6%, 5·3–10·0)
Total number of individuals using insulin	318 (11·5%)	327 (10·8%)	..	352 (11·8%)	293 (10·5%)	..	645 (11·1%)
Total number of individuals using insulin and self-monitoring of blood glucose	126 (42·0%, 35·1–49·0)	101 (31·9%, 26·5–37·3)	0·038	123 (36·2%, 30·3–42·0)	104 (37·8%, 31·1–44·6)	0·74	227 (36·9%, 32·5–41·4)
Glycaemic parameters							
Total number of individuals with glycaemic parameters	2171 (81·5%)	2663 (84·6%)	..	2563 (85·2%)	2271 (80·9%)	..	4834 (81·6%)
Mean HbA_{1c}	8·1% (8·0–8·2)	8·0% (7·9–8·1)	0·55	8·1% (8·0–8·1)	8·1% (8·0–8·2)	0·74	8·1% (8·0–8·1)
Mean HbA_{1c}§	8·0% (0·1)	7·9% (0·1)	..	8·0% (0·1)	7·9% (0·1)	..	7·9% (0·1)

(Table 1 continues on next page)

	Urban (n=2633)	Rural (n=3156)	p value	Male (n=3010)	Female (n=2779)	p value	Overall (n=5789)
(Continued from previous page)							
Blood pressure							
Total number of individuals with blood pressure parameters	2588 (98·3%)	3110 (98·6%)	..	2964 (98·3%)	2734 (98·5%)	..	5698 (98·0%)
Mean systolic blood pressure	141·4 (140·0–142·8)	139·6 (138·7–140·5)	0·036	140·0 (139·1–141·0)	140·9 (139·7–142·1)	0·22	140·5 (139·5–141·3)
Mean diastolic blood pressure	83·7 (82·9–84·5)	84·2 (83·7–84·7)	0·28	84·6 (84·1–85·1)	83·4 (82·7–84·0)	0·0009	84·0 (83·5–84·4)
Lipid parameters, mg/dL							
Total number of individuals with lipid parameters	2201 (82·8%)	2685 (85·2%)	..	2595 (86·4%)	2291 (81·6%)	..	4886 (82·6%)
Mean cholesterol	184·1 (181·5–186·6)	187·9 (185·8–190·0)	0·024	181·6 (179·5–183·8)	191·0 (188·6–193·4)	<0·0001	186·1 (184·5–187·8)
Mean triglycerides	188·1 (180·4–195·7)	189·2 (183·3–195·1)	0·82	195·1 (188·7–201·6)	181·5 (174·2–188·9)	0·0078	188·7 (183·9–193·4)
Mean HDL cholesterol	38·8 (38·2–39·3)	39·3 (38·8–39·8)	0·17	37·4 (36·9–37·8)	40·9 (40·4–41·4)	<0·0001	39·1 (38·7–39·4)
Mean LDL cholesterol	107·7 (105·5–109·8)	110·7 (108·9–112·5)	0·033	105·2 (103·4–107·1)	113·8 (111·7–115·9)	<0·0001	109·3 (107·9–110·7)
Mean non-HDL cholesterol¶	145·3 (142·8–147·8)	148·6 (146·6–150·6)	0·042	144·3 (142·2–146·3)	150·1 (147·8–152·4)	0·0002	147·0 (145·5–148·6)
Medication use							
Total number of individuals with drug details	1460 (55·5%)	1904 (60·3%)	..	1689 (56·1%)	1675 (60·3%)	..	3364 (58·1%)
Glucose-lowering drugs							
Total number of individuals	1358 (91·4%)	1765 (93·0%)	..	1558 (92·3%)	1565 (92·4%)	..	3123 (92·3%)
Single drug	963 (71·8%, 67·9–75·7)	1210 (67·9%, 65·4–70·4)	0·098	1103 (71·0%, 68·4–73·7)	1070 (68·1%, 65·2–71·0)	0·10	2173 (69·5%, 67·4–71·7)
Multiple drugs	395 (28·2%, 24·3–32·1)	555 (32·1%, 29·6–34·6)	0·098	455 (29·0%, 26·3–31·6)	495 (31·9%, 29·0–34·8)	0·10	950 (30·5%, 28·3–32·6)
Blood pressure-lowering drugs							
Total number of individuals	451 (31·4%)	602 (32·0%)	..	456 (27·4%)	597 (36·0%)	..	1053 (31·8%)
