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The poor quality of diabetes care in a cluster randomized community survey from Delhi (DEDICOM-II): A crisis, an opportunity

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Abstract

Aims: To evaluate the quality of care in known diabetes patients of Delhi.

Methods: A cross-sectional survey was conducted using a two-stage cluster design. In all, 30 of 150 wards were chosen in Stage 1 (using a random computer-generated seed value and then selecting wards at a predefined sampling interval; Probability Proportionate to Size—Systematic) and one colony from each ward was selected randomly in Stage 2. The selected areas were surveyed house-to-house in one-of-four random directions to recruit a minimum of 25 subjects (known diabetes ≥1 year; 35–65 years of age) per area. Data were collected by interview, blood sampling and from medical records by specifically trained research staff.

Results: A total of 843 subjects (of 1315 eligible) were enrolled from 11,490 houses. For the intermediate outcome measures, an estimated 33.5% (95% CI 27.3–40.2) had an HbA_{1c} value >10%, 67.2% (95% CI 62.8–71.4) had an LDL cholesterol level >100 mg/dl and 57.3% (95% CI 50.4–63.9) had BP levels >140/90 mmHg. For the processes of care in the last 1 year, 25.6% (95% CI 19.7–32.6) of the patients had an HbA_{1c} (A1c) estimation and 2.4% (95% CI 1.1–4.9) had a dilated eye examination and 4.1% (95% CI 2.6–6.2) had foot examination. Diabetes self-management education was provided to only 11.3% (95% CI 8.6–14.7) while nutrition counselling was provided to 56.0% (95% CI 51.7–60.2).

Conclusions: The glycaemic control, lipid control and BP management of known diabetes patients in Delhi are unacceptably poor and a wide gap exists between practice recommendations and delivery of diabetes care in Delhi.

KEYWORDS
epidemiology, health care delivery

1 | INTRODUCTION

Diabetes (type 2 diabetes mellitus) is a major and worsening public health crisis in India with an estimated 69.2 million patients and a reported prevalence of approximately 11.2% and 5.2% in urban and rural areas, respectively.[1] Despite the rising prevalence, serious long-term co-morbidities and well-established evidence-based standards for care,[2-4] translation of recommendations to care of the ordinary patient continues to be deficient in most Asian[5-7] countries. Assessment of quality-of-care in communities can help draw attention to the need for improvement, provide a benchmark for monitoring changes over time and possibly be a catalyst for betterment. Many developed countries have well-established

diabetes registries and public health databases, allowing for periodic overviews of quality-of-diabetes-care (QODC) and associated morbidities.[6-15] Similar information is not available in many developing countries making the digital collection/tracking of representative information difficult. Several studies from India and other low- and middle-income countries [16] have reported on the quality of diabetes care parameters from clinics/healthcare facilities, but population-based studies on the subject are few. Those available were either not designed to study the quality of diabetes care (provide limited information like only HbA_{1c} values[1,17,18];) and/or are constrained by their design of including only those patients who visited health centres or those known to health workers (added selection bias). The same authors had conducted a community survey in the higher- and middle-income populace of Delhi in 2005–2006 and documented the status of quality of diabetes care.[19] After more than a decade, the earlier data have become outdated. Therefore, we decided to repeat a similar survey of the quality of diabetes care in Delhi. As against the first survey, we chose not to restrict ourselves to the middle- and higher-income groups to allow for wider socio-demographic distribution. We hypothesized that this change would allow for improved representativeness and a better analysis of the socio-demographic determinants of the QODC variables. Similar to the first survey and many other works on the subject, we report our findings using the National Diabetes Quality Improvement Alliance measures (NDQIA[20]; for better comparability.

What is already known about this subject?

- Community-based information on the quality of diabetes care from low- and middle-income countries is scarce.

What are the new findings?

- The delivery of diabetes care in Delhi is extremely poor.
- Most patients had poor glycaemic control, were hypertensive and dyslipidaemic
- The current estimates are much worse than previous figures from Delhi, India and the wider world
- This threatens a large proportion of the population with eminently preventable morbidity

How might these results change clinical practice?

The data strengthen the case for refocusing efforts towards the delivery of primary diabetes care.

2 | PARTICIPANTS AND METHODS

2.1 | Survey

A summary of the study design is presented in Figure 1. This survey was conducted between April 2018 and July 2020. Subjects between the ages of 35 and 65 years with known diabetes for 1 year (diagnosed by a registered medical practitioner using at least one blood glucose estimation) were included in the survey. Those with Type 1 diabetes, gestational diabetes, cancer, a renal, hepatic or intestinal disease requiring ongoing treatment or hospital admission (>1 week in the last 1 year) or inability to communicate (due to mental illness or physical disability) were excluded.

Similar to the first survey,[19] a two-stage cluster-randomized sampling approach was used to select 30 of the 150 wards (Stage 1). A random computer-generated seed value was generated, and then wards were selected at a predefined sampling interval (population×30]/150; Probability-Proportionate-to-Size—systematic method). Population sizes were used from the available census population data.[21] In stage 2, a house-to-house survey was conducted in a randomly selected colony in the ward to identify 40 known diabetes patients sequentially. The research team visited patients identified by the field team to screen for selection criteria. It was anticipated that of the 40 identified potential subjects, 25 would qualify and consent for participation and blood sampling. The enrolled subjects were administered a standardized pre-tested proforma based on the DQIP (Diabetes Quality Improvement Project, updated as NDQIA, and more recently adapted to the National Voluntary Consensus Standards for Adult Diabetes Care)[20] after a written informed consent. The proforma was filled by interview or by review of records by a specifically research team. An overnight fasting sample was drawn subsequently with an appointment.

2.2 | Diabetes care in Delhi

Diabetes care in Delhi (population of over 16 million) is provided by a mix of healthcare facilities that vary widely in infrastructure and staffing. Healthcare facilities include 88 public hospitals, 1160 private hospitals and nursing homes, 1298 dispensaries and over 54 polyclinics public maternity homes.[22] Most of the care for diabetes in the city is provided by fee-for-service general doctors with variable and often limited qualifications and expertise in diabetes care. They work at individual practices, nursing homes or hospitals without any uniform functioning requirements or reporting obligations specific to diabetes care. Affordability, accessibility and doctor popularity tend to be the key determinants of the choice of care provider, potentially distorting the system. Average consultation times are extremely short (often

