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Prevalence and risk factors for self-reported diabetes among adult men and women in India: findings from a national cross-sectional survey

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Abstract

Objective: We examined the distribution of diabetes and modifiable risk factors to provide data to aid diabetes prevention programmes in India.
Design: Population-based cross-sectional survey of men and women included in India's third National Family Health Survey (NFHS-3, 2005–2006).
Setting: The sample is a multistage cluster sample with an overall response rate of 98 %. All states of India are represented in the sample (except the small Union Territories), covering more than 99 % of the country's population.
Subjects: Women (*n* 99 574) and men (*n* 56 742) aged 20–49 years residing in the sample households.
Results: Prevalence of diabetes was 1598/100 000 (95 % CI 1462, 1735) among men and 1054/100 000 (95 % CI 974, 1134) among women in India. Rural–urban and marked geographic variation were found with higher rates in south and north-eastern India. Weekly and daily fish intake contributed to a significantly higher risk of diabetes among both women and men. Risks of diabetes increased with increased BMI, age and wealth status of both women and men, but no effects of the consumption of milk/curd, vegetables, eggs, television watching, alcohol consumption or smoking were found. Daily consumption of pulse/beans or fruits was associated with a significantly reduced risk of diabetes among women, whereas non-significant inverse associations were observed in the case of men.
Conclusions: Prevalence was underestimated using self-reports. The wide variation in self-reported diabetes is unlikely to be due entirely to reporting biases or access to health care, and indicates that modifiable risk factors exist. Prevention of diabetes should focus on obesity and target specific socio-economic groups in India.

Keywords
Diabetes
Men
Women
India

Type 2 diabetes has become a major health challenge worldwide[1]. In 2000, there were an estimated 175 million people with diabetes worldwide and by 2030 the projected estimate of diabetes is 354 million[2,3]. The greatest relative rise is predicted in the developing countries of the Middle Eastern Crescent, Sub-Saharan Africa and the Indian subcontinent. By the year 2030, over 85 % of the world's diabetic patients will live in developing countries, reflecting their greater populations[3]. India, the world's second most populous country, now has more people with type 2 diabetes (more than 50 million) than any other nation[4] and the prevalence is expected to increase to 79·4 million in 2030[3]. The prevalence of diabetes in Asian Indians ranges from 2·7 % in rural India to 14·0 % in urban India[5–10] and is higher in migrant Asian Indian people compared with other ethnic groups[11–13]. In India, prevalence appears to be increasing in both urban[14–17] and rural areas[6,18,19]. Specific data available only for urban areas showed higher prevalence in south than in north India[9]. The increasing health challenge of diabetes in Asia as well as India has been well established in a series of recent studies[4,5,20–24].

The increase in diabetes in developing countries has been attributed to increased consumption of saturated fats and sugars and increased sedentary behaviour associated with urbanization and Westernization[23,25–27], underpinned by parallel increases in obesity[28–30]. Obesity and weight gain significantly increase the risk of diabetes[31,32], and physical inactivity further elevates the risk, independently of obesity[33–36]. Several lifestyle factors also affect the incidence of type 2 diabetes[37]. Cigarette smoking is associated with a small increase[38,39] and moderate alcohol consumption with a decrease in the risk of diabetes[40,41]. In addition, high

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consumption of eggs[42], chicken or meat[43–46] and fish[47] has been associated with an increased risk of diabetes whereas a low-fibre diet with high intake of vegetables and fruits[48,49] and legumes[50,51] is associated with a decrease in diabetes risk. In most of the studies, dietary and lifestyle factors have been considered individually, although behavioural factors are typically correlated with one another. In the present study we aimed to describe the geographic variation in prevalence of diabetes among a representative national sample of Indian women and men, contrasting rural and urban rates, and to examine the effect of modifiable risk factors including dietary and lifestyle factors on diabetes prevalence.

Methods

Data from India's third National Family Health Survey (NFHS-3, 2005–2006) were used. Briefly, this survey was designed on the lines of the Demographic and Health Surveys (www.measuredhs.com) that have been conducted in many developing countries since the 1980s. The NFHS has been conducted in India for successive three rounds, each at an interval of 5 years. The third round of the NFHS (i.e. NFHS-3) collected demographic, socio-economic and health information from a nationally representative probability sample of 124 385 women aged 15–49 years and 74 369 men aged 15–54 years residing in 109 041 households. The sample is a multistage cluster sample with an overall response rate of 98 %. All states of India are represented in the sample (except the small Union Territories), covering more than 99 % of the country's population. Full details have been published[52]. The analysis in the present study focuses on 99 574 women and 56 742 men aged 20–49 years living in the sample households.

Response variable

The survey asked several questions relating to specific health problems of the individual, including whether the respondent currently has diabetes. The question was: 'Do you currently have diabetes?' The survey was conducted using an interviewer-administered questionnaire in the native language of the respondent using a local, commonly understood term for diabetes. A total of eighteen languages were used in the survey with back translation into English to ensure accuracy and comparability. It is important to recognize that reported diabetes is not as accurate as clinical measures of diabetes. No physician diagnosis of diabetes could be obtained to verify self-reports and it was not possible to take fasting blood glucose to establish a diagnosis. In our analysis, this reported prevalence of diabetes is the response variable.

Predictor variables

The survey collected information on demographic, socio-economic factors and food habits. Consumption of selected foods was assessed by asking 'How often do you yourself consume the following items: daily, weekly, occasionally or never?' related to milk or curd, pulses or beans, green leafy vegetables, other vegetables, fruits, eggs, and chicken, meat or fish. Frequency of watching television (almost every day, at least once weekly, less than once weekly, not at all) was used as a measure of sedentary behaviour. Use of tobacco was measured as never smoker and ever smoker. Use of alcohol was quantified as drinks almost every day, about once weekly, less than once weekly and never.

Participants were weighed using a solar-powered scale with an accuracy of ± 100 g. Height was measured using an adjustable wooden measuring board, specifically designed to provide accurate measurements (to the nearest 0·1 cm) in a developing-country field situation. The weight and height data were used to calculate BMI. Women who were pregnant at the time of the survey or women who had given birth during the two months preceding the survey were excluded from these measurements. Thresholds for BMI were defined as $<18{\cdot}5\ \mathrm{kg/m^2}$ (underweight), 18·5 to $24{\cdot}9\ \mathrm{kg/m^2}$ (normal weight), 25·0 to $29{\cdot}9\ \mathrm{kg/m^2}$ (overweight) and $\geq 30{\cdot}0\ \mathrm{kg/m^2}$ (obese).