Single drug	374 (84·2%, 79·9–88·6)	505 (83·8%, 80·4–87·2)	0·88	366 (79·8%, 75·4–84·1)	513 (87·1%, 84·0–90·1)	0·0051	879 (84·0%, 81·3–86·7)
Multiple drugs	77 (15·8%, 11·4–20·1)	97 (16·2%, 12·8–19·6)	0·88	90 (20·2%, 15·9–24·6)	84 (12·9%, 9·9–16·0)	0·0051	174 (16·0%, 13·3–18·7)
Lipid-lowering drugs							
Total number of individuals	266 (16·4%)	308 (16·4%)	..	289 (16·6%)	285 (16·3%)	..	574 (16·4%)
Single drug	191 (72·9%, 65·8–80·1)	226 (74·7%, 69·5–79·8)	0·68	196 (69·8%, 63·6–76·1)	221 (77·9%, 72·4–83·4)	0·043	417 (73·9%, 69·5–78·4)
Multiple drugs	75 (27·1%, 19·9–34·2)	82 (25·3%, 20·2–30·5)	0·68	93 (30·2%, 23·9–36·4)	64 (22·1%, 16·6–27·6)	0·043	157 (26·1%, 21·6–30·5)
Angiotensin II receptor blocker	211 (14·6%, 12·0–17·2)	206 (10·7%, 9·0–12·4)	0·016	185 (11·1%, 9·2–13·0)	232 (13·6%, 11·4–15·8)	0·090	417 (12·4%, 10·9–13·8)
Angiotensin converting enzyme inhibitors	42 (2·3%, 1·3–3·2)	54 (2·7%, 2·0–3·5)	0·48	46 (2·3%, 1·5–3·2)	50 (2·7%, 1·8–3·6)	0·55	96 (2·5%, 2·0–3·1)
Health habits							
Total number of individuals smoking	337 (13·8%)	446 (13·8%)	..	723 (24·8%)	60 (2·3%)	..	783 (12·7%)
Smoking <10 per day	197 (56·9%, 49·4–64·5)	195 (44·8%, 39·5–50·2)	0·012	358 (50·4%, 45·8–54·9)	34 (52·6%, 36·1–69·0)	0·79	392 (50·5%, 46·0–55·1)
Smoking ≥10 per day	140 (43·1%, 35·5–50·6)	251 (55·2%, 49·8–60·5)	0·012	358 (49·6%, 45·1–54·2)	34 (47·4%, 31·0–63·9)	0·79	391 (49·5%, 44·9–54·0)
Total number of individuals using alcohol	349 (14·1%)	443 (14·3%)	..	768 (26·8%)	24 (1·1%)	..	792 (13·0%)
Alcohol <30 mL per day	27 (63·4%, 57·1–69·6)	291 (66·2%, 61·4–71·0)	0·49	497 (63·9%, 60·1–67·8)	21 (89·0%, 75·9–100)	0·025	518 (64·9%, 61·1–68·7)
Alcohol ≥30 mL per day	122 (36·6%, 30·4–42·9)	152 (33·8%, 29·0–38·6)	0·49	271 (36·1%, 32·2–39·9)	3 (11·0%, 0·0–24·1)	0·025	274 (35·1%, 31·3–38·9)
Total number of individuals reported passive smoking	457 (19·0%, 16·6–21·4)	528 (19·1%, 17·2–21·0)	0·93	516 (20·8%, 18·8–22·9)	469 (17·5%, 15·5–19·6)	0·028	985 (19·1%, 17·6–20·5)

Data are shown as median (IQR), n (%), n (weighted %, 95% CI), or mean (SE). p value was compared with urban residents or males, as appropriate. All percentages do not correspond to the numbers because they are weighted; details on glucose-lowering, blood pressure-lowering, and lipid-lowering drugs were available only in a subset of the study population (16 of 30 Indian states). *Includes primary health care, government hospitals, and government medical college hospitals. †Includes general physicians, diabetologists, endocrinologists, private hospitals, and medical college hospitals. ‡Others include unani, siddha, homeopathy, indigenous (local herbal remedies), and unorganised (ie, those who practice medicine without a license). §Adjusted for the duration of diabetes. ¶Calculated by subtracting HDL cholesterol from total cholesterol.