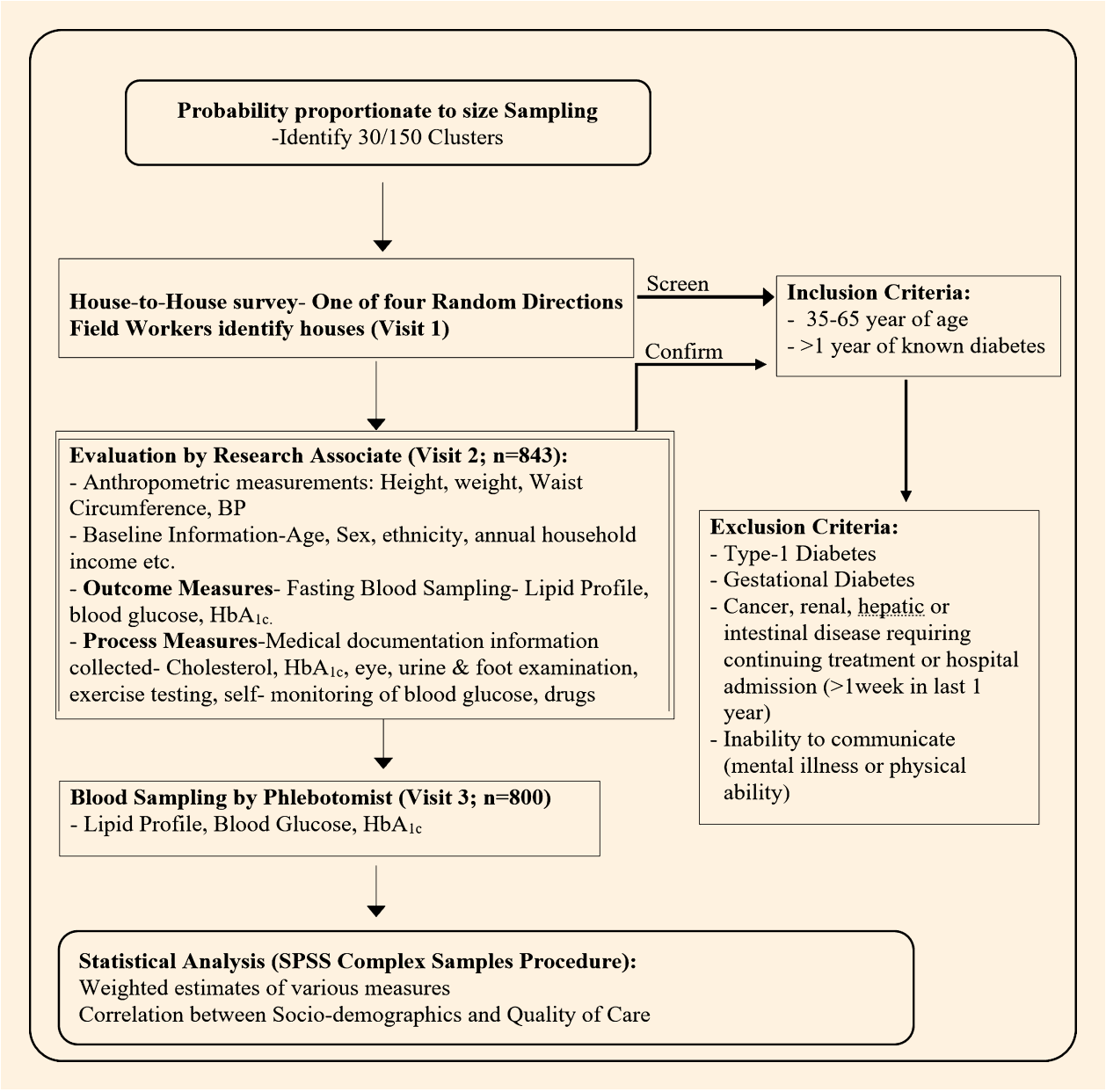

FIGURE 1 Summary of study design

<5 min.[23]; Comprehensive diabetes care facilities are few and often out of reach for the poor.

2.3 | Quality of care measures

A standard questionnaire was used to collect baseline information on age, duration since diagnosis (DSD), gender, education, annual household income, medical benefits (government employee insurance or personal/employer medical insurance or reimbursement), alcohol use, smoking, qualification of the primary care provider (PCP), place of healthcare and the number of visits to the PCP. Information on $HbA_{1c,}$ cholesterol, urine, eye and foot examinations, self monitoring of blood glucose (SMBG), and prescription of oral hypoglycaemic agents (OHAs), insulin, aspirin and lipid-lowering drugs was collected from records and by interview. Standardization of recorded laboratory data was not considered feasible. Any emergency visits with the reason for visit (low or high blood glucose or BP control, etc.) were also noted. The cardiometabolic control of the subjects was summarized as ABCD: HbA_{1c} <7% (53 mmol/mol), BP <140/90 mmHg, LDL cholesterol <2.56 mmol and self-reported non-smoking.[24]

The study definitions (Appendix 1) were adapted from the work done by NDQIA for survey work with the objective of maximizing comparability with existing datasets while maintaining the logistical viability of a community survey.

Weight was recorded using a manual weighing scale (sensitivity 500 g), height using a SECA stadiometer (sensitivity 0.1 cm) and waist circumference (WC) at the level of umbilicus using a measuring tape (sensitivity 0.1 cm). BP was recorded using an OMRON electronic instrument (sensitivity 1 mmHg; accuracy ±3 mmHg) validated in an earlier trial [25] following all WHO recommendations.[26] Height, weight and WC were recorded with light clothing and without shoes.

2.4 | Biochemical analysis

Blood sample (5 ml) was drawn by a phlebotomist into three vacutainers (lipid profile, blood glucose and HbA_{1c}) and transported in ice from the field site to the laboratory within 2 h. The HbA_{1c} sample (EDTA) was stored at 4°C until processing (within 24 h). The other vacutainers were centrifuged at 1310 *g*. Lipid profile and blood glucose estimation were done using a Hitachi 902 analyzer. HbA_{1c} was tested by low-pressure liquid chromatography (Biorad Diastat analyzer; DCCT aligned). Some of the samples (5%) were randomly re-run to ensure quality control (the coefficients of variation for HbA_{1c}, serum cholesterol and fasting blood glucose were 2.1%, 5.1% and 4.1%, respectively).

2.5 | Sample size considerations

It was determined that 768 subjects would be adequate to estimate the prevalence of poor glycaemic control ($HbA_{1c} > 8\%$ [>64 mmol/mol]; expected to be ~50% based on earlier data[19]) with an acceptable relative error of 10% assuming an alpha error of 0.05 and 80% power. This sample-size calculation assumed a cluster random sampling design and was based on an estimated population of known type 2 diabetes mellitus patients in Delhi of 1,122,000 (based on available data[1]). We assumed a design effect of 2.0 (considering the lack of information on within- or between-cluster variations). Based on the above estimation and feasibility considerations, we decided to recruit at least 25 subjects each from the 30 clusters.

2.6 | Data analysis

Data entry and analysis were done using the SPSS v 22.0 software. 'Complex Samples Procedure' accounting for the survey methodology (inter- and intra-cluster variation) was used for calculating weighted means/proportion estimates on the population characteristics, quality of care measures, current medication and compliance. Complex samples linear and logistic regression was used to study the influence of baseline characteristics.

3 | RESULTS

3.1 | Demographic profile

A total of 11,490 houses (289 to 1030 per cluster) were screened. We identified 1640 known diabetes patients, of which 238 failed to meet the inclusion criteria (39 had diabetes for less than 1 year; 28 had never had any blood glucose estimation and 171 were outside the specified age), and 87 were excluded. In the case of 472 patients, the research team was denied access by relatives or self or the subject refused consent after discussion. Hence, 843 type 2 diabetes mellitus subjects were administered the questionnaire. Out of 843 recruited subjects, 43 refused to give blood samples after initial recruitment; therefore, laboratory data are available for 800 subjects. The subjects recruited ($n = 843$) were comparable to those who refused consent for age, DSD, ethnicity and gender ($p > 0.05$; data not presented). Also, the subjects who refused consent specifically for blood sampling ($n = 43$) were comparable to those who consented ($n = 800$) for all baseline characteristics ($p > 0.05$; data not presented).

The baseline characteristics of the subjects are depicted in Table 1. As presented, the recruited subjects were having diabetes for the last ~7 years and had a mean age of ~53 years. 75% of the subjects were having a BMI of >25 kg/m^2 while ~84% had a WC beyond cut-offs. Significant socio-demographic differences were noted between men and women. One in five subjects had a graduate or postgraduate education, while ~17% were illiterate (27.1% in women vs. 7.6% in men). A vast majority of the women (81.6%) were unemployed. More than one-fourth of the men were current smokers (4.1% in women) while 47.4% (2.4% in women) were currently consuming alcohol. More than half of the subjects were not covered under any medical benefit/reimbursement scheme/insurance. Endocrinologists were providing care to 8.6% of patients, while ~26% were self-medicating. Self-reported co-morbidities existed in 16.6%, 19.3% and 1.5% for coronary artery disease, hypertension and stroke, respectively.

3.2 | Quality of care measures

The quality of care of the subjects as per the selected measure set is summarized in Table 2 and Figure 2 presents the distribution of these variables. Among the intermediate outcome measures, it is noteworthy that ~33% of the subjects had an HbA_{1c} of >10 (>86 mol/mol), while ~58% had an $HbA_{1c} > 8.0$ (>64 mmol/mol) highlighting that most of the type 2 diabetes mellitus patients had very poor glycaemic control. Only one-fourth (24.9% [20.9–29.4]) of the subjects had an $HbA_{1c} < 7\%$. While ~19% were aware of having hypertension on examination, 57.3% (95% CI

TABLE 1 Baseline characteristics of the population (based on $n = 843$; weighted means/proportions)

Characteristic	Overall % Prevalence/Mean (95% CI) ($n = 843$)	Women % Prevalence/Mean (95% CI) ($n = 438$)	Men % Prevalence/Mean (95% CI) ($n = 405$)[a]
Age (year; mean)	53.0 (52.1–54.0)	53.0 (52.0–54.1)	53.0 (51.7–54.4)
Age distribution (%)			
35–44 years	16.2 (13.9–18.8)	15.5 (11.8–20.1)	16.9 (12.8–22.1)
45–54 years	34.2 (29.8–38.9)	33.3 (28.3–38.8)	35.1 (28.8–41.9)
55–65 years	49.6 (44.0–55.1)	51.2 (45.4–56.9)	48.0 (39.2–56.9)
Sex (%)[a]	—	49.8 (45.5–54.2)	50.1 (45.8–54.5)
Mean BMI (kg/m^2; mean)	28.2 (27.8–28.6)	29.5 (28.8–30.2)	26.9 (26.4–27.3)
BMI >25 kg/m^2	74.6 (70.7–78.1)	81.1 (74.7–86.2)	68.1 (61.8–73.8)
Waist circumference (cm)	100.7 (99.6–101.7)	100.5 (98.9–102.2)	100.8 (99.5–102.0)
Waist circumference >cut-off[b]	84.6 (81.1–87.6)	82.4 (77.2–86.5)	86.9 (81.3–91.0)
Duration Since Diagnosis (years)	7.1 (6.7–7.5)	7.0 (6.4–7.7)	7.2 (6.4–8.1)
Education level[d]			
Postgraduate (Professional or Honour's)	5.4 (3.1–9.2)	6.6 (3.1–13.2)	4.2 (2.3–7.7)
Graduate	14.4 (9.7–20.9)	10.1 (6.0–16.6)	18.6 (12.1–27.5)
Intermediate or Post- High School	9.0 (5.9–13.6)	8.3 (4.9–13.8)	9.8 (6.0–15.5)
High School Certificate	24.5 (20.7–28.7)	17.6 (12.9–23.5)	31.4 (27.3–35.8)
Middle School Certificate	14.3 (11.8–17.3)	12.2 (8.8–16.7)	16.5 (13.3–20.3)
Primary School certificate	15.0 (12.6–17.9)	18.1 (14.7–22.1)	12.0 (8.4–16.9)
Illiterate	17.3 (11.3–25.6)	27.1 (18.3–38.1)	7.6 (4.0–13.4)
Occupation[d]			
Professional	4.1 (1.4–11.4)	3.2 (0.9–10.4)	5.0 (1.8–13.2)
Semi-professional	10.2 (6.5–15.5)	2.8 (1.1–6.8)	17.5 (11.1–26.3)
Clerical, Shop owner	17.6 (11.8–25.4)	1.7 (0.8–3.5)	33.4 (22.5–46.3)
Skilled worker	10.6 (7.9–14.3)	2.7 (1.3–5.6)	18.5 (12.9–26.0)
Semi-skilled worker	10.3 (6.2–16.8)	4.3 (1.9–9.4)	16.3 (10.0–25.4)
Unskilled worker	4.4 (2.7–7.4)	4.0 (1.6–9.6)	4.8 (2.6–8.9)
Unemployed	42.8 (37.6–48.1)	81.2 (72.8–87.5)	4.5 (2.4–8.4)
Monthly income (INR)[d]			
>41,430	23.0 (14.7–34.3)	22.0 (13.9–33.0)	24.1 (14.2–38.0)
20,715–41,429	20.5 (15.9–26.1)	20.7 (15.2–27.6)	20.4 (15.2–26.8)
10,357–20,714	30.2 (24.1–37.1)	31.1 (23.7–39.7)	29.3 (23.0–36.6)
2092–10,356	26.2 (20.0–33.4)	26.2 (18.1–36.3)	26.1 (20.4–32.9)
<2091	0.0 (0.0–0.2)	0.0 (0.0–0.3)	0.0 (0.0–0.3)
Type of family			
Nuclear	46.5 (40.2–52.9)	42.6 (35.6–50.0)	50.3 (42.9–57.6)
Living in			
Own or family house	82.5 (68.5–91.2)	86.0 (72.7–93.4)	79.1 (63.6–89.2)
Rented house	17.2 (8.6–31.5)	14.0 (6.6–27.3)	20.4 (10.3–36.3)
With relatives	0.2 (0.0–1.8)	0	0.5 (0.1–3.4)
Number of family members	6 (5.3–6.6)	6.01 (5.2–6.8)	6 (5.3–6.4)
Smoking user			
Current	15.8 (11.8–20.7)	4.1 (1.4–11.6)	27.3 (21.5–34.0)

(Continues)

TABLE 1 (Continued)

Characteristic	Overall % Prevalence/Mean (95% CI) (n = 843)	Women % Prevalence/Mean (95% CI) (n = 438)	Men % Prevalence/Mean (95% CI) (n = 405)[a]
Former	7.8 (5.6–10.9)	0.9 (0.3–2.9)	14.6 (10.5–20.1)
Never	76.4 (70.4–81.6)	94.9 (87.4–98.1)	58.1 (50.7–65.2)
Alcohol user			
Current	25.1 (21.7–28.8)	2.4 (0.9–6.6)	47.6 (42.4–52.8)
Former	9.9 (7.4–13.1)	1.7 (0.7–4.1)	18.0 (14.1–22.7)
Never	65.0 (60.7–69.1)	95.8 (91.7–98.0)	34.4 (29.9–39.2)
Past history			
Coronaryisease	16.6 (9.9–26.6)	16.2 (9.1–24.3)	17.0 (10.0–27.4)
Hypertension	19.3 (12.3–28.8)	24.5 (16.6–34.5)	14.1 (7.7–24.3)
Brain stroke	1.5 (0.6–3.4)	1.3 (0.5–3.4)	1.7 (0.4–6.5)
Medical benefits			
None	55.4 (44.3–66.0)	60.2 (48.5–70.9)	50.6 (38.5–62.5)
Private medical insurance	24.0 (16.1–34.2)	18.1 (11.7–27.1)	29.9 (20.0–42.1)
CGHS/ECHS/ESI[e]	17.3 (9.0–30.7)	18.2 (9.5–32.0)	16.4 (7.5–31.9)
Medical reimbursement	3.1 (0.9–9.9)	3.0 (1.1–7.7)	3.2 (0.7–13.1)
Healthcare provider (last 1 year)			
Local doctor clinic	32.1 (26.1–38.8)	34.3 (26.1–43.5)	30.0 (23.1–38.0)
Government hospital	33.1 (25.8–41.2)	36.9 (29.8–44.7)	29.2 (21.0–39.0)
Private hospital	5.6 (4.0–7.7)	6.6 (4.3–9.8)	4.6 (2.6–8.1)
Alternative medicine[f]	3.2 (1.9–5.1)	2.7 (1.1–6.5)	3.7 (2.2–6.2)
Self-medication	26.0 (19.6–33.7)	19.6 (13.4–27.6)	32.5 (24.1–42.1)
Qualification of PCP (showing to doctor n = 621; Self-medication n = 222)			
Endocrinologist	8.6 (5.9–12.4)	7.3 (3.9–13.3)	9.9 (6.5–14.7)
General physician	56.4 (51.3–61.4)	64.7 (59.1–70.0)	48.2 (41.0–55.4)
Specialist physician[g]	2.4 (1.2–4.6)	2.0 (0.8–4.8)	2.8 (1.2–6.3)
Qualification not known	6.6 (3.5–12.0)	6.4 (3.2–12.3)	6.7 (3.4–12.8)
Currently taking treatment (prescribed drugs)			
Oral hypoglycaemic agent	66.2 (59.3–72.5)	75.1 (68.0–81.0)	57.4 (49.0–65.4)
Insulin	9.3 (7.1–12.2)	7.3 (4.1–12.8)	11.3 (7.1–17.5)
Oral hypoglycaemic agent + Insulin	6.7 (4.6–9.7)	5.7 (3.1–10.4)	7.7 (4.1–14.1)
Cholesterol lowering drug	16.0 (13.3–19.1)	15.0 (12.4–18.2)	16.6 (12.9–21.1)
Availability of medical records for last 1 year			
Prescription	49.1 (41.7–56.4)	55.7 (46.6–64.5)	42.5 (35.4–49.9)
Reports	35.5 (29.6–41.8)	38.4 (30.9–46.5)	32.5 (26.8–38.8)

Abbreviation: PCP, primary care provider.

[a]Includes one transgender.

[b]Cut-offs for Indian adults are >80 cm in women and >90 cm in men.

[c]Migrated to Delhi from elsewhere in India.

[d]From The Kuppuswamy Scale.[33]

[e]Individuals receiving any medical benefit (government insurance schemes, private medical insurance or medical reimbursement.

[f]Includes practitioners of homeopathy, ayurvedic medicine, naturopathy and alternative systems.

[g]Other than endocrinologist (MBBS and/or MD in any other specialty).

TABLE 2 Quality of diabetes care parameters ($n = 843$; weighted means/proportions)

Characteristic	Overall % Prevalence/Mean (95% CI) ($n = 843$)	Women % Prevalence/Mean (95% CI) ($n = 438$)	Men % Prevalence/Mean (95% CI) ($n = 405$)
HbA_{1c} estimation in last 1 year	25.6 (19.7–32.6)	26.1 (18.2–35.8)	25.2 (19.1–32.5)
Biennial lipid profile	22.3(17.9–27.4)	21.8(15.6–29.7)	22.8(18.0–28.4)
Dilated eye examination in last 1 year	2.4 (1.1–4.9)	1.8 (0.7–4.5)	2.9 (1.3–6.3)
Foot examination in last 1 year[b]	4.1(2.6–6.2)	2.8(1.3–5.9)	5.3(3.3–8.6)
Testing for microalbuminuria in last 1 year	1.2 (0.6–2.3)	1.1(0.4–3.0)	1.4(0.5–3.6)
≥1 emergency visit to PCP in last 1 year[a]	14.8 (12.2–17.9)	16.6 (12.8–21.4)	13.1 (10.0–16.9)
Aspirin use	9.3 (7.2–12.0)	7.8 (4.8–12.2)	10.8 (7.8–14.7)
Current smokers	15.8 (11.8–20.7)	4.1 (1.4–11.6)	27.3 (21.5–34.0)
Quality improvement measures (assessed at study examination) ($n = 800$)			
HbA_{1c} (%(mmol/mol))			
<6.0% (<42)	5.7 (4.1–7.8)	5.4 (3.2–8.8)	6.0 (4.0–8.8)
6.0%–6.9% (42–52)	19.2 (15.5–23.6)	21.2 (16.7–26.6)	17.2 (12.1–23.8)
7.0%–7.9% (53–63)	16.5 (14.4–18.7)	19.8 (16.1–24.0)	13.1 (10.1–16.7)
8.0%–8.9% (64–74)	14.6 (11.4–18.4)	13.0 (9.5–17.4)	16.3 (11.0–23.5)
9.0%–9.9% (75–85)	10.6 (8.1–13.6)	8.4 (5.4–12.7)	12.9 (9.2–17.6)
≥10% (≥86)	33.5 (27.3–40.2)	32.3 (25.9–39.4)	34.7 (26.3–44.1)
LDL (mmol/L(mg/dl))			
<2.5 (<100)	32.8 (28.6–37.2)	32.5 (26.8–38.8)	33.0 (27.3–39.1)
2.5–3.3 (100–129)	33.4 (29.0–38.1)	33.4 (28.2–39.0)	33.4 (27.6–39.8)
3.4–4.1 (130–159)	23.4 (19.6–27.7)	24.8 (20.5–29.8)	21.9 (15.9–29.4)
≥4.2 (≥160)	10.3 (7.4–14.1)	9.1 (6.1–13.3)	11.5 (7.7–16.9)
HDL (mmol/L (mg/dl))			
<1.0 (<40)	33.5 (29.5–37.8)	23.3 (17.7–30.0)	44.1 (38.9–49.4)
1.0–1.2 (40–49)	34.3 (31.0–37.9)	36.4 (30.7–42.5)	32.2 (26.7–38.2)
1.3–1.5 (50–59)	22.3 (18.9–26.1)	28.9 (25.2–32.9)	15.5 (10.6–22.0)
≥1.6 (≥60)	9.8 (7.8–12.4)	11.4 (7.3–17.3)	8.3 (5.6–11.9)
Triglyceride (mmol/L (mg/dl))			
<3.9 (<150)	41.7 (36.5–47.1)	44.5 (39.5–49.6)	38.8 (31.8–46.4)
3.9–5.1 (150–199)	26.9 (22.4–31.9)	25.8 (20.1–32.6)	28.0 (20.7–36.7)
5.2–10.3 (200–399)	25.7 (22.2–29.6)	25.6 (21.6–30.1)	25.8 (20.2–32.4)
≥10.4 (≥400)	5.7 (4.1–7.8)	4.1 (2.3–7.2)	7.4 (5.1–10.6)
Systolic Blood pressure (mmHg)			
<120	16.7 (14.2–19.4)	17.3 (13.6–21.7)	16.0 (12.3–20.7)
120–129	18.0 (15.1–21.2)	19.2 (15.1–24.0)	16.7 (13.5–20.6)
130–139	19.5 (16.2–23.2)	19.4 (14.6–25.4)	19.5 (15.3–24.6)
140–149	17.6 (15.5–19.9)	17.6 (13.3–22.9)	17.6 (13.7–22.4)
150–159	14.7 (11.5–18.6)	12.7 (8.0–19.4)	16.7 (13.0–21.1)
160–169	7.7 (5.2–11.1)	7.6 (4.4–12.8)	7.7 (4.7–12.4)
170–179	2.9 (1.8–4.6)	3.0 (1.8–5.1)	2.8 (1.4–5.3)
≥180	3.1 (1.8–5.2)	3.2 (1.4–6.9)	2.9 (1.7–5.1)
Diastolic blood pressure (mmHg)			
<75	9.0 (6.3–12.8)	10.6 (6.7–16.6)	7.4 (4.6–11.6)
75–79	8.8 (6.6–11.6)	10.1 (7.3–13.8)	7.5 (4.6–12.1)

(Continues)

TABLE 2 (Continued)

Characteristic	Overall % Prevalence/Mean (95% CI) (n = 843)	Women % Prevalence/Mean (95% CI) (n = 438)	Men % Prevalence/Mean (95% CI) (n = 405)
80–89	35.5 (30.5–40.8)	38.0 (33.3–43.0)	33.0 (26.1–40.7)
90–99	25.7 (21.9–29.8)	24.7 (18.8–31.6)	26.7 (21.1–33.0)
100–109	15.2 (11.2–20.4)	11.7 (7.7–17.6)	18.7 (13.2–25.9)
≥110	5.8 (4.0–8.4)	4.8 (2.8–8.1)	6.7 (4.3–10.4)
Additional quality of care measures (based on questionnaire and medical records) (n = 843)			
Diabetes self-management education	11.3 (8.6–14.7)	8.6 (5.2–14.1)	14.0 (9.7–19.6)
Nutrition counselling (by PCP/dietician)	56.0 (51.7–60.2)	62.3 (58.0–66.4)	49.8 (43.0–56.6)
Smoking cessation counselling	9.0 (6.7–12.0)	1.5 (0.6–3.8)	16.4 (12.6–21.2)
Satisfied with care provided (yes)	70.1 (63.7–75.8)	71.9 (64.5–78.3)	68.3 (60.8–75.0)
Glucose monitoring Advised	18.8 (14.1–24.5)	17.2 (12.9–22.4)	20.4 (14.5–27.9)
Advised SMBG (≥1/week)	9.3 (7.1–12.1)	7.6 (4.3–13.0)	11.0 (7.9–15.1)
SMBG done frequency (≥1/week)[b]	9.6 (6.2–14.6)	8.5 (4.7–15.0)	10.7 (6.5–17.1)
Exercise prescription	50.5 (46.2–54.8)	56.3 (51.7–60.8)	44.8 (39.8–49.9)
Foot care advice	13.3 (10.3–17.0)	13.4 (10.0–17.8)	13.1 (9.5–17.9)
Care for weight advice	20.1 (16.6–24.2)	23.5 (19.5–28.1)	16.7 (11.6–23.5)
Influenza vaccine	0.1(0.0–1.1)	0.3(0.0–2.1)	0.7(0.2–2.5)
Pneumococcal vaccine	0.4(0.1–1.3)	0.1(0.0–0.7)	0.6(0.2–2.6)

Abbreviation: PCP, primary care provider.

[a]For hypoglycaemia, hyperglycaemia, high blood pressure or any other morbidity.

[b]Including those who were not advised by PCP but doing.

50.4–63.9) had systolic blood pressure (SBP) > 140 or a diastolic blood pressure (DBP) > 90 mmHg. Also, a majority were dyslipidaemic with two-thirds of the subjects having an LDL level >2.5 mmol/L (Target <2.5 mmol/L in type 2 diabetes mellitus patients), one-third having an HDL level <1 mmol/L (target >1 mmol/L in type 2 diabetes mellitus patients) while approximately two-thirds had a triglyceride >3.9 mmol/L. 21.8% (18.1–26.1%) had elevated triglycerides along with low HDL (commonly described as Indian atherogenic dyslipdemia). More than two-thirds were satisfied with the care they were receiving. As presented in Table S1, only 4.3% (0.9–2.9) of the subjects met all four ABCD criteria of cardiometabolic control while >40% met one (often non-smoking) or none of the four criteria.

3.3 | Medication and compliance

66.2% (SE 3.2; n = 843) were advised OHAs, of which 96.4% of patients (SE 1.8; n = 551) reported compliance with the OHA prescribed, 16.0% were prescribed cholesterol-lowering agents (SE 1.4; n = 843) of which 98.9% (SE 1.1; n = 117) reported compliance with cholesterol-lowering drugs while 10.2% (SE 1.2; n = 843) were prescribed aspirin and 96.2% (SE 2.5; n = 88) were complying with aspirin prescriptions. One-third of the patients (32.0% SE 2.4; n = 277) had not visited their PCP in the last 1 year, and 85.0% (SE 5.8; n = 134) claimed to be following advice on SMBG. On combining these parameters into an aggregate compliance score (assigning a score of +1 for following advice on taking OHAs, SMBG, and the PCP in the last 1 year), only 20.6% (SE 2.3; n = 843) of the subjects were compliant (score = 3).

3.4 | Determinants of care

To study the relationship between the demographic characteristics of the population and the quality of care received, a regression analysis was done with glycaemic control, lipid control, BP control and process of care measures as outcomes of interest (dependent variable). Socio-demographic and disease characteristics were found to have a significant correlation (p < 0.1) in bivariate analysis, and other factors considered to have relevance (Table 3) were added to the model as covariates or factors. As depicted, adjusted for 'DSD', higher age correlated with better glycaemic control. Similarly, higher BMI was associated with better glycaemic control, possibly because WC was included

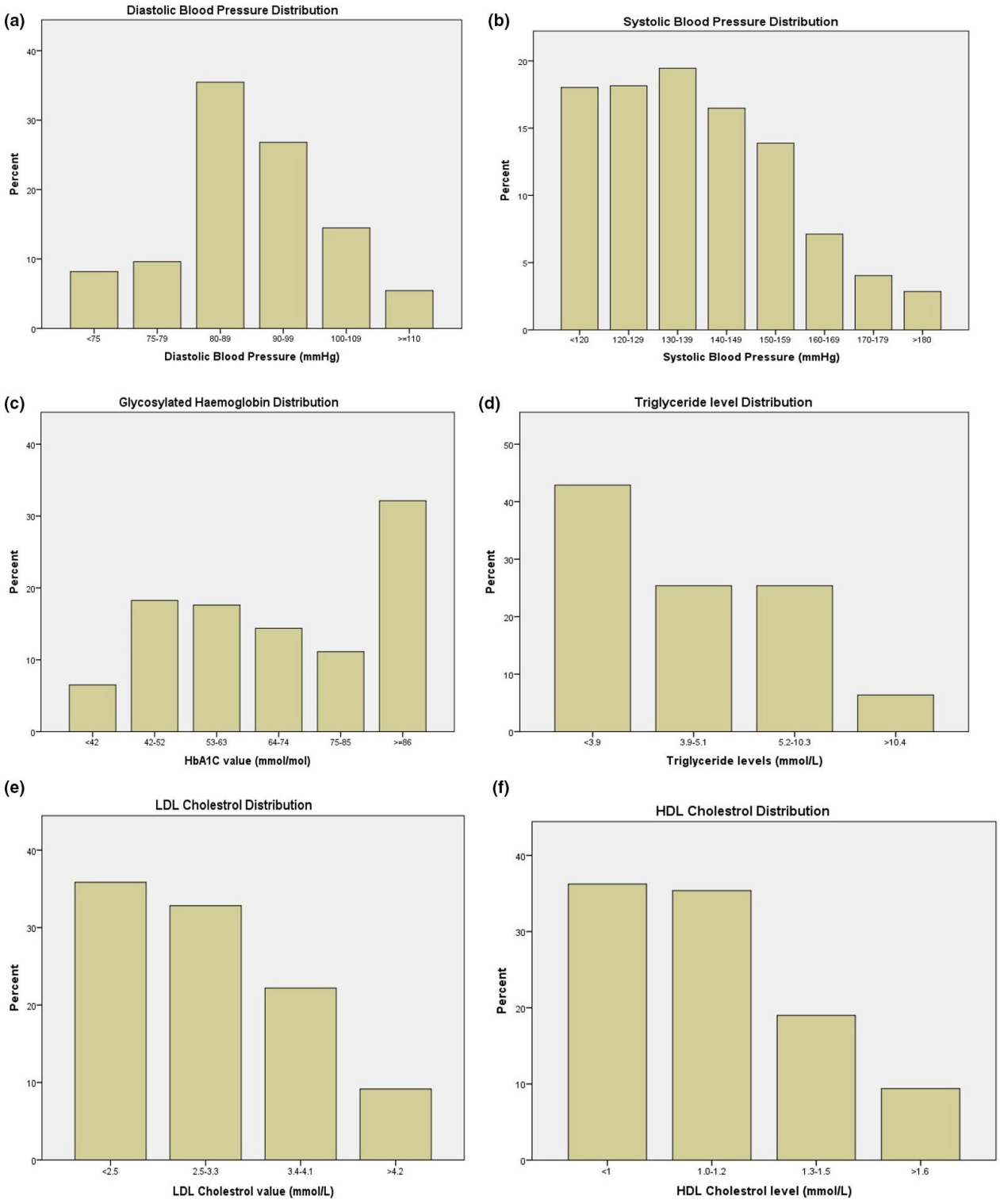

FIGURE 2 Intermediate outcomes of diabetes care

in the model, implying that for those with mainly central adiposity, HbA_{1c} was worse. Other than physical attributes such as age, DSD and BMI and socio-demographic characteristics such as college education, higher income, SMBG and care by an endocrinologist were associated with better glycaemic control.

4 | DISCUSSION

Our community survey provides detailed account of the poor status of QODC in Delhi. Most of the patients had poor glycaemic control, were hypertensive and dyslipidaemic. There was widespread non-adherence to clinical and biochemical

TABLE 3 Linear regression models based on glycaemic control, lipid control, SBP, diabetes self-management education, biennial lipid profile and HbA_{1c} in last 1 year ($N = 799$)

	HbA_{1c} ($r^2 = 0.141$)				Cholesterol ($r^2 = 0.075$)				BP ($r^2 = 0.117$)		
Parameter	**Mean Diff.**	**95% CI**		**Sig.**	**Mean Diff.**	**95% CI**		**Sig.**	**Mean Diff.**	**95% CI**	
Age[a]	−0.051	−0.082	−0.020	**0.002**	−0.523	−0.980	−0.067	**0.026**	−0.347	−0.476	−0.219
Sex[b]	0.126	−0.303	0.555	0.553	−9.261	−21.237	2.715	0.124	4.007	1.609	6.405
Smoking[c]	−0.634	−1.162	−0.106	**0.020**	0.023	−13.842	13.888	0.997	−1.774	−4.442	0.894
Duration since diagnosed[a]	0.112	0.072	0.153	**<0.001**	−0.261	−0.898	0.377	0.410	−0.244	−0.432	−0.057
Body Mass Index[a]	−0.091	−0.136	−0.045	**<0.001**	−1.346	−2.897	0.204	0.086	0.228	−0.128	0.584
Qualification of PCP[d]	−0.574	−1.140	−0.008	**0.047**	−1.492	−15.449	12.465	0.828	−2.681	−5.860	0.498
College education[e]	−0.625	−1.149	−0.102	**0.021**	−5.441	−13.590	2.708	0.182	−1.404	−4.206	1.398
Income[f]	0.138	−0.349	0.625	0.566	7.140	−0.838	1.833	0.077	0.884	−1.938	0.642
Institutional care[g]	−0.085	−0.559	0.389	0.717	−8.726	−16.897	0.555	**0.037**	0.416	−2.891	3.723
Waist circumference[a]	0.018	0.001	0.035	**0.043**	0.083	−0.613	0.779	0.809	−0.055	−0.251	0.142
Compliance score[a]	0.192	−0.027	0.411	0.084	−5.293	−10.316	−0.271	**0.040**	0.375	−0.979	1.729

Note: Model: Dependent variables were HbA_{1c} value, LDL: HDL ratio, BP, Diabetes Self-management Education, HbA_{1c} estimation in last 1 year and Biennial Cholesterol Estimation.

Independent variables were Age, Sex, Smoking, Duration since diagnosis, Body mass Index, Waist circumference, Institutional care, Qualification of PCP, College education, Income, Compliance score.

795 subjects were included in the model as blood sampling was done in 800 subjects of which 5 refused to comment on income.

Abbreviation: PCP, primary care provider.

[a]These variables were used as continuous variables in the above model.

[b]Mean difference indicates males minus females.

[c]Mean difference indicates current smokers minus former or non-smokers.

[d]Denotes difference between diabetologist vs. other practitioners.

[e]Mean difference indicates College level education minus school or lesser education.

[f]Mean difference indicates income <Rs 20,715 vs. income >Rs 20,715.

[g]Care in an institution (government or private) with more than 25 beds.

preventive care checks at the care provider and patient levels. Care by specialized doctors, higher income and better education were associated with better quality of care, possibly reflecting poor penetrance of care to deprived/vulnerable sections. The finding of high patient satisfaction levels with the care received was also probably reflective of poor awareness and low expectations.

The current study was conducted in Delhi, a hotbed of diabetes (type 2 diabetes mellitus), using a robust cluster-randomized community-survey methodology to generate relevant and representative population-based data on the quality of diabetes care. The study is strengthened by the use of centralized laboratory estimates, single team standardized BP/anthropometric measurements and a standard pre-defined measure set. The study documents the laboratory and care process measures in internationally comparable slabs as per the NDQIA-based definitions addressing an important lacuna in existing knowledge. The limitations of the study include that it is partly based on self-reported data, which can be subject to recall bias. Record verification was possible for only a minority of patients (49.1% for prescription; 35.5% for reports) and where available documentation was generally incomplete and poor. The study does not record caloric intake or exercise. The socio-economic status of the subjects (income and education) participating in the current study was comparable with census data. Also, the NDQIA/DQIP measure sets were designed for evaluating the quality of care in managed care institutions/digital databases and were specifically modified by us for the needs of a community survey accommodating for the poor availability of records.

Several studies[1,15-19,27-31] have attempted to evaluate the quality of diabetes care. Compared to a similar study (based on similar criteria) from the United States,[15] the current study documents a much higher proportion of diabetes patients with poor glycaemic control ($HbA_{1c} > 10$; 6.8% vs. 33.5% in our study) despite ours being a younger population with a shorter duration of disease. Our study had a higher proportion with raised LDL cholesterol (>2.5 mmol/L; 43.4% vs. 67.1% in our study) and with elevated BP > 130/80 mmHg (47.9% vs. 70.8% in our study). Also, a much lower proportion of the

Diabetes self-management education ($r^2 = 0.115$)					Biennial lipid profile ($r^2 = 0.168$)				HbA_{1c} estimation in last 1 year ($r^2 = 0.158$)			
Sig.	Mean Diff.	95% CI		Sig.	Mean Diff.	95% CI		Sig.	Mean Diff.	95% CI		Sig.
0.000	−0.001	0.002	−0.005	0.451	0.001	−0.005	0.002	0.444	0.002	−0.005	0.008	0.612
0.002	0.111	0.028	0.194	0.011	0.066	−0.025	0.157	0.148	0.006	−0.070	0.082	0.871
0.184	−0.030	−0.110	0.049	0.444	0.001	−0.007	0.004	0.972	0.053	−0.021	1.470	0.153
0.013	0.006	0.000	0.013	0.063	0.001	−0.004	0.009	0.640	0.000	−0.006	0.006	0.922
0.200	0.009	−0.029	0.010	0.347	0.020	0.003	0.036	**0.023**	0.012	0.000	0.023	0.050
0.095	0.160	0.064	0.256	**0.002**	0.199	0.084	0.314	**0.001**	0.147	−0.036	0.331	0.112
0.314	−0.051	−0.027	0.130	0.192	0.116	−0.036	0.268	0.130	0.162	0.051	0.274	**0.006**
0.526	0.028	−0.048	0.104	0454	0.114	0.031	0.198	**0.009**	0.103	0.025	0.180	**0.011**
0.799	0.024	−0.031	0.078	0.385	−0.030	−0.096	0.036	0.363	0.008	−0.052	0.068	0.790
0.573	0.005	−0.003	0.013	0.193	−0.002	−0.009	0.005	0.622	−0.001	−0.005	0.008	0.695
0.575	0.056	0.031	0.081	**<0.001**	0.067	0.031	0.103	**0.001**	0.077	0.047	0.106	**<0.001**

Delhi subjects received diabetes self-management education. Very few were regularly screened for early detection of complications. SMBG was often not prescribed or complied with at the recommended frequency (85% followed advice on SMBG and 8.3% were monitoring more than one time per week versus 58.4% monitoring more than once per day in the US population). Concepts like pneumococcal or annual influenza vaccination were hardly practiced (<0.5%).

In comparison to a European report covering eight countries, the current study recorded much poorer quality of care parameters including intermediate outcomes (Mean HbA_{1c} varied from 6.9 in France to 7.5 in Italy vs. 8.8 in our study)[32] and adherence to processes of care (>95% compliance with HbA_{1c} examination in last 1 year in all eight countries compared to 25.6% in our study; >85% compliance with cholesterol testing vs. 22.3% in our study; >47% compliance with foot examination compared to 4.1% in our study).

In the context of low- and middle-income countries, Shivashankar et al.[16] reviewed the literature reporting on quality of diabetes care over two decades (1993–2012), including India. The review records many clinic-based studies[16] on the quality of diabetes care but population-based studies were few.[16,18,19] Although some of the studies record on a variable set of measures, most of the studies were not specifically designed to assess quality of care and hence were inherently incomplete. In comparison with population-based studies from China, Thailand, Iran and Jordan[16], the current survey documented poorer glycaemic control, lipid control and BP control despite ours being a younger population with a comparable DSD. In the Indian context, for the intermediate laboratory outcomes, the currents results are even worse than the high prevalence of HbA_{1c} > 10% recorded in known diabetes patients in the recent INDIAB study (n = 480; HbA_{1c} > 10% is 25.4% compared with 33.5% in our study).[1] The INDIAB study reported that ~60% of the subjects had not had an HbA_{1c} evaluation in the last 1 year, while in our study, the proportion was higher at 75%. It is noteworthy that the INDIAB study focused on the prevalence of diabetes, hypertension, dyslipidaemias,

etc., and not on known diabetes patients. The proportion of subjects with glycaemic control (HbA_{1c} < 7%; 24.9% vs. 30%), cholesterol control (LDL <100 mg/dl; 30.9% vs. 45%), BP control (<140/90 mmHg [42.7% vs. 55%]) and non-smoking in our study is worse (lower) than the 2015–2016 results of the CARRS survey[24] conducted in Chennai, Delhi and Karachi. The mean LDL in the current study was lower than that in SN-DREAMS study[17] while the glycaemic control was poorer. The documented mean HbA_{1c} and SBP in the current survey were comparable to the CURES study.[18] In comparison with our own survey more than 13 years ago,[19] the current survey records a much poorer glycaemic control (HbA_{1c} > 10% in 13.8% vs. 33.5% in the current study). This was not related to the inclusion of lower socio-economic in the current survey, HbA_{1c} > 10% is 35.7% (29.0–43.1) in the middle socio-economic class and 29.2% (18.2–43.2) in the higher socio-economic class. Some processes of care like HbA_{1c} estimation recorded better application while other differences like preventive counsellings were unremarkable.

The poor quality of diabetes care, as documented by our study, endangers a large section of the population with a high decadal risk of Coronary Artery Disease (estimated 200,000 new cases projected to Delhi's ~1,122,000 diabetes patients; based on UK Prospective Diabetes Study risk engine) and stroke (estimated 57,000 new cases). It is also estimated to result in 134,000 fatalities. While these numbers are approximations, it is necessary to acknowledge this impending public health tragedy and that these consequences are eminently preventable. There is evidence that a 1% reduction in HbA_{1c} can reduce myocardial infarction risk by 16%. Furthermore, a 10 mmHg reduction in SBP could decrease all-cause mortality (18%), myocardial infarction (21%), stroke (44%) and microvascular complications (37%). Also, improving lipid profile can reduce the risk for CAD by 25%–55%.

In conclusion, the study documents that a wide gap exists between effective evidence-based diabetes management practices and their implementation even in an urban metropolis like Delhi, where diabetes care is widely accessible compared to the rest of the country. However, the grim current scenario also strengthens the case for developing interventions targeted at patients, care providers and other stakeholders for improving the quality of diabetes care. Subsequently, the specified intervention can be upscaled using governmental or non-governmental means towards minimizing preventable morbidity and the related public health expenditure.

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JN conceived the idea, developed the study design, supervised the execution of the study plan, supervised the data analysis and will act as guarantor for the paper. SR was involved with the study design, data analysis and drafting of the manuscript. SG executed the study plan and carried out the data analysis. ASL provided subject matter expertise in the design of the questionnaire and data analysis. All the authors were involved in the finalization of the manuscript. We acknowledge the efforts of the field team involved in data collection. The logistical support and guidance provided by the Medical Director (Dr Sneh Bhargava) and the Director (Mr Abhishek Bhartia) played a crucial role in the successful exercise.

ETHICAL APPROVAL

The project was approved by the Institutional Ethics Committee at Sitaram Bhartia Institute of Science and Research (ref no IEC/SBISR/2015/2).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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APPENDIX 1

Study definitions

1. *Dilated eye examination*: An eye examination after using pupil dilating eye drops (based on drug name or photophobia after instillation) was taken to indicate dilated eye examination (DEE)
2. *Foot examination*: Any foot examination testing for foot sensations using hot or cold objects, weights placed on the great toe, a fork-like vibration device and hammer or pin
3. *Diabetes self-management education*: Any individual counselling or group class on self management for at least 15 min by a dietician/diabetes counsellor/nurse/doctor
4. *Self monitoring of Blood Glucose (SMBG)*: Includes monitoring by glucometer, strips, self-urine testing and/or laboratory estimation of blood or urine glucose by self or by relative, but not by a practitioner during a health check-up
5. *Smoking cessation counselling*: Any counselling or group class on cessation of smoking by doctor/diabetes educator or counsellor

6. *Nutrition counselling*: Any group class or individual counselling on dietary advice for a minimum of 5 min by a dietician/diabetes counsellor/nurse/doctor
7. *Care for weight*: Any advice on reducing weight with specified goals by the PCP for a subject whose weight was checked during visit to PCP
8. *Health facilities* were classified into Hospitals (>25 beds; Public or Private), Nursing Homes (5–25 beds; private) and other small Institutions (<5 beds; public or private). Non-profit or NGO hospitals were included in the classification of private
9. *Socio-economic status* was categorized into higher, middle and lower socio-economic classes using the inflation-adjusted Kuppuswamy scale.[33] The scale is based on the income, education and occupation of the subjects. Scores of 3–10 were classified as Lower Socio-economic Class (LSEC), 11–15 as Middle Socio-economic Class (MSEC) and ≥16 as Higher Socio-economic Class (HSEC)
10. *Alternative medicine*: Practitioners of homeopathy, ayurvedic medicine, naturopathy or other alternative systems
11. *Medical benefits*: Any form of medical benefits including insurance, central government schemes, partial or complete reimbursement by the employer
12. *Primary care providers (PCP)*: Any qualified or unqualified person to whom the patient visits regularly or most often for care of diabetes