Because the effects of the risk factors on the prevalence of diabetes are likely to be confounded with the effects of other risk factors, it is necessary to statistically control or adjust for such factors. Control variables included in the present study were age, education, wealth status of the household and place of residence. Age was divided into three categories as 20–29 years, 30–39 years and 40–49 years. Education was classified as no education, primary (5–7 years completed), secondary (8–9 years) or higher (10+ years). Wealth index (based on thirty-three assets and housing characteristics and graded as lowest, second, middle, fourth and highest) was computed using previously described methods (see Appendix). Place of residence was defined as urban or rural.

Statistical analysis

Descriptive statistics were calculated with the use of standard methods. Prevalence of diabetes was computed as the number of diabetes cases per 100 000 persons. Trend tests were also carried out scoring the variables in different categories by using likelihood ratio tests. Because our response variable – prevalence of diabetes – is dichotomous, we used logistic regression to estimate the odds ratios of the risk factors for diabetes after controlling for socio-economic and demographic factors and examining for the independent effects of risk factors. As certain states and certain categories of respondents were oversampled, in all analyses sample weights were used to restore the representativeness of the sample.

Results are presented in the form of odds ratios with 95 % confidence intervals. The estimation of confidence intervals takes into account the design effects due to clustering at the level of the primary sampling unit. Before

carrying out the multivariate models, we tested for the possibility of multicollinearity between the predictor variables. In the correlation matrix of predictor variables, all pairwise Pearson correlation coefficients were <0·5, suggesting that multicollinearity is not a problem. All analyses including the logistic regression models were conducted using the STATA 10 statistical software package (StataCorp., College Station, TX, USA)[53].

Human subjects' informed consent

The analysis presented herein is based on secondary analysis of existing survey data, with all identifying information removed. The survey obtained informed consent from each respondent before asking questions.

Results

Prevalence of diabetes by state and residence

Table 1 shows diabetes prevalence among men and women by state and residence. Prevalence of diabetes was 1054/100 000 (95 % CI 974, 1134) among women and 1598/100 000 (95 % CI 1462, 1735) among men in India. Overall the prevalence rates were higher in men but inconsistent patterns were seen in different states.

Marked geographic variation and rural urban differences in prevalence were observed. Goa had the highest overall diabetes prevalence among men (5215/100 000; 95 % CI 3835, 6594) while Kerala has highest overall diabetes prevalence among women (2953/100 000; 95 % CI 2352, 3554). Rajasthan, Uttar Pradesh, Assam and Arunachal Pradesh all had diabetes prevalence levels below 500/100 000 among women while only Rajasthan and Mizoram had a diabetes prevalence level below 500/100 000 among men.

Overall there was a large urban–rural variation of diabetes in India. Comparisons between states showed that most had higher diabetes rates in urban compared with rural areas, with similar urban-to-rural ratios in men and women. Prevalence ratios showed a marked variation and were as high as sixteen-fold (women, Meghalaya, north-eastern region) but several states showed no marked urban–rural differences in men or women (Rajasthan, Himachal Pradesh, Manipur, Sikkim, Goa).

Risk factors for diabetes

Table 2 shows the percentage distribution of women and men by diabetes status and Table 3 shows the prevalence rates per 100 000 persons by risk factors and socio-demographic characteristics for women and men. Diabetes was more common among both women and men who consumed milk or curd, eggs, fish, chicken or meat daily, who were either overweight or obese, who watched television almost every day, and in those who were the oldest age group, lived in urban areas and in wealthier households (all $P<0·0001$). No differences in prevalence were seen for vegetable and fruit consumption or smoking tobacco. Strong associations between age and diabetes prevalence were observed. No clear pattern of prevalence by education was seen. Diabetes prevalence increased according to the wealth of the household and was almost double in urban women and men compared with their rural counterparts.

Table 4 presents unadjusted and adjusted logistic regression results showing the effect of modifiable risk factors and socio-economic and demographic characteristics on diabetes among women and men in separate models. Model I presents unadjusted results, Model II presents results independently for the risk factors adjusted for sociodemographic factors which may be confounders and Model III presents results adjusted for both risk factors and confounders.

Unadjusted results show that the risk of diabetes was 1·3 times higher (OR = 1·29; 95 % CI 1·13, 1·47) among women and 1·6 times higher among men (OR = 1·59; 95 % CI 1·37, 1·84) who consumed milk or curd weekly compared with those who consumed them occasionally/never. However, this effect disappeared in women and was markedly attenuated in men (OR = 1·21; 95 % CI 1·02, 1·43) after controlling for the potential confounders. Daily intake of fish was associated with 1·6 times higher risk of diabetes among women (OR = 1·59; 95 % CI 1·33, 1·90) and 1·4 times higher risk among men (OR = 1·44; 95 % CI 1·20, 1·73) as compared with occasional/never consumers. Weekly fish intake also contributed to a higher risk of diabetes both among women (OR = 2·05; 95 % CI 1·67, 2·53; $P<0·0001$) and men (OR = 2·14; 95 % CI 1·70, 2·70) even after controlling the effects of potential confounders. Daily chicken/meat consumption was found to be associated with higher diabetes risk among men (OR = 1·25; 95 % CI 1·06, 1·48) but not among women. The odds of diabetes were higher for both women and men who consumed eggs daily or weekly in the crude analyses but in adjusted models these effects disappeared.

Daily consumption of pulse/beans (OR = 0·71; 95 % CI 0·58, 0·86) and fruits (OR = 0·77; 95 % CI 0·66, 0·90) was associated with a significantly reduced risk of diabetes among women whereas non-significant inverse associations were also observed in the case of men. No effect of daily vegetable consumption on diabetes was found either in women or men in both crude and adjusted analyses.

Considering BMI status, the crude odds were more than six times higher among obese women and almost two times higher in obese men; the effect remained strong but was partly attenuated in the fully adjusted model. Diabetes was three times higher among obese women (OR = 3·05; 95 % CI 2·49, 3·73) and 1·5 times higher among obese men (OR = 1·49; 95 % CI 1·06, 2·08) in the adjusted analysis. The unadjusted odds of diabetes were higher among those who watched television almost every day for both women and women but in adjusted models these effects disappeared. However, no effects of alcohol consumption or smoking on diabetes were found in the adjusted analyses.

Table 1 Prevalence of diabetes (per 100 000 persons with 95 % CI) among women (*n* 99 574) and men (*n* 56 742) aged 20–49 years by Indian state and residence, 2005–2006

	Women							Men						
	Urban		Rural		Total		Number	Urban		Rural		Total		Number
India and states	Prevalence	95 % CI	Prevalence	95 % CI	Prevalence	95 % CI	of women	Prevalence	95 % CI	Prevalence	95 % CI	Prevalence	95 % CI	of men
India	1653	1490, 1814	752	663, 841	1054	974, 1134	1049	2239	2006, 2471	1230	1060, 1399	1598	1462, 1735	1036
Northern region														
Delhi	2207	1592, 2822	–	–	2048	1477, 2620	2767	2239	1270, 3208	–	–	2073	1175, 2970	1151
Haryana	2627	1357, 3898	802	368, 1237	1368	872, 1865	2232	2459	516, 4402	962	196, 1727	1445	630, 2261	868
Himachal Pradesh	1157	405, 1908	1223	726, 1719	1216	765, 1666	2649	694	−265, 1654	888	113, 1663	862	179, 1544	843
Jammu and Kashmir	1556	747, 2364	232	5, 460	637	343, 932	2616	1779	234, 3325	183	−175, 541	691	139, 1242	827
Punjab	1361	677, 2045	825	423, 1228	1027	667, 1387	3042	2340	974, 3707	1338	417, 2259	1779	986, 2572	1068
Rajasthan	366	8, 725	302	61, 543	321	121, 521	3075	439	−168, 1045	414	−54, 882	422	50, 794	1178
Uttaranchal	1826	842, 2809	743	324, 1161	1047	638, 1457	2326	2768	877, 4660	599	−77, 1274	1385	572, 2197	790
Central region														
Chhattisgarh	1178	515, 1840	664	304, 1024	784	468, 1100	2969	4124	2145, 6102	405	−52, 862	1298	704, 1893	1132
Madhya Pradesh	1622	866, 2377	284	74, 495	664	401, 927	5167	523	−124, 1170	790	245, 1335	709	281, 1136	2252
Uttar Pradesh	912	503, 1322	344	185, 502	495	335, 654	9184	1149	706, 1593	512	307, 716	707	511, 904	8938
Eastern region														
Bihar	2326	1459, 3193	1155	652, 1658	1348	904, 1792	2871	1055	135, 1975	1610	503, 2716	1488	601, 2376	987
Jharkhand	1774	912, 2635	496	130, 863	843	488, 1199	2305	2029	541, 3517	648	−83, 1379	1061	381, 1740	811
Orissa	1508	797, 2220	474	206, 741	658	404, 912	3653	4667	2718, 6616	892	277, 1507	1641	1011, 2272	1355
West Bengal	2514	1723, 3304	1479	1006, 1952	1810	1410, 2220	5498	2707	1425, 3989	2781	1746, 3815	2755	1946, 3565	2273
North-eastern region														
Arunachal Pradesh	773	−98, 1645	349	−45, 744	468	93, 843	1249	588	−561, 1738	769	−98, 1636	719	16, 1423	560
Assam	875	306, 1444	330	86, 574	434	209, 660	3139	1481	305, 2658	666	84, 1247	844	322, 1367	1163
Manipur	1217	699, 1734	1081	632, 1530	1127	782, 1472	3747	1840	1165, 2515	1768	1161, 2375	1793	1333, 2253	3322
Meghalaya	2973	1749, 4197	217	−83, 518	978	572, 1383	1660	2088	276, 3890	977	−123, 2078	1270	329, 2210	550
Mizoram	1615	744, 2486	886	180, 1592	1297	717, 1877	1482	348	−333, 1030	379	−362, 1120	362	−140, 864	551
Nagaland	1214	671, 1757	387	78, 696	625	355, 895	3139	1629	1030, 2227	1202	650, 1755	1337	915, 1760	3217
Sikkim	1672	692, 2651	1383	664, 2103	1445	841, 2048	1671	3321	1188, 5454	2273	805, 3741	2509	1275, 3744	661
Tripura	2368	839, 3897	1909	1100, 2718	1994	1277, 2712	1473	6207	2280, 10 134	3097	1500, 4695	3627	2141, 5114	598
Western region														
Goa	2387	1606, 3169	2009	1298, 2721	2221	1683, 2759	2957	5657	3621, 7692	4673	2884, 6461	5215	3835, 6594	1029
Gujarat	1437	796, 2079	979	516, 1442	1180	797, 1563	3059	1429	378, 2479	568	13, 1123	942	387, 1497	1192
Maharashtra	703	449, 956	470	179, 760	589	397, 781	7347	2039	1529, 2549	964	544, 1385	1541	1205, 1877	7368
Southern region														
Andhra Pradesh	2020	1362, 2679	329	86, 573	896	621, 1170	5898	4060	3132, 4988	2403	1745, 3061	2979	2442, 3517	6084
Karnataka	1237	734, 1739	465	222, 707	778	528, 1028		2511	1794, 3227	939	586, 1291	1610	1243, 1977	4709
Kerala	3410	2330, 4490	2704	1986, 3422	2953	2352, 3554	3045	6590	3987, 9193	3607	2127, 5086	4688	3351, 6026	959
Tamil Nadu	3277	2369, 4186	1860	1309, 2411	2547	2023, 3071	5077	2826	1969, 3683	1396	891, 1900	2121	1620, 2622	4951

Table 2 Distribution of women (*n* 99 574) and men (*n* 56 742) aged 20–49 years according to diabetes status by risk factors and background characteristics, India, 2005–2006

Risk factors and other background characteristics	Women					Men				
	Yes		No		χ^2	Yes		No		χ^2
	n	%	*n*	%	*P* value	*n*	%	*n*	%	*P* value
Consumption of milk or curd					<0·001					<0·001
Occasionally/never	419	39·9	43 686	44·4		594	57·8	27 158	45·0	
Weekly	138	13·2	14 929	15·2		162	15·6	12 023	19·9	
Daily	492	46·9	39 860	40·5		280	27·0	21 159	35·1	
Consumption of vegetables					0·097					0·003
Occasionally/never	80	8·5	5319	5·4		23	2·2	2608	4·3	
Weekly	286	27·4	27 378	27·8		312	33·4	19 276	31·9	
Daily	674	64·3	63 393	66·8		700	10·3	38 465	63·7	
Consumption of pulses/beans					<0·001					<0·001
Occasionally/never	151	14·4	10 362	10·5		582	56·2	29 769	49·3	
Weekly	360	34·3	36 233	36·8		346	33·4	23 571	39·1	
Daily	538	51·3	51 875	52·7		107	10·3	7000	11·6	
Consumption of fruits					<0·001					<0·001
Occasionally/never	567	54·1	59 465	60·4		419	42·7	32 215	42·7	
Weekly	276	26·3	26 443	26·8		368	37·5	20 464	37·5	
Daily	206	19·6	12 577	12·8		195	19·9	7694	19·9	
Consumption of eggs					<0·001					<0·001
Occasionally/never	627	59·7	66 663	67·7		499	50·9	35 676	59·1	
Weekly	363	34·6	28 410	28·8		405	41·3	21 705	36·0	
Daily	60	5·7	3413	3·5		77	7·8	2993	5·0	
Consumption of fish					<0·001					<0·001
Occasionally/never	595	56·8	70 369	71·5		563	54·3	39 940	66·2	
Weekly	304	29·0	21 763	22·1		352	34·0	16 377	27·1	
Daily	149	14·2	6353	6·5		121	11·7	4032	6·7	
Consumption of chicken or meat					<0·001					<0·001
Occasionally/never	743	70·8	76 020	77·2		604	61·8	43 294	71·7	
Weekly	292	27·8	21 640	22·0		369	37·6	16 346	27·1	
Daily	14	1·3	825	0·8		8	0·8	733	1·2	
BMI status					<0·001					<0·001
Underweight	119	11·6	24 867	26·3		90	9·1	11 109	19·6	
Normal weight	471	445·9	55 854	59·1		607	61·5	38 805	68·6	
Overweight	280	27·3	10 695	11·3		240	24·3	5767	10·2	
Obese	157	15·3	3031	3·2		50	5·1	855	1·5	
Smokes tobacco					0·514					<0·001
No	1030	98·2	96 668	98·2		713	68·8	37 414	62·0	
Yes	19	1·8	1817	1·8		323	31·2	22 934	38·0	
Consumption of alcohol					0·020					0·181
Never	1037	99·0	96 025	97·5		630	60·9	36 677	60·8	
Less than once weekly	7	0·7	1059	1·1		223	21·5	13 837	22·9	
About once weekly	3	0·3	1007	1·0		123	11·9	7192	11·9	
Almost every day	1	0·1	394	0·4		59	5·7	2644	4·4	
Watching television					<0·001					<0·001
Not at all	255	24·3	35 129	35·7		659	63·6	29 398	16·1	
Less than once weekly	96	9·2	10 340	10·5		155	15·0	9993	18·6	
At least once weekly	100	9·5	10 850	11·0		112	10·8	11 231	16·6	
Almost every day	598	57·0	42 144	42·8		110	10·6	9719	48·7	
Age (years)					<0·001					<0·001
20–29	113	10·8	43 061	43·7		91	8·8	23 036	38·2	
30–39	342	32·6	33 171	33·7		196	18·9	18 846	31·2	
40–49	594	56·6	22 253	22·6		749	72·3	18 466	30·6	
Education					<0·001					<0·001
No education	338	32·3	44 753	45·4		138	13·3	11 129	18·4	
Primary	192	18·3	14 270	14·5		155	15·0	10 543	17·5	
Secondary	435	41·5	31 217	31·7		503	48·6	29 488	48·9	
Higher	83	7·9	8240	8·4		239	23·1	9169	15·2	
Wealth index					<0·001					<0·001
Lowest	71	6·8	17 211	17·5		47	4·5	7596	12·6	
Second	141	13·4	18 394	18·7		100	9·7	10 252	17·0	
Middle	152	14·5	19 541	19·8		144	13·9	13 447	22·2	
Fourth	275	26·2	20 640	21·0		233	22·5	14 629	24·2	
Highest	411	39·1	22 699	23·0		512	49·4	14 424	23·9	
Residence					<0·001					<0·001
Rural	498	47·5	65 698	33·3		483	46·7	37 527	62·2	
Urban	551	52·5	32 787	66·7		552	53·3	22 822	37·8	
Total	1050	100·0		100·0		1036	100·0		100·0	

Table 3 Prevalence of diabetes (per 100 000 persons) with 95 % CI among women (*n* 99 574) and men (*n* 56 742) aged 20–49 years by risk factors and background characteristics, India, 2005–2006

Risk factors and background characteristics	Women			Men		
	Prevalence	95 % CI	*P* for trend	Prevalence	95 % CI	*P* for trend
Consumption of milk or curd			0·0043			0·0000
Occasionally/never	949	832, 1066		1274	1036, 1512	
Weekly	915	718, 1113		1189	929, 1450	
Daily	1220	1088, 1352		2010	1798, 2221	
Consumption of vegetables			0·2149			0·0130
Occasionally/never	1114	777, 1450		887	355, 1419	
Weekly	961	819, 1103		1440	1216, 1663	
Daily	1087	986, 1188		1732	1552, 1912	
Consumption of pulses/beans			0·0073			0·0000
Occasionally/never	1440	1157, 1723		1540	1088, 1992	
Weekly	983	852, 1114		1205	1012, 1397	
Daily	1026	918, 1134		1893	1689, 2098	
Consumption of fruits			0·0000			0·0000
Occasionally/never	944	841, 1046		1283	1094, 1471	
Weekly	1034	888, 1180		1764	1538, 1990	
Daily	1613	1355, 1870		2467	2058, 2876	
Consumption of eggs			0·0000			0·0003
Occasionally/never	931	839, 1023		1379	1214, 1544	
Weekly	1260	1096, 1424		1833	1591, 2076	
Daily	1717	1183, 2252		2496	1688, 3304	
Consumption of fish			0·0000			
Occasionally/never	839	754, 924		1289	1143, 1434	
Weekly	1380	1181, 1579		2057	1753, 2361	
Daily	2297	1862, 2731		3044	2224, 3865	
Consumption of chicken or meat			0·0000			0·0000
Occasionally/never	968	879, 1057		1310	1137, 1483	
Weekly	1330	1146, 1514		1874	1649, 2100	
Daily	1695	670, 2720		2311	1590, 3032	
BMI status			0·0000			0·0000
Underweight	476	356, 596		811	560, 1063	
Normal weight	837	738, 936		1513	1341, 1685	
Overweight	2554	2212, 2896		3733	3115, 4350	
Obese	4921	4008, 5835		4507	3032, 5983	
Smokes tobacco			0·9195			0·0705
No	1054	974, 1135		1700	1527, 1873	
Yes	1019	341, 1696		1434	1210, 1657	
Consumption of alcohol			0·0313			0·7657
Never	1069	987, 1151		1560	1389, 1731	
Less than once weekly	695	4, 1386		1639	1333, 1945	
About once weekly	274	−52, 601		1632	1255, 2009	
Almost every day	353	−284, 990		1913	1216, 2609	
Watching television			0·0000			0·0000
Not at all	720	594, 846		1140	818, 1461	
Less than once weekly	921	679, 1164		991	693, 1290	
At least once weekly	909	686, 1132		1552	1216, 1887	
Almost every day	1400	1269, 1532		2079	1874, 2285	
Age (years)			0·0000			0·0000
20–29	262	199, 325		398	270, 526	
30–39	1019	880, 1158		939	754, 1124	
40–49	2602	2345, 2858		3651	3292, 4010	
Education			0·0000			0·0000
No education	750	643, 858		1382	1042, 1722	
Primary	1331	1090, 1572		1296	1008, 1585	
Secondary	1373	1218, 1529		1540	1354, 1726	
Higher	1002	764, 1240		2485	2075, 2894	
Wealth index			0·0000			0·0000
Lowest	408	266, 550		856	509, 1204	
Second	759	574, 944		1029	734, 1324	
Middle	773	610, 937		870	643, 1097	
Fourth	1314	1124, 1504		1540	1280, 1801	
Highest	1777	1584, 1969		3203	2842, 3565	
Residence			0·0000			0·0000
Rural	752	663, 841		1230	1060, 1399	
Urban	1653	1491, 1815		2239	2006, 2471	
Total	1054	974, 1134		1598	1462, 1735	

Table 4 Unadjusted and adjusted effects of risk factors and socio-economic and demographic characteristics on diabetes from logistic regression analysis among women (*n* 99 574) and men (*n* 56 742), India, 2005–2006 (dependent variable: diabetes; yes = 1, no = 0)

	Women						Men					
	Model I Unadjusted		Model II Adjusted only for confounders*		Model III Adjusted for risk factors† and confounders*		Model I Unadjusted		Model II Adjusted only for confounders*		Model III Adjusted for risk factors† and confounders*	
Risk factors and confounders	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Consumption of milk or curd												
Occasionally/never[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	1·29	1·13, 1·47	0·95	0·83, 1·09	1·00	0·86, 1·15	1·59	1·37, 1·84	1·13	0·96, 1·32	1·21	1·02, 1·43
Daily	0·96	0·79, 1·17	0·82	0·68, 1·00	0·89	0·73, 1·08	0·93	0·76, 1·14	0·86	0·70, 1·05	0·89	0·72, 1·10
Consumption of vegetables												
Occasionally/never[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	0·81	0·65, 1·01	0·74	0·59, 0·93	0·91	0·68, 1·20	1·58	1·15, 2·16	1·20	0·87, 1·65	1·12	0·80, 1·56
Daily	0·86	0·65, 1·14	0·81	0·64, 1·13	0·94	0·70, 1·26	1·35	0·97, 1·87	1·19	0·86, 1·66	1·24	0·88, 1·74
Consumption of pulses or beans												
Occasionally/never[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	0·71	0·59, 0·85	0·60	0·50, 0·72	0·68	0·56, 0·83	1·23	0·98, 1·55	0·94	0·86, 1·66	1·02	0·80, 1·31
Daily	0·68	0·56, 0·82	0·67	0·55, 0·82	0·71	0·58, 0·86	0·78	0·61, 0·99	0·75	0·58, 0·95	0·78	0·61, 1·01
Consumption of fruits												
Occasionally/never[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	1·72	1·47, 2·02	1·00	0·83, 1·21	0·94	0·77, 1·15	1·95	1·64, 2·31	1·22	1·00, 1·48	0·94	0·76, 1·15
Daily	1·10	0·95, 1·27	0·79	0·68, 0·92	0·77	0·66, 0·90	1·38	1·20, 1·59	1·07	0·92, 1·25	0·93	0·79, 1·10
Consumption of eggs												
Occasionally/never[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	1·86	1·42, 2·43	1·59	1·21, 2·09	1·09	0·80, 1·49	1·83	1·44, 2·34	1·97	1·53, 2·52	1·39	1·04, 1·86
Daily	1·36	1·19, 1·55	1·28	1·12, 1·46	1·06	0·90, 1·26	1·34	1·17, 1·52	1·42	1·24, 1·63	1·11	0·93, 1·31
Consumption of fish												
Occasionally/never[Ref.]	1·00		1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	2·78	2·32, 3·33	2·19	1·82, 2·64	2·05	1·67, 2·53	2·41	1·97, 2·93	2·06	1·68, 2·53	2·14	1·70, 2·70
Daily	1·65	1·44, 1·90	1·58	1·37, 1·81	1·59	1·33, 1·90	1·61	1·40, 1·85	1·66	1·44, 1·92	1·44	1·20, 1·73
Consumption of chicken or meat												
Occasionally/never[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Weekly	1·76	1·04, 2·99	1·54	0·90, 2·63	0·87	0·48, 1·58	1·78	1·40, 2·27	0·77	0·38, 1·56	0·41	0·19, 0·91
Daily	1·38	1·20, 1·58	1·24	1·08, 1·42	0·89	0·75, 1·06	1·44	1·26, 1·64	1·59	1·39, 1·82	1·25	1·06, 1·48
BMI status												
Normal weight[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Underweight	0·57	0·46, 0·69	0·69	0·56, 0·85	0·69	0·56, 0·85	4·74	3·74, 6·00	0·67	0·54, 0·83	0·69	0·56, 0·86
Overweight	3·11	2·68, 3·61	1·89	1·61, 2·21	1·86	1·59, 2·18	5·77	3·99, 8·34	1·41	1·19, 1·67	1·37	1·15, 1·62
Obese	6·13	5·10, 7·38	3·05	2·50, 3·73	3·05	2·49, 3·73	1·88	1·52, 2·32	1·43	1·02, 2·00	1·49	1·06, 2·08
Smokes tobacco												
No[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Yes	0·97	0·61, 1·53	0·93	0·58, 1·48	1·29	0·81, 2·06	0·84	0·74, 0·96	1·18	1·02, 1·35	0·80	0·69, 0·92
Consumption of alcohol												
Never[Ref.]							1·00	Ref.	1·00	Ref.	1·00	Ref.
Less than once weekly	NI		NI		NI		1·23	0·90, 1·68	1·11	0·81, 1·53	0·96	0·70, 1·33
About once weekly	NI		NI		NI		1·05	0·85, 1·30	1·10	0·88, 1·37	0·96	0·76, 1·20
Almost every day	NI		NI		NI		1·05	0·90, 1·23	1·15	0·98, 1·34	1·08	0·91, 1·27

Table 4 *Continued*

	Women						Men					
	Model I Unadjusted		Model II Adjusted only for confounders*		Model III Adjusted for risk factors† and confounders*		Model I Unadjusted		Model II Adjusted only for confounders*		Model III Adjusted for risk factors† and confounders*	
Risk factors and confounders	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Watching television												
Not at all[Ref.]	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.	1·00	Ref.
Less than once weekly	1·96	1·69, 2·27	1·01	0·83, 1·22	0·88	0·72, 1·07	1·84	1·52, 2·23	1·24	0·98, 1·57	1·01	0·79, 1·29
At least once weekly	1·27	1·00, 1·60	0·82	0·64, 1·05	0·78	0·61, 1·00	1·37	1·08, 1·73	1·39	1.08, 1.79	1·32	1·02, 1·71
Almost every day	1·28	1·01, 1.62	0·98	0·77, 1·25	0·94	0·73, 1·20	0·87	0·68, 1·11	0·94	0·73, 1·21	0·94	0·73, 1·22
Age (years)												
20–29[Ref.]	1·00	Ref.			1·00	Ref.	1·00	Ref.			1·00	Ref.
30–39	3·92	3·17, 4·85			3·40	2·73, 4·22	2·37	1·84, 3·06			2·30	1·76, 3·00
40–49	10·18	8·32, 12·45			8·27	6·69, 10·21	9·48	7·62, 11·81			9·41	7·46, 11·87
Education												
No education[Ref.]	1·00	Ref.			1·00	Ref.	1·00	Ref.			1·00	Ref.
Primary	1·78	1·49, 2·13			1·41	1·16, 1·71	0·94	0·75, 1·17			0·74	0·58, 0·94
Secondary	1·84	1·60, 2·12			1·48	1·23, 1·77	1·12	0·94, 1·33			0·73	0·59, 0·91
Higher	1·34	1·05, 1·70			1·03	0·77, 1·38	1·82	1·49, 2·22			0·77	0·59, 1·00
Wealth index												
Lowest[Ref.]	1·00	Ref.			1·00	Ref.	1·00	Ref.			1·00	Ref.
Second	1·87	1·40, 2·49			1·66	1·23, 2·23	1·20	0·91, 1·60			1·18	0·88, 1·58
Middle	1·90	1·43, 2·53			1·40	1·03, 1·90	1·02	0·76, 1·35			0·90	0·66, 1·23
Fourth	3·25	2·50, 4·23			1·77	1·30, 2·42	1·81	1·41, 2·34			1·50	1·10, 2·05
Highest	4·42	3·43, 5·69			1·68	1·20, 2·36	3·83	3·03, 4·84			2·64	1·89, 3·69
Residence												
Rural[Ref.]	1·00	Ref.			1·00	Ref.	1·00	Ref.			1·00	Ref.
Urban	2·22	1·96, 2·51			1·46	1·25, 1·70	1·84	1·62, 1·09			1·01	0·87, 1·18

Ref., reference category; NI, not included.
*Confounders are age, residence, education and wealth index.
†Risk factors are consumption of milk/curd, consumption of vegetables/fruits, consumption of pulses/beans, consumption of fish, consumption of eggs/meat/chicken, BMI status, smokes tobacco, consumption of alcohol and watching television.

Age was the strongest risk factor for diabetes in these data. The odds of suffering from diabetes were 8·3 times higher (OR = 8·27; 95% CI 6·69, 10·21) among women and 9·4 times higher (OR = 9·41; 95% CI 7·46, 11·87) among men aged more than 40 years. Women with primary or secondary education had greater odds of diabetes in crude analyses which remained strong in the adjusted analysis. Men with higher education had greater unadjusted odds of diabetes but this effect was attenuated to null after full adjustment. By contrast, the wealth index remained significantly associated with increased risk of diabetes even after full adjustment.

Discussion

There is marked country-wide variation in diabetes prevalence in India. Urban rates tend to be highest in the southern region but high urban rates are found in most regions. Consumption of fish, chicken or meat was associated with higher risk of diabetes and consumption of pulses/ beans and fruit was associated with a lower risk of diabetes. Overweight and obesity were also associated with a significantly higher risk of diabetes but watching television was not. Higher wealth was associated with increased risk of diabetes but educational attainment was not. No strong evidence for associations of diabetes risk with daily milk/curd consumption, vegetable consumption, smoking tobacco or alcohol was found. Findings were broadly similar for men and women.

The prevalence of self-reported diabetes in this large nationally representative survey was comparatively low (about 1%) reflecting the young age of this population and the use of self-reports rather than biochemical assessments. Estimates from a recent study of rural–urban migrants showed an age-adjusted prevalence of diabetes (diagnosed using both self-reports and fasting blood glucose in relatively affluent populations) of 10–15% in urban people and 5–6% in rural people of similar age to those recruited in NFHS-3[54]. In most urban parts of India the health system is well enough developed for diagnosis of symptomatic diabetes, but at younger ages (<30 years) diabetes may not be symptomatic and NFHS-3 prevalence estimates are undoubtedly conservative, particularly for rural India where diagnosis may be much less likely to occur.

The geographic variation in diabetes prevalence indicates that within most regions of India, some states stand out as 'hot spots' reflecting variation between states in their epidemiological transition. Economically more prosperous states (e.g. Goa, Kerala) would be expected to have higher rates of diabetes compared with poorer states (e.g. Rajasthan) which may be mediated by more calorific diets and lower levels of physical activity.

We did not find that daily milk consumption was protective for diabetes in India although there was evidence that weekly milk consumption might be harmful among men (analysis not shown). Previous studies have shown higher dairy intake may lower the risk of type 2 diabetes, but these studies were conducted in developed countries[55–58] with the exception of a recent study of middle-aged Chinese women[59]. Our negative finding in India, which has a very different confounding structure to that in Western countries, suggests that the protective effect of milk consumption may be due to residual or uncontrolled confounding in Western studies. It is also possible that reverse causation arises, resulting in people with diabetes taking milk daily as they believe it is protective. The Diabetes India website (www.diabetesindia.com) does recommend up to 1 litre of milk daily as part of a diabetic diet. Confirmation of our findings in other Indian studies would be helpful in determining whether such advice should be withdrawn.

Our finding of daily and weekly fish consumption increasing the risk of diabetes was robust, suggesting that a non-vegetarian diet is harmful. It is supported by recent findings showing similar effects, that regular eating of red meat is associated with increased propensity to gain weight which may be the important factor in determining risk[42,43,60–62,]. However, this finding warrants further investigation looking into the cooking methods and mechanisms, which vary throughout the country. In India, fish are eaten dried, fried or fried-cooked with heavy spices and oil. This method of preparation of fish may not be beneficial for diabetes, which our finding shows. The coastal states of India such as Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal are the states where lots of sea fish are eaten along with freshwater fish. Incidentally, those are also the states where diabetes prevalence is higher among men and in urban areas.

However, results of studies that investigated the association between fish intake and type 2 diabetes risk are inconclusive. In contrast with our findings, two earlier cohort studies in the West showed protective effects of fish intake[63,64]. An ecological study reported that high fish intake may reduce the risk of type 2 diabetes in populations with a high prevalence of obesity[65]. Cross-sectional studies reported inverse[66,67], no[68,69] or positive[70,71] associations between habitual fish intake and diabetes status. Prospective evidence suggested that fish intake is inversely[63,64,72] or not associated[73] or positively associated[74] with the risk of type 2 diabetes. However, studies conducted in this field did not report associations between different types of fish, process of cooking the fish and type 2 diabetes risk.

In the present study, a significant inverse association was found between intakes of pulses/beans and fruit and diabetes among Indian women but among men no effect was found. Various studies in the West have also shown benefits from a vegetarian diet in prevention of diabetes[59,61]. There is also convincing evidence that consumption of

fruits and vegetables decrease the risks of obesity and diabetes[74]. In spite of the growing body of evidence which highlights the protective effect of fruits and vegetables, their intakes are still inadequate in many low- and middle-income countries[75,76]. The World Health Survey in 2002–2003 showed that over three-quarters of men and women from fifty-two low- and middle-income countries consumed less than the minimum recommended five daily servings of fruits and vegetables[75]. The fruit and vegetable intake among the population in India is about 100 g/capita per d or less[77] compared with 300 g consumed in Australia, several European countries and the USA. Even so, the fruit and vegetable consumption in these high-income countries is still less than the WHO/FAO recommended level of 400 g or five servings daily[78].

We did not find strong evidence of any effect of alcohol or smoking tobacco on type 2 diabetes which has been found in previous developed-country studies[79–82]. This may reflect the cross-sectional nature of our data which cannot assess directionality of relationships. Also it might be possible that there is reverse causality and people are engaging in health-protective behaviours in the knowledge of a diagnosis of diabetes.

Current public health campaigns in developing as well as developed countries to reduce obesity and type 2 diabetes have largely focused on increasing exercise, but have paid little attention to the reduction of sedentary behaviours. Several studies have emphasized the importance of reducing prolonged television watching and other sedentary behaviours for preventing obesity and diabetes[26,83,84]. However, in India, the specific role of television in diabetes risk has yet not been quantified[4]. In our data, adjustment of confounders and other risk factors removed any effect of television watching on diabetes. It is possible that levels of television viewing are too low to be a good marker of sedentary behaviour in the Indian context or that uncontrolled confounders explain the Western findings.

The socio-economic associations with diabetes might be expected to be mediated through obesity but adjustment for BMI did not attenuate the association with diabetes whereas the more modest association with higher educational attainment was fully attenuated in adjusted models. The differential effects of wealth and education suggest that the effect is not simply due to better access to health care resulting in greater likelihood of getting a diagnosis of diabetes. Recent studies have shown complex patterns of association between socio-economic position and development of diabetes, with protective effects of income among whites but not blacks and protective effects of education among blacks but not whites in the USA[85]. By contrast findings in developing countries tend to show the opposite effects, which relates to the patterning of risk factors with economic and social transitions. In Indian factory workers, representing the emerging urban elites in the vanguard of social transition, higher educational attainment is associated with lower risk of diabetes and other CVD risk factors[86]. In the UK there is evidence that markers of socio-economic position operate in different directions in South Asian groups compared with white groups depending on the health outcome and the marker used[87].

Strengths and limitations of the study

The strengths of our study include the large nationally representative study sample allowing comparisons to be made between states and urban *v.* rural settings and the ability to examine socio-economic and lifestyle patterning of diabetes risk. The major weaknesses of the study are the collection of only self-reported diabetes, which has resulted in a marked underestimation of prevalence, and its focus on people aged <60 years in whom diabetes is less common. Self- reported data, especially in rural areas, can be flawed owing to several factors such as lack of awareness, low educational status and hesitation to disclose diseases. Despite these shortcomings rigorous precautions were taken in the NFHS to obtain reliable self-reported data such as the survey used the local terminology and commonly understood term of the disease, rigorously trained interviewers and supervisors and standard quality checks. However, underestimation of diabetes may be less problematic in examining associations with risk factors. Moreover, we were unable to distinguish between type 1 and 2 diabetes diagnoses. In these analyses, the cross-sectional design precludes causal inferences and we were limited to the questions used to elicit lifestyle and dietary information. In future national family household surveys, it would be very valuable to make biochemical estimates of raised blood glucose using near-patient testing devices which would provide a much more accurate means of mapping trends in diabetes rates.

Conclusions

The prevalence of diabetes was underestimated using self-reports. The wide variation in self-reported diabetes is unlikely to be due entirely to reporting biases or access to health care, and indicates that modifiable risk factors exist. Confirming our negative findings on milk consumption, alcohol and smoking and our positive findings on animal products in Indian studies with better ascertainment of diabetes would be helpful. Prevention of diabetes should focus on lifestyle aspects of obesity and target specific socio-economic groups in India.

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manuscript; S.E. helped in the analysis of result and interpretation of the data; both authors are responsible for final editing and approval of the manuscript.

References

1. King H, Aubert RE & Herman WH (1998) Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* **21**, 1414–1431.
2. Shaw JE, Sicree RA & Zimmet PZ (2010) Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract* **87**, 4–14.
3. Wild S, Roglic G, Green A *et al.* (2004) Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* **27**, 1047–1053.
4. Diamond JED (2011) Diabetes in India. *Nature* **469**, 479.
5. Ramachandran A & Snehalatha C (2009) Current scenario of diabetes in India. *J Diabetes* **1**, 18–28.
6. Tiwari RR, Deb PK, Debbarma A *et al.* (2008) Risk factor analysis in self-reported diabetes in a rural Kerala population. *Int J Diabetes Dev Ctries* **28**, 91–94.
7. Mohan V, Shantirani CS & Deepa R (2003) Glucose intolerance (diabetes and IGT) in a selected South Indian population with special reference to family history, obesity and lifestyle factors – The Chennai Urban Population Study (CUPS 14). *J Assoc Physicians India* **51**, 771–777.
8. Ramachandran A, Snehalatha C, Kapur A *et al.* (2001) Diabetes Epidemiology Study Group in India (DESI): high prevalence of diabetes and impaired glucose tolerance in India: national urban diabetes survey. *Diabetologia* **44**, 1094–1101.
9. Asha Bai PV, Krishnaswami CV & Chellamariappan M (1999) Prevalence and incidence of type-2 diabetes and impaired glucose tolerance in a selected Indian urban population. *J Assoc Physicians India* **47**, 1060–1064.
10. Ramachandran A, Jali MV, Mohan V *et al.* (1986) High prevalence of diabetes in an urban population in South India. *BMJ* **297**, 587–590.
11. Simmons D (1995) Ethnic comparisons in diabetes and insulin levels. *Asia Pac J Clin Nutr* **4**, 346–348.
12. Knight TM, Smith Z, Whittles A *et al.* (1992) Insulin resistance, diabetes and risk markers for ischaemic heart disease in Asian men and non-Asian men in Bradford. *Br Heart J* **67**, 343–350.
13. Ramaiya K, Kodali VRR & Alberti KGMM (1990) Epidemiology of diabetes in Asians of the Indian subcontinent. *Diabetes Metab Rev* **6**, 125–146.
14. Gupta R & Misra A (2007) Type 2 diabetes in India: regional disparities. *Br J Diabetes Vasc Dis* **7**, 12–16.
15. Mohan V, Deepa M, Deepa R *et al.* (2006) Secular trends in the prevalence of diabetes and glucose tolerance in urban South India – the Chennai Urban Rural Epidemiology Study (CURES-17). *Diabetologia* **49**, 1175–1178.
16. Misra A, Pandey RM, Devi JR *et al.* (2001) High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India. *Int J Obes Relat Metab Disord* **25**, 1722–1729.
17. Ramachandran A, Snehalatha C, Latha E *et al.* (1997) Rising prevalence of NIDDM in an urban population in India. *Diabetologia* **40**, 232–237.
18. Vijayakumar G, Arun R & Kutty VR (2009) High prevalence of type 2 diabetes mellitus and other metabolic disorders in rural central Kerala. *J Assoc Physicians India* **57**, 563–567.
19. Ramachandran A, Snehalatha C & Vijay V (2004) Low risk threshold for acquired diabetogenic factors in Asian Indians. *Diabetes Res Clin Pract* **65**, 185–195.
20. Mohan V, Radhika G, Vijayalakshmi P *et al.* (2010) Can the diabetes/cardiovascular disease epidemic in India be explained, at least in part, by excess refined grain (rice) intake? *Indian J Med Res* **131**, 369–372.
21. Pradeepa R, Anjana RM, Unnikrishnan R *et al.* (2010) Risk factors for microvascular complications of diabetes among south Indian subjects with type 2 diabetes – the Chennai Urban Rural Epidemiology Study (CURES) Eye Study-5. *Diabetes Technol Ther* **12**, 755–761.
22. Ramachandran A, Ma RCW & Snehalatha C (2010) Diabetes in Asia. *Lancet* **375**, 408–418.
23. Chan JCN, Malik V, Jia W *et al.* (2009) Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *JAMA* **301**, 2129–2140.
24. Mehta SR, Kashyap AS & Das S (2009) Diabetes mellitus in India: the modern scourge. *MJAFI* **65**, 50–54.
25. Fall CH (2001) The genesis of 'Fetal origins of adult disease'. *Int J Diabetes Dev Ctries* **21**, 3–8.
26. Hu FB, Leitzmann MF, Stampfer MJ *et al.* (2001) Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. *Arch Intern Med* **161**, 1542–1548.
27. Gopalan C (1992) Nutrition in developmental transition in South-East Asia WHO/SEARO, New Delhi. *Asia Pac J Clin Nutr* **1**, 191.
28. Popkin BM, Horton S, Kim S *et al.* (2001) Trends in diet, nutritional status, and diet-related non-communicable diseases in China and India: the economic costs of the nutrition transition. *Nutr Rev* **59**, 379–390.
29. Zimmet P, de Courten M, Allison M *et al.* (editors) (2001) *Epidemiology, Evidence for Prevention of Type 2 Diabetes. The Epidemiology of Diabetes Mellitus: An International Perspective*, pp. 42–49. Chichester: John Wiley & