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Natural History of Type 2 Diabetes in Indians: Time to Progression

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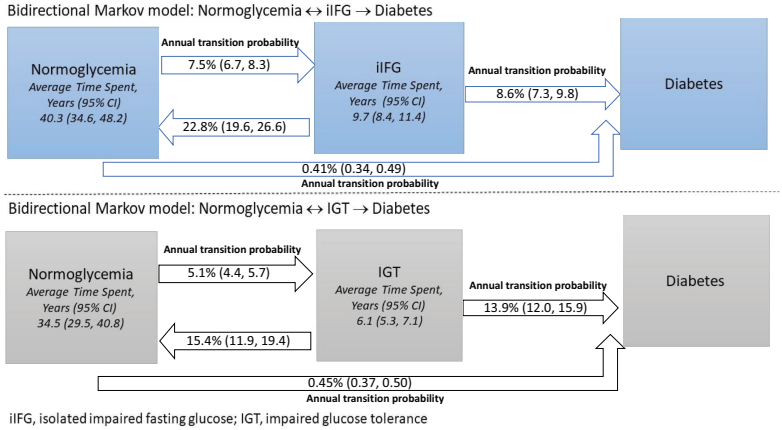
Natural History of Type 2 Diabetes in Indians: Time to Progression

Aim:

To understand what is the natural history of diabetes in Indians.

Data:

Prospective data from adults aged >20 years from the Chennai site of the Centre for Cardiometabolic Risk Reduction in South Asia (CARRS)



Continuous-time Markov models to estimate annual transition probabilities through multiple progressive states across two pathways (normoglycemia ↔ iIFG → diabetes; normoglycemia ↔ IGT → diabetes), allowing for regression from prediabetes to normal but assuming diabetes as an absorbing state.

Conclusion: Individuals reside in normoglycemic states for, on average, 35–40 years, thus providing time to investigate ways to prevent prediabetes.

ARTICLE HIGHLIGHTS

- **Why did we undertake this study?**
  We conducted this study to understand the natural history of diabetes in Indian populations.
- **What is the specific question(s) we wanted to answer?**
  We wanted to describe the natural history of diabetes in Indians.
- **What did we find?**
  Progression to diabetes among the Indian population is rapid once an individual has prediabetes (6 years for impaired glucose tolerance and 9.7 years for isolated impaired fasting glucose). Regression to normoglycemia from prediabetes is three times more likely than a progression from normoglycemia to prediabetes.
- **What are the implications of our findings?**
  In the Indian population, individuals reside in normoglycemic states for, on average, 35–40 years, which provides time to investigate ways to prevent prediabetes.

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BRIEF REPORT

OBJECTIVE

To describe the natural history of diabetes in Indians.

RESEARCH DESIGN AND METHODS

Data are from participants older than 20 years in the Centre for Cardiometabolic Risk Reduction in South Asia longitudinal study. Glycemic states were defined per American Diabetes Association criteria. Markov models were used to estimate annual transition probabilities and sojourn time through states.

RESULTS

Among 2,714 diabetes-free participants, 641 had isolated impaired fasting glucose (iIFG), and 341 had impaired glucose tolerance (IGT). The annual transition to diabetes for those with IGT was 13.9% (95% CI 12.0, 15.9) versus 8.6% (7.3, 9.8) for iIFG. In the normoglycemia ↔ iIFG → diabetes model, mean sojourn time in normoglycemia was 40.3 (34.6, 48.2) years, and sojourn time in iIFG was 9.7 (8.4, 11.4) years. For the normoglycemia ↔ IGT → diabetes model, mean sojourn time in normoglycemia was 34.5 (29.5, 40.8) years, and sojourn time in IGT was 6.1 (5.3, 7.1) years.

CONCLUSIONS

Individuals reside in normoglycemia for 35–40 years; however, progression from prediabetes to diabetes is rapid.

Indian people are at heightened risk of type 2 diabetes (1,2). However, it is unclear how Indians transition through the natural history of diabetes (e.g., from normoglycemia to prediabetes [impaired fasting glucose [IFG] or impaired glucose tolerance [IGT]), reversal to normoglycemia, and from prediabetes to diabetes), and how long people reside in each state (sojourn time).