Table 1: **Baseline characteristics, cardiometabolic risk factors control, and health habits among individuals with self-reported diabetes**

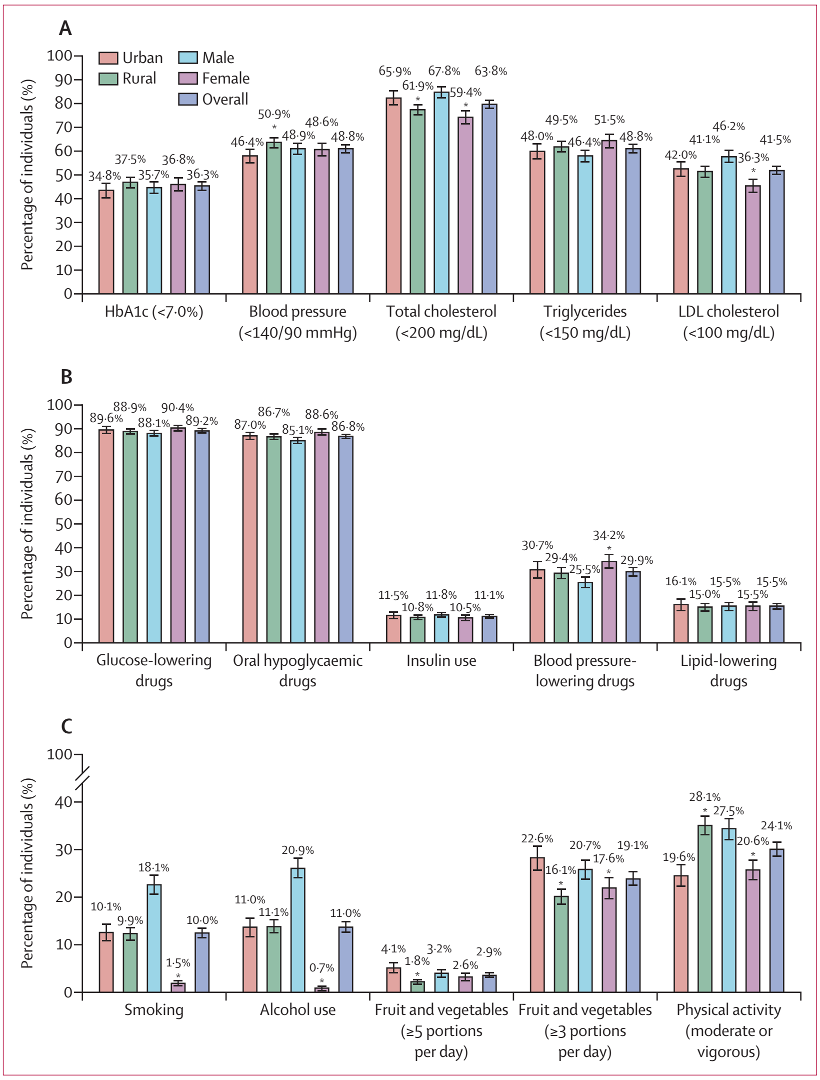

***Figure 1:* Achievement of cardiometabolic risk factors, medication use, and lifestyle health habits among individuals with self-reported diabetes**

Error bars indicate 95% CIs. (A) Cardiometabolic risk factor control with HbA_{1c} values unadjusted for the duration of diabetes (appendix p 12). (B) Medication use. (C) Health habits. LDL=low-density lipoprotein. *Indicates a p value of less than 0·05 compared with urban residents or males, as appropriate.

study conducted in 30 states and union territories of India.[10] 5979 were excluded because they refused to participate (n=3780), were not available (n=1369), or their house was locked (n=830). 113 043 individuals (33 537 from urban areas and 79 506 from rural areas) participated in the study. For this analysis, 5789 adults (2633 in urban areas and 3156 in rural areas) with self-reported diabetes were included in the study population.

The weighted prevalence of self-reported diabetes was 5·4% (95% CI 5·2–5·6; 5789 of 113 043 patients), which was significantly higher in urban areas (2633 [7·9%, 95% CI 7·5–8·4] of 33 537 patients *vs* rural areas 3156 [4·2%, 4·0–4·4] of 79 506; p<0·0001) and among males (3010 [6·0%, 5·7–6·2] of 52 602 *vs* females 2779 [4·9%, 4·7–5·2] of 60 441; p<0·0001; appendix p 11).

Table 1 shows the baseline characteristics of the study population. The median age was 56·1 years (IQR 55·7–56·5) and 3010 (52·0%) of 5789 were male. Compared with rural residents, urban residents had significantly more obesity and had higher education (technical, undergraduate, or postgraduate) attainment. Most individuals used private health care (3036, weighted proportion 62·0%). 4743 (83·3%) individuals used allopathic (modern) medications for diabetes, with similar rates observed among residing in urban and rural areas. Only 951 (weighted proportion 16·7%) of the study population and 227 (weighted proportion 36·9%) of those on insulin reported using self-monitoring of blood glucose. Most individuals self-monitored their blood glucose once per month (406, weighted proportion 41·8%) or once per week (382, weighted proportion 39·8%). More males used multiple drugs for blood pressure and lipid control than females. Smoking 10 or more cigarettes per day was significantly higher in rural areas and 985 (weighted proportion 19·1%) were passive smokers.

Figure 1A and appendix (p 12) present the control of cardiometabolic risk factors among those with self-reported diabetes. Overall, 1748 (weighted proportion 36·3%, 95% CI 34·7–37·9) of 4834 people with glycaemic measurements and diabetes achieved glycaemic control with no significant differences between urban and rural areas or between males and females. Blood pressure control was achieved by 2819 (weighted proportion 48·8%, 47·2–50·3) of 5698 people who had blood pressure measurements available. Significantly more residents in rural areas had good blood pressure control (p=0·013). Among 4886 individuals who had lipid measurements available, 3133 (weighted proportion 63·8%, 62·2–65·4) people with lipid measurements achieved good total cholesterol control, 2411 (weighted proportion 48·8%, 47·2–50·5) achieved good triglyceride control, and 2043 (weighted proportion 41·5%, 39·9–43·1) achieved good LDL cholesterol control. Total and LDL cholesterol control was better among males (p<0·0001), and triglyceride control was better among females (p=0·0026; figure 1A). Significantly more residents in urban areas had good total cholesterol control (p=0·022). Only 419 (weighted proportion 7·7%) of 5297 individuals with self-reported diabetes achieved all three ABC targets (HbA_{1c}, blood pressure, and cholesterol) and 367 (weighted proportion 6·6%) of 5295 achieved ABC and non-smoking targets (appendix p 13).

Figure 1B and appendix (p 12) show the use of various medications among individuals with self-reported diabetes. Overall, 5092 (weighted proportion 89·2%, 95% CI 88·2–90·3) of 5718 were on glucose-lowering drugs, 645 (weighted proportion 11·1%, 10·1–12·1) of 5718 were on insulin, 1053 (weighted proportion 29·9%, 27·8–32·0) of 3600 were on blood pressure-lowering drugs, and only 574 (weighted proportion 15·5%, 14·0–17·0) of 3600 were on lipid-lowering drugs. Use of glucose (p=0·017) and blood pressure-lowering drugs (p<0·0001) was significantly higher among females than males. There were no significant differences in medication use between residents in urban and rural areas.

Figure 1C and appendix (p 12) show the health habits of the study population. Smoking and alcohol use were significantly more frequent among males than females (both p<0·0001), but only 566 (weighted proportion 10·0%) of 5789 individuals reported smoking and

	ABC targets									Health habits			
	Number of people	HbA_{1c}	Systolic blood pressure	Diastolic blood pressure	Total cholesterol	LDL cholesterol	HDL (males)	HDL (females)	Mean trigly-cerides	Smoking	Alcohol	Fruits and vegetables	Physical activity
Andhra Pradesh (undivided)	210	7·9	138·3	79·2	180·0	98·7	37·0	40·8	213·9	9·0	14·1	3·0	27·3
Arunachal Pradesh	95	8·2	140·0	86·5	168·7	80·9	35·6	39·9	252·6	7·2	15·1	2·1	41·5
Assam	142	7·7	137·3	77·2	163·4	89·4	35·2	41·6	182·7	12·7	8·6	2·5	42·8
Bihar	104	8·8	134·0	77·7	166·1	85·7	35·3	39·7	211·2	3·5	5·7	3·1	20·6
Chandigarh	125	8·7	143·3	81·4	179·9	101·9	33·9	43·5	199·5	15·7	19·6	3·1	21·9
Chhattisgarh	155	8·0	140·4	85·2	179·6	104·3	34·9	39·7	191·0	8·7	20·8	2·1	37·6
Delhi	214	7·9	146·6	90·0	202·7	121·2	41·6	42·6	197·0	11·3	18·0	1·3	13·8
Goa	607	7·5	138·0	82·9	196·5	122·6	39·2	41·7	166·7	1·5	8·8	1·8	7·2
Gujarat	156	8·2	131·9	75·1	178·1	105·9	36·3	45·1	156·4	10·6	1·0	2·8	25·7
Haryana	154	8·7	142·7	85·8	187·0	109·4	40·1	41·8	183·0	18·6	8·3	1·6	16·2
Himachal Pradesh	244	8·2	141·2	85·6	189·5	111·9	39·8	42·5	183·0	16·6	25·6	1·6	28·0
Jharkhand	84	8·2	144·0	79·0	172·2	93·0	30·8	41·5	222·6	8·6	4·3	2·9	51·7
Karnataka	137	8·5	131·7	76·5	172·1	91·9	34·1	39·8	217·8	9·9	12·2	2·3	23·4
Kerala	616	8·3	143·3	84·1	195·4	122·7	39·4	40·5	163·4	5·8	7·4	2·9	24·8
Madhya Pradesh	117	8·2	139·9	85·0	178·5	108·5	35·9	40·3	162·7	9·2	7·8	1·7	22·9
Maharashtra	80	7·9	138·0	82·9	173·8	96·9	31·3	35·0	222·2	7·1	9·0	2·4	25·9
Manipur	134	8·0	137·8	86·2	177·7	95·2	37·8	40·5	215·7	7·5	9·2	2·3	34·5
Meghalaya	95	7·6	138·7	83·8	183·0	105·0	35·7	38·0	205·4	21·6	6·8	2·5	17·6
Mizoram	91	7·4	133·2	78·3	176·8	98·1	37·2	38·7	203·6	33·7	8·8	2·8	34·6
Nagaland	130	7·8	149·2	90·0	185·2	106·0	33·6	38·4	218·1	10·0	7·7	1·8	30·3
Odisha	193	8·1	143·0	85·6	181·4	111·0	36·5	38·8	164·0	2·1	3·6	2·2	48·8
Puducherry	503	7·9	136·3	85·4	192·7	116·1	37·1	38·4	194·5	5·8	14·9	1·3	23·0
Punjab	194	9·0	148·5	82·6	182·9	101·5	37·7	39·4	214·3	2·0	8·4	2·4	20·0
Rajasthan	111	8·3	139·5	83·8	196·1	122·6	38·6	41·6	167·9	9·7	2·9	1·6	13·3
Sikkim	227	7·8	141·8	89·9	195·1	112·2	38·8	41·8	211·9	11·0	17·8	1·9	24·0
Tamil Nadu	191	8·2	140·1	82·3	178·3	106·1	34·7	39·5	176·6	14·2	11·8	1·3	28·5
Tripura	166	7·3	139·5	81·6	168·4	87·8	35·8	41·2	213·5	22·3	7·0	3·0	29·4
Uttar Pradesh	103	8·4	134·9	86·6	196·4	115·8	40·6	43·3	192·8	11·1	2·5	1·6	23·4
Uttaranchal	248	7·9	142·8	89·4	189·0	112·7	37·0	41·6	185·6	16·1	15·7	1·2	15·6
West Bengal	163	8·0	146·9	87·8	186·1	111·8	41·7	43·4	158·9	18·8	6·3	1·9	30·0

(Figure 2 continues on next page)

	Good	Satisfactory	Poor
Colour code	Green	Orange	Red
HbA_{1c} (%)	<7·0	7·0–8·9	≥9·0
Systolic blood pressure (mm Hg)	<140	140–159	≥160
Diastolic blood pressure (mm Hg)	<90	90–99	≥100
Total cholesterol (mg/dL)	<200	200–229	≥230
Triglycerides (mg/dL)	<150	150–199	≥200
HDL cholesterol (mg/dL)	≥40 (male); ≥50 (female)	30–39 (male); 40–49 (female)	<30 (male); <40 (female)
LDL cholesterol (mg/dL)	<100	100–129	≥130
Smoking (%)	<10	10–19	≥20
Alcohol (%)	<10	10–19	≥20
Fruits and vegetables (portions per day)	≥3	1–3	<1
Physical activity (%; moderate or vigorous)	≥60%	30–59%	<30%

Figure 2: **Indian states and respective cardiometabolic risk factors**

612 (weighted proportion 11·0%) of 5787 reported alcohol use. Overall, 1079 (weighted proportion 19·1%) of 5789 people reported consuming 3 or more portions of fruit and vegetables per day, with only 162 (weighted proportion 2·9%) meeting the WHO recommendations (≥5 portions per day). Fruit and vegetable intake was significantly higher in the urban areas (p=0·0003) and among males consuming 3 or more servings per day (p=0·016). 1411 (weighted proportion 24·0%) of 5778 individuals were physically active. The proportion of physically active individuals was significantly higher in rural areas and among males (both p<0·0001).

Cardiometabolic risk profiles of individuals with diabetes by country region are shown in the appendix (p 14). The west region had the highest proportion of individuals with good blood pressure control, whereas the north east region had the highest proportion of those with good control of HbA_{1c} and LDL cholesterol. Smoking rates were highest in the north east and alcohol use was highest in the north region. Fruit and vegetable consumption and physical activity were highest in the east.

Figure 2 presents the cardiometabolic risk factors among individual Indian states. No state had a mean HbA_{1c} suggestive of good glycaemic control, with values ranging from 7·3% in Tripura to 9·0% in Punjab. Most states had mean systolic and diastolic blood pressure values in the good or satisfactory control range, and none were in the poor control category. Few states had people with mean HDL cholesterol levels within the good control range and only ten states had people with LDL cholesterol levels in the good control range. Smoking rates were highest in Mizoram, Tripura, and Meghalaya, whereas alcohol use was highest in Himachal Pradesh and lowest in Gujarat. Only Andhra Pradesh (undivided), Bihar, Chandigarh, and Tripura reported a mean intake of 3 or more portions of fruit and vegetables per day. Physical activity levels were low (poor control category) in most states.

Because this study was conducted over 10 years, a sensitivity analysis was done to look for significant time period related differences in the results. The control of various cardiometabolic risk factors split into two time periods (2008–14 and 2015–20) is shown in the appendix (p 15). The proportion of individuals with HbA_{1c} of less than 7·0% and blood pressure lower than 140/90 mm Hg did not differ significantly between the two time periods. There was a reduction (p<0·0001) in the proportion of individuals achieving LDL cholesterol control during 2015–20 compared with 2008–14.

Table 2 shows multiple logistic regression assessing the factors influencing achievement of diabetes treatment targets. Younger age (20–59 years), longer duration of diabetes (≥10 years), and use of multiple drugs was associated with a lower chance of achieving HbA_{1c} of less than 7·0%. However being younger (20–59 years), consuming more than 3 portions of fruit and vegetables per day, and doing moderate or vigorous exercise were associated with a greater chance of controlling blood pressure, whereas, being from an urban area, longer diabetes duration (≥10 years), and medication use were associated with a lower likelihood of blood pressure control. Education higher than high school, intake of more than 3 portions of fruit and vegetables, longer duration of diabetes (≥10 years), and medication use were associated with achieving lipid control. Higher education, male sex, rural residence, and shorter duration of diabetes were associated with better achievement of combined ABC targets. Smoking and alcohol intake were not significantly associated with achievement of any of the treatment targets. A sensitivity analysis showed small differences in the results when the diabetes treatment targets were set at different thresholds for HbA_{1c} (<6·5%, <7·5%, or <8·0%), blood pressure (<130/80 mm Hg or <150/90 mm Hg), or LDL (<70 mg/dL; appendix pp 16–18).

Discussion

For the first time to our knowledge, we present data on the achievement of diabetes treatment targets (specifically HbA_{1c}, blood pressure, and LDL cholesterol) in a population-based study in India. We found that a third of individuals with self-reported diabetes have good glycaemic control and fewer than half have good blood pressure control and LDL cholesterol, with considerable heterogeneity between regions and states. Higher education, male sex, rural residence, and shorter duration of diabetes were associated with better achievement of combined ABC targets.

Compared with earlier studies which were primarily clinic based and included patients with newly diagnosed diabetes, our results show some improvement in

	Glycaemic control (A; HbA_{1c} <7·0%)		Blood pressure control (B; blood pressure <140/90 mm Hg)		Lipid control (C; LDL <100 mg/dL)		Combined ABC targets	
	OR (95%CI)	p value	OR (95%CI)	p value	OR (95%CI)	p value	OR (95%CI)	p value
Age								
≥60 years	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
40–59 years	0·65 (0·56–0·75)	<0·0001	1·38 (1·22–1·56)	<0·0001	1·02 (0·88–1·18)	0·78	0·91 (0·72–1·16)	0·45
20–39 years	0·57 (0·42–0·77)	0·0002	2·72 (2·09–3·54)	<0·0001	1·20 (0·92–1·56)	0·17	1·37 (0·92–2·03)	0·12
Sex								
Male	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
Female	1·05 (0·91–1·21)	0·52	0·99 (0·87–1·11)	0·82	0·66 (0·58–0·76)	0·0007	0·67 (0·53–0·84)	0·0007
Area of residence								
Rural	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
Urban	0·89 (0·77–1·02)	0·096	0·83 (0·72–0·96)	0·013	1·04 (0·90–1·19)	0·63	0·72 (0·56–0·92)	0·0088
Duration of diabetes								
<10 years	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
≥10 years	0·68 (0·58–0·80)	<0·0001	0·74 (0·64–0·85)	<0·0001	1·20 (1·03–1·40)	0·019	0·67 (0·51–0·89)	0·0055
Education								
Lower than high school	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
Higher than high school	1·04 (0·87–1·24)	0·65	0·98 (0·84–1·13)	0·75	1·21 (1·03–1·41)	0·018	1·33 (1·02–1·73)	0·036
Smoking								
<10 per day	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
≥10 per day	0·71 (0·48–1·04)	0·075	1·16 (0·81–1·66)	0·40	0·86 (0·58–1·26)	0·43	0·93 (0·52–1·67)	0·81
Alcohol								
<30 mL per day	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
≥30 mL per day	1·11 (0·75–1·64)	0·59	0·96 (0·67–1·38)	0·82	1·18 (0·82–1·69)	0·38	1·76 (0·96–3·25)	0·069
Fruits and vegetables								
<3 portions per day	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
≥3 portions per day	0·95 (0·79–1·13)	0·54	1·24 (1·06–1·45)	0·0086	1·36 (1·13–1·64)	0·0012	1·17 (0·89–1·54)	0·25
Physical activity								
Sedentary	1 (ref)	..	1 (ref)	..	1 (ref)	..	1 (ref)	..
Moderate or vigorous	0·86 (0·73–1·00)	0·055	1·27 (1·10–1·47)	0·0015	1·12 (0·96–1·30)	0·14	1·13 (0·87–1·48)	0·36
Medication*								
No	1 (ref)	..	1 (ref)	..	1 (ref)	..	NA	..
Yes	0·98 (0·77–1·25)	0·87	0·50 (0·41–0·59)	<0·0001	3·68 (2·91–4·65)	<0·0001	NA	..
Medication count*†								
Single	1 (ref)	..	1 (ref)	..	1 (ref)	..	NA	..
Multiple	0·70 (0·57–0·85)	0·0005	1·04 (0·71–1·52)	0·84	1·45 (0·76–2·74)	0·25	NA	..

*OR for combined ABC cannot be calculated because there are too few cases in the no medication and single medication categories. †Single means taking only one medicine for control of glycaemia, blood pressure, or lipids. Multiple means taking more than one medicine for control of glycaemia, blood pressure, or lipids.

Table 2: **Multiple logistic regression on factors influencing the achievement of diabetes treatment targets**

glycaemic control among individuals with diabetes in India.[7,8] However, most high-income countries report a substantially higher proportion of individuals with a HbA_{1c} of less than 7·0%.[24,25] Poor achievement of glycaemic targets despite widespread use of anti-diabetic drugs suggests a lack of timely escalation of treatment, which could be due to insufficient monitoring and follow-up. We found that only 227 (36·9%) of 645 people who were on insulin performed any self-monitoring of blood glucose, notwithstanding guidance that all individuals with diabetes should self-monitor glucose concentrations regularly.[26] Regular follow-up with health-care providers can help to achieve better glycaemic control and prevent complications.[27] The rates of blood pressure control in our study also represent an improvement from previous studies,[28] which showed that only a sixth of individuals with hypertension in India achieved blood pressure targets. This difference could be because we have included only individuals with known diabetes who are more likely to be on treatment for hypertension.

Our results suggest that a pronounced number of individuals with diabetes across India have markedly elevated LDL cholesterol and are at high risk for adverse cardiovascular outcomes. The use of statins is exceedingly low in India, probably because of low health literacy and widespread misconceptions regarding the side-effects of these drugs in addition to the cost. Notably, the LDL cholesterol target used in our study (<100 mg/dL) is high and many individuals with diabetes would qualify for lower targets (eg, <70 mg/dL) on the basis of their cardiovascular risk status.

Concerningly, only 7·7% of individuals with diabetes in India achieved combined ABC targets. This result is similar to a 2021 study[9] from three cities in South Asia, which showed that less than 7% attained combined targets. A systematic review[29] of 24 studies from 20 countries reported better achievement of glycaemic and lipid targets than seen in our study. Achievement of treatment targets in our study was worse than that in the US National Health and Nutrition Examination Survey (2015–18),[30] but similar to a cross-sectional analysis of pooled data from 55 nationally representative surveys in low-income and middle-income countries.[31] Our findings underscore the need for improvement strategies in the management of diabetes in India.[32–34]

State-wise assessment revealed that the highest mean HbA_{1c} levels were found in Punjab, Bihar, Chandigarh, Haryana, and Karnataka. Except for Bihar, these are among the more prosperous states of India with robust health-care systems. Investigating why economic development and availability of quality health care are not associated with achievement of glycaemic targets in these states is important.

Our results suggest that there is considerable scope for improving adoption of health habits in individuals with known diabetes. For example, only less than 20% of the population reported consuming three portions of fruit and vegetables per day (compared with WHO recommendations of five servings a day) and less than 25% performed any moderate or vigorous physical activity. There is an urgent need to improve awareness regarding a healthy diet and importance of physical activity among the Indian population using means of educational and social media initiatives by governmental and non-governmental agencies.

Despite women self-reporting equal use of oral hypoglycaemic, lipid-lowering, and blood pressure-lowering agents, women had significantly lower attainment of lipid treatment targets than men. This could reflect gender inequities in accessibility and affordability of treatment, because it is likely that gender inequities related to compliance and regularity of medication use still exist. Women also reported less frequent self-monitoring, lower physical activity, and fruit and vegetable intake than men; however, these differences were not statistically significant. Rural residence was associated with better achievement of blood pressure goals, which could partly be explained by higher physical activity in rural areas. Moreover, a higher proportion of residents in rural areas use public health care (government), in which medications are provided free of cost, possibly improving access to treatment and compliance, whereas in urban areas patients pay out of pocket, which could affect regularity of treatment. Strengthening public health-care facilities throughout the country will most likely be an effective way to improve overall diabetes care in India.

The strengths of our study include representativeness of the study population, a national sample covering urban and rural areas of all 30 Indian states, and use of standardised methods for the assessment of treatment targets. Different states were sampled at different timepoints, which is the main limitation of this study. However, sensitivity analysis shows that the differences between states at various timepoints probably represent true differences rather than secular changes. A study in India[9] on the trends of risk factor control among individuals with diabetes over a period similar in duration to that of our study also revealed no differences over time; therefore, our results are unlikely to be biased. Our results do not provide information on individuals younger than 20 years. Furthermore, being an epidemiological study, we were unable to do detailed biochemical tests to differentiate between type 1 and type 2 diabetes. The cross-sectional nature of the study does not allow for inferences of causality to be made.

In conclusion, our results suggest that glycaemic, blood pressure, and lipid control remain suboptimal in the Indian population with self-reported diabetes. As recommended by the *Lancet* Commission on diabetes,[35] policy makers in the government should devise programmes and action plans to strengthen diabetes care infrastructure at the primary, secondary, and tertiary levels and ensure access to high quality, affordable, and appropriate diabetes care at all levels. Similar goals are being pursued by the Government of India through the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke and the Ayushman Bharat Scheme to effectively improve overall management of diabetes in India. As health is primarily the responsibility of each state in India, our findings on inter-regional and interstate variations in the attainment of treatment targets could assist state Governments in formulating targeted policies for improving diabetes care in areas under their jurisdiction.

The ICMR-INDIAB investigators

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Contributors

RMA, RU, and VM conceived, designed, and implemented the study; trained the team, designed quality assurance measures, and interpreted the data. MD and RP designed and coordinated the study, and interpreted the data. BS, AKD, SB, AB, SVM, VKD, PKJ, SMJ, AG, SC, and NT supervised the study in their respective states. SJ, MKA, TK, and RSD provided scientific input, were involved in the quality control, and helped to revise the manuscript. NE helped in the field coordination of the study. MD and UV were responsible for data management. UV and RS were responsible for the statistical analyses. RMA, RU, MD, and VM drafted the manuscript. All authors contributed to the critical revision of the manuscript. RMA and VM take full responsibility for the overall content of this work. VM is the guarantor of this work and takes responsibility for the integrity and accuracy of the data analysis. All authors had full access to all the data in the study and accept responsibility to submit for publication. RMA, MD, UV, RP, and VM have accessed and verified all the data in the study.

Declaration of interests

We declare no competing interests.

Data sharing

Data are available upon reasonable request to the corresponding author. All relevant data are included in this Article or the appendix.

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