RESEARCH DESIGN AND METHODS

We used data from the Chennai site of the longitudinal Centre for Cardiometabolic Risk Reduction in South Asia (CARRS) study (2010–2012) (3,4), up to the fourth follow-up (2016–2017) and implemented a continuous-time Markov model (5).

Inputs

Glycemic states (normoglycemia, IGT, iIFG, diabetes) were defined according to American Diabetes Association criteria, and distributions and characteristics of each glycemic state and the rates of progression from one stage to the next were obtained from the CARRS study (3,4) (details of definitions and cohort are provided in the Supplementary Material) (6).

Among 5,961 participants with glucose measurements at baseline, 3,475 were free of diabetes. Of these, 2,714 participants had had a complete oral glucose tolerance test and

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Table 1—Characteristics of participants in normoglycemia, iIFG, and IGT

Characteristic	Normoglycemia* (n = 2,205)	iIFG† (n = 641)	IGT‡ (n = 341)
Age (years), mean (SD)	37.6 (10.8)§	40.9 (10.3)¶	43.7 (12.5)⊥
Age (years), median (IQR)	36.0 (30.0, 44.0)§	40.0 (33.0, 48.0)¶	42.0 (35.0, 51.0)⊥
Sex, n (%)			
Male	924 (41.9)§	183 (28.5)¶	160 (46.9)⊥
Female	1,281 (58.1)	458 (71.5)	181 (53.1)
Family history of diabetes§, n (%)	745 (33.8)§	237 (37.0)	139 (40.8)
Weight (kg), mean (SD)	61.6 (12.0)§	65.5 (12.2)¶	66.3 (12.0)
Height (cm), mean (SD)	157.1 (8.9)§	155.1 (8.4)¶	156.9 (9.0)
BMI (kg/m^2), mean (SD)	25.0 (4.7)§	27.2 (4.6)¶	27.0 (4.7)
Waist circumference (cm), mean (SD)			
Overall	81.6 (11.1)§	85.7 (10.4)¶	88.1 (10.6)⊥
Male	84.8 (10.7)§	89.5 (10.3)¶	90.9 (10.8)
Female	79.5 (10.8)§	84.2 (10.1)¶	85.7 (9.8)
Total cholesterol (mg/dL), mean (SD)	180.4 (36.3)§	187.4 (37.1)¶	189.9 (34.3)
Triglycerides (mg/dL), median (IQR)	107.0 (78.0, 150.0)§	124.0 (89.0, 171.0)¶	137.0 (100.0, 186.0)⊥
LDL cholesterol (mg/dL), mean (SD)	111.7 (28.9)§	118.2 (31.6)¶	117.5 (27.9)
HDL cholesterol (mg/dL), mean (SD)			
Overall	41.1 (9.5)	40.1 (8.2)¶	40.3 (10.4)
Male	39.6 (10.6)	37.8 (8.3)	39.7 (12.0)
Female	42.1 (8.5)	41.1 (7.9)	40.8 (10.4)
FPG (mg/dL), mean (SD); median (IQR)	90.0 (7.1)§; 90.0 (85.0, 95.0)§	102.7 (7.9)¶; 103.0 (100.0, 107.0)¶	98.3 (10.0)⊥; 98.0 (91.0, 106.0)⊥
Glucose level at 30 min (mg/dL), mean (SD); median (IQR)	140.7 (28.2)§; 140.0 (119.0, 160.0)§	164.0 (29.5)¶; 165.0 (144.0, 185.0)¶	174.4 (30.0)⊥; 176.0 (155.0, 193.0)⊥
Glucose level at 120 min (mg/dL), mean (SD); median (IQR)	94.7 (20.9)§; 94.0 (81.0, 107.0)§	107.1 (22.7)¶; 106.0 (93.0, 122.0)¶	138.6 (29.1)⊥; 143.0 (116.0, 159.0)⊥
HbA_{1c} (%), mean (SD); median (IQR)	5.6 (0.4)§; 5.6 (5.3, 5.8)§	5.8 (0.4)¶; 5.8 (5.6, 6.1)¶	5.9 (0.4); 5.9 (5.6, 6.1)
HbA_{1c} (mmol/mol), mean (SD); median (IQR)	38 (0.4)§; 38 (34, 40)§	40 (0.4)¶; 40 (38, 43)¶	41 (0.4); 41 (38, 43)
Insulin, fasting (pmol/L), median (IQR)	6.4 (4.4, 9.4)	7.7 (5.5, 10.8)¶	8.5 (6.7, 11.2)
Insulin level at 30 min (pmol/L), median (IQR)	46.6 (32.2, 72.8)	48.2 (33.7, 71.5)	53.1 (35.6, 76.2)
Insulin level at 120 min (pmol/L), median (IQR)	31.4 (22.4, 51.0)§	40.0 (26.3, 65.0)¶	59.6 (37.8, 98.6)
HOMA-IR** (μIU/mL*mmol/L), median (IQR)	1.4 (1.0, 2.1)§	2.0 (1.4, 2.8)¶	2.1 (1.6, 2.8)
HOMA-β†† (μIU/mL/mmol/L), median (IQR)	89.0 (61.2, 130.9)	69.3 (48.9, 101.1)¶	91.5 (66.2, 129.9)⊥
DIo‡‡, median (IQR)	0.1 (0.1, 0.3)§	0.1 (0.1, 0.2)¶	0.1 (0.0, 0.1)⊥
Insulinogenic Index§§, median (IQR)	0.9 (0.5, 1.8)§	0.7 (0.4, 1.3)¶	0.6 (0.4, 1.0)⊥

DIo, Oral Disposition Index; FPG, fasting plasma glucose; IQR, interquartile range; IR, insulin resistance. *Normoglycemia defined as FPG <5.6 mmol/L (100 mg/dL) and 2-hour postload glucose (2h-PG) <7.8 mmol/L (140 mg/dL) and no medication. †IFG defined as FPG between 5.6 and 6.9 mmol/L (100–125 mg/dL) and 2h-PG <7.8 mmol/L (140 mg/dL) and no medication. ‡IGT defined as FPG <7.0 mmol/L (126 mg/dL) and 2h-PG between 7.8–11.0 mmol/L (140–199 mg/dL) and no medication. §Significant P value for normoglycemia versus IGT. ¶Significant P value for normoglycemia versus iIFG. ⊥Significant P value for iIFG versus IGT. #Diabetes defined as FPG ≥7.0 mmol/L (126 mg/dL) or 2-h PG ≥11.1 mmol/L (200 mg/dL) or HbA1c ≥6.5% (48 mmol/mol) or on medication. **HOMA-IR = fasting insulin (μU/L) × fasting glucose (nmol/L)/22.5 or (I0(μIU/mL) × G0 (mmol/L)/22.5). ††HOMA-B = (20 × insulin)/(glucose − 3.5) or (20 × I0(μIU/mL)/G0 (mmol/L) − 3.5). ‡‡DIo = (ΔI0 − 30/ΔG0 − 30) × (1/fasting insulin). §§Insulinogenic Index = (ΔI0–30/ΔG0–30) where ΔI0–30 = insulin at 30 min minus fasting insulin; ΔG0–30 = glucose at 30 min minus FPG.

at least one follow-up assessment before 2017 to estimate changes in glycemia. The characteristics of the 2,714 participants included in the final analyses (Supplementary Fig. 3) were similar to those of the overall sample (Supplementary Table 1). Because only 187 people had combined IFG and IGT, they were classified as having IGT.

Multistate Analysis

We used multistate Markov models (7,8) to calculate annual transition probabilities for each state specified in Supplementary Fig. 1. The mean sojourn time was also calculated. For every participant, the outcome of interest was iIFG, IGT, or diabetes. Time was estimated from date of interview to the time of outcome

diagnosis, last date of visit, or death, whichever came first. We fitted two models: *1*) normoglycemia to iIFG and regression to normoglycemia or progression to diabetes (i.e., normoglycemia ↔ iIFG → diabetes); and *2*) normoglycemia to IGT and regression to normoglycemia or progression to diabetes (normoglycemia ↔ IGT → diabetes). In the base case analysis, we assumed bidirectional change in states, allowing regression from prediabetes to normoglycemia (Supplementary Fig. 1). In a sensitivity analysis, we examined unidirectional progression, which assumes people cannot move back from prediabetes to normoglycemia (Supplementary Fig. 2). We performed stratified analyses by age (≤40 years vs. >40 years), sex, and BMI (<23 kg/m^2 vs. ≥23 kg/m^2) (9) to estimate the annual transition probabilities for each set of models. The data were analyzed using the msm package in R software, version 3.2.4, and Stata 16.0/MP.

RESULTS

As shown in Table 1, iIFG was nearly twice as frequent as IGT, and iIFG was more frequent in women (71.5%), and IGT in men (53.1%). Those with normoglycemia, followed by iIFG, and then IGT, had the lowest mean age (normoglycemia vs. iIFG vs. IGT: 37.6 vs. 40.9 vs. 43.7 years, respectively), weight (61.6 vs. 65.5 vs. 66.3 kg, respectively), BMI (25.0 vs. 27.2 vs. 27.0 kg/m^2, respectively), waist circumference (81.6 vs. 85.7 vs. 88.1 cm, respectively), triglyceride levels (107.0 vs. 124.0 vs. 137.0 mg/dL, respectively), and total cholesterol level (180.4 vs. 187.4 vs. 189.9 mg/dL, respectively). The insulin levels at 0, 30, 120 min (iIFG: 7.7, 48.2, and 40.0 vs. IGT: 8.5, 53.1, and 59.6, respectively) and HOMA-β (iIFG vs IGT: 69.3 vs. 91.5 μIU/mL/mmol/L, respectively) were lower in those with iIFG compared with participants with IGT, thus indicating iIFG is a more insulin-deficient state of prediabetes.

Table 2—Normoglycemia↔ iIFG →diabetes multistate Markov model annual probability of transition across states (overall and stratified by age, sex, and BMI)

	n	Annual transition probabilities, % (95% CI)
Overall		
Normoglycemia → normoglycemia	1,937	92.1 (91.2, 92.9)
Normoglycemia → iIFG	276	7.5 (6.7, 8.3)
Normoglycemia → diabetes	64	0.41 (0.34, 0.49)
iIFG → iIFG	193	68.6 (65.2, 71.8)
iIFG → normoglycemia	207	22.8 (19.6, 26.6)
iIFG → diabetes	78	8.6 (7.3, 9.8)
Age ≤40 years		
Normoglycemia → normoglycemia	1,362	93.2 (92.1, 94.2)
Normoglycemia → iIFG	164	6.4 (5.5, 7.4)
Normoglycemia → diabetes	37	0.35 (0.27, 0.45)
iIFG → iIFG	98	67.5 (62.7, 71.6)
iIFG → normoglycemia	121	24.1 (19.9, 29.5)
iIFG → diabetes	42	8.4 (6.8, 10.0)
Age >40 years		
Normoglycemia → normoglycemia	575	89.5 (87.4, 91.4)
Normoglycemia → iIFG	112	9.9 (8.1, 11.9)
Normoglycemia → diabetes	27	0.56 (0.41, 0.73)
iIFG → iIFG	95	69.7 (64.4, 74.2)
iIFG → normoglycemia	86	21.6 (17.0, 27.1)
iIFG → diabetes	36	8.7 (6.7, 10.6)
Male participants		
Normoglycemia → normoglycemia	769	92.7 (91.2, 93.9)
Normoglycemia → iIFG	87	6.8 (5.6, 8.1)
Normoglycemia → diabetes	40	0.52 (0.38, 0.72)
iIFG → iIFG	49	64.6 (56.9, 70.4)
iIFG → normoglycemia	61	23.9 (17.9, 31.6)
iIFG → diabetes	20	11.4 (9.0, 13.9)
Female participants		
Normoglycemia → normoglycemia	1,168	91.7 (90.6, 92.9)
Normoglycemia → iIFG	189	7.9 (6.8, 9.0)
Normoglycemia → diabetes	24	0.37 (0.28, 0.46)
iIFG → iIFG	144	70.4 (66.5, 73.6)
iIFG → normoglycemia	146	22.4 (18.9, 26.3)
iIFG → diabetes	58	7.2 (5.9, 8.6)
BMI <23 kg/m^2		
Normoglycemia → normoglycemia	655	94.2 (92.4, 95.6)
Normoglycemia → iIFG	59	5.5 (4.1, 7.1)
Normoglycemia → diabetes	16	0.34 (0.21, 0.54)
iIFG → iIFG	18	59.1 (45.6, 68.6)
iIFG → normoglycemia	43	32.0 (23.1, 46.9)
iIFG → diabetes	11	8.8 (5.7, 11.9)
BMI ≥23 kg/m^2		
Normoglycemia → normoglycemia	1,099	90.5 (89.2, 91.8)
Normoglycemia → iIFG	194	8.9 (7.7, 10.2)
Normoglycemia → Diabetes	38	0.48 (0.38, 0.59)
iIFG → iIFG	158	69.6 (65.7, 72.9)
iIFG → normoglycemia	153	22.1 (18.6, 26.3)
iIFG → diabetes	63	8.3 (6.9, 9.8)

Markov Model Transition Probabilities

Normoglycemia ↔ iIFG → Diabetes Pathway Model

The estimated mean annual probability of remaining in normoglycemia and in iIFG were 92.1% (95% CI 91.2, 92.9) and 68.6% (65.2, 71.8), respectively (Table 2). The annual probability of conversion from normoglycemia to iIFG was 7.5% (6.7, 8.3) and from iIFG to normoglycemia was 22.8% (19.6, 26.6). Thus, it is about three times more likely for iIFG to revert to normoglycemia than it is for normoglycemia to progress to iIFG. The annual probability of conversion from iIFG to diabetes was 8.6% (5.7, 11.9). The estimated mean sojourn times were 40.3 (34.6, 48.2) years and 9.7 (8.4, 11.4) years in normoglycemia and iIFG, respectively (Fig. 1).

The annual probability of transition for normoglycemia to iIFG was greater for those age >40 (9.9% [95% CI 8.1, 11.9]) years compared with those age ≤40 (6.4% [5.5, 7.4]) years (Table 2). The

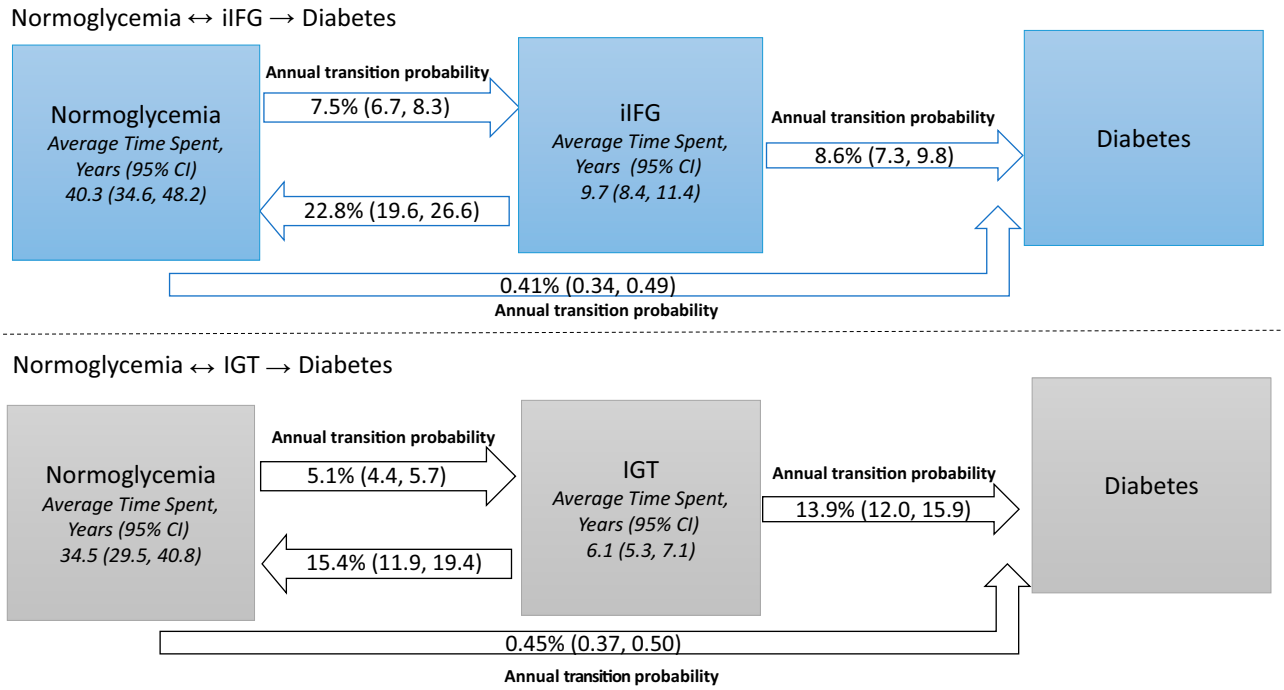

Figure 1—Multistate Markov models. The annual probability of remaining in the same state or transitioning to the next state.

annual probability of transition from iIFG to diabetes was higher in female participants than male participants (female: 7.9% [6.8, 9.0]; male: 6.8% [5.6, 8.1]). The annual probability of transition from normoglycemia to iIFG was greater for those with BMI ≥23 kg/m^2 (8.9% [7.7, 10.2]) compared with BMI <23 kg/m^2 (5.5% [4.1, 7.1]).

Normoglycemia ↔ IGT → Diabetes Pathway Model

The estimated annual probability of remaining in normoglycemia and IGT were 94.5% (95% CI 93.8, 95.2) and 70.1% (67.1, 73.8), respectively (Table 3). The annual probability of transition from normoglycemia to IGT was 5.1% (4.4, 5.7) and from IGT to normoglycemia was 15.4% (11.9, 19.4). Thus, it is about three times more likely for IGT to revert to normoglycemia than it is for normoglycemia to progress to IGT. The annual probability of transition from IGT to diabetes was 13.9% (12.0, 15.9). The estimated mean sojourn times were 34.5 (29.5, 40.8) years and 6.1 (5.3, 7.1) years for normoglycemia and IGT, respectively (Fig. 1).

The annual probability of transition from normoglycemia to IGT was higher among those aged >40 years (7.6% [95% CI 6.2, 9.1]) as compared with those aged ≤40 years (3.9% [3.3, 4.7]) (Table 3). The annual transition probability from normoglycemia to IGT was higher in men (6.8% [5.7, 8.0]) than women (3.9% [3.1, 4.6]). The annual probability of transition from normoglycemia to IGT was higher among those with BMI ≥23 kg/m^2 (6.2% [5.2, 7.1]) as compared with those with BMI <23 kg/m^2 (3.5% [2.6, 4.5]).

Sensitivity Analysis (Unidirectional Models)

In a sensitivity analysis, the probabilities of transition based on unidirectional models (i.e., not allowing regression from prediabetes to normoglycemia) were similar to those of base case bidirectional models (Supplementary Tables 1–4).

CONCLUSIONS

In an urban Indian population aged ≥20 years, progression to diabetes is rapid once an individual has prediabetes. On average, people reside 35–40 years in normoglycemic states, and only 9.7 years in iIFG or 6.1 years in IGT before advancing to diabetes (assuming bidirectional transition from normoglycemia to prediabetes). Prediabetes represents a fragile state, with a nearly three times likelihood of either iIFG or IGT reverting to normoglycemia than normoglycemia progressing to prediabetes. However, at the onset of prediabetes, and after accounting for reversibility, the rate of progression from prediabetes to diabetes was rapid, and those with IGT progressed to diabetes faster (13.9% per annum) than those with iIFG (8.6% per annum).

Similar to our findings, several studies have reported a high incidence of diabetes and prediabetes in Indians (1,10–12). In addition, we found a higher rate of conversion from normoglycemia to iIFG than to IGT, suggesting reduced insulin secretion (lower HOMA of β-cell function [HOMA-β]) as an early defect (13). However, among those with prediabetes, those with IGT had a more rapid conversion to diabetes, suggesting poorer insulin sensitivity as a key factor at later stages in those already susceptible, and iIFG and IGT being potentially different phenotypes with differences in pathophysiology (13–15). Similar to previous reports (16), we also found that iIFG is the more frequent (almost two-thirds) prediabetes manifestation in Indians, iIFG is the common phenotype in women, and IGT the more common phenotype in men. Although lifestyle interventions are effective in reducing the incidence of diabetes among adults with IGT (17,18), these interventions seem not effective in individuals with iIFG (19).

The strengths of our study include data from a representative sample, high response and retention rates, multiple time points of follow-up, and objective measures of glycemia derived from three-step oral glucose tolerance tests. To our knowledge, no previous study of diabetes in Indians has estimated time to progression or time spent

Table 3—Normoglycemia ↔ IGT→ diabetes multistate Markov model annual probability of transition across states (overall and stratified by age, sex, and BMI)

	n	Annual transition probability, % (95% CI)
Overall		
Normoglycemia → normoglycemia	1,894	94.5 (93.8, 95.2)
Normoglycemia → IGT	193	5.1 (4.4, 5.7)
Normoglycemia → diabetes	60	0.45 (0.37, 0.50)
IGT → IGT	67	70.1 (67.1, 73.8)
IGT → normoglycemia	71	15.4 (11.9, 19.4)
IGT → diabetes	66	13.9(12.0, 15.9)
Age ≤40 years		
Normoglycemia → normoglycemia	1,333	95.7 (94.9, 96.4)
Normoglycemia → IGT	106	3.9 (3.3, 4.7)
Normoglycemia → diabetes	34	0.36 (0.28, 0.47)
IGT → IGT	27	71.6 (66.4, 76.2)
IGT → normoglycemia	29	13.5 (8.9, 19.2)
IGT → diabetes	33	14.9 (11.9, 17.9)
Age >40 years		
Normoglycemia → normoglycemia	561	91.7 (90.1, 93.2)
Normoglycemia → IGT	87	7.6 (6.2, 9.1)
Normoglycemia → diabetes	26	0.64 (0.47, 0.82)
IGT → IGT	40	69.4 (63.9, 74.5)
IGT → normoglycemia	42	17.6 (12.6, 23.7)
IGT → diabetes	33	12.9 (10.3, 15.6)
Male participants		
Normoglycemia → normoglycemia	762	92.6 (91.3, 93.8)
Normoglycemia → IGT	100	6.8 (5.7, 8.0)
Normoglycemia → diabetes	39	0.59 (0.46, 0.74)
IGT → IGT	43	69.2 (63.7, 74.1)
IGT → normoglycemia	43	17.4 (12.4, 23.3)
IGT → diabetes	30	13.4 (10.8, 16.3)
Female participants		
Normoglycemia → normoglycemia	1,132	95.7 (94.9, 96.7)
Normoglycemia → IGT	93	3.9 (3.1, 4.6)
Normoglycemia → diabetes	21	0.35 (0.26, 0.43)
IGT → IGT	24	71.9 (66.9, 76.3)
IGT → normoglycemia	28	13.6 (9.1, 19.0)
IGT → diabetes	36	14.4 (11.5, 17.3)
BMI <23 kg/m^2		
Normoglycemia → normoglycemia	647	96.2 (95.1, 97.2)
Normoglycemia → IGT	41	3.5 (2.6, 4.5)
Normoglycemia → diabetes	15	0.27 (0.16, 0.41)
IGT → IGT	12	69.4 (57.1, 78.4)
IGT → normoglycemia	14	18.6 (9.6, 32.4)
IGT → diabetes	6	12.1 (7.5, 16.8)
BMI ≥23 kg/m^2		
Normoglycemia → normoglycemia	1,062	93.3 (92.3, 94.3)
Normoglycemia → IGT	135	6.2 (5.2, 7.1)
Normoglycemia → Diabetes	35	0.51 (0.41, 0.63)
IGT → IGT	51	71.0 (66.6, 75.0)
IGT → normoglycemia	53	15.9 (11.4, 20.7)
IGT → diabetes	49	13.1 (10.8, 15.5)

in each glycemic state. Given the fragility of the prediabetes state, we conservatively assumed bidirectional transition from normoglycemia to iIFG or IGT (in separate models), but we also performed sensitivity analyses to explore the effect of unidirectional transitions and other assumptions. The results for transition probabilities across states were robust regardless of assumption of bidirectional or unidirectional progression, but the estimates of time in each state were substantially longer under assumption of bidirectionality. Last, we performed stratified analyses by age, sex, and BMI. Our study has some limitations, including that data are from one city; however, diabetes incidence across urban India is quite similar, and the sample reflects the age and sociodemographic distribution of populations of cities in India.

In conclusion, we found a high rate of conversion from normoglycemia to IFG or IGT in Indians, and once an individual has prediabetes, the conversion to diabetes is rapid. On the hopeful side, people at risk for diabetes reside in normoglycemic states for an average of 35–40 years, and those transitioning through the more frequent iIFG stage reside there for an average of 9.7 years (as opposed to 6.1 years in IGT). These findings suggest the need to test interventions to prevent the occurrence of prediabetes.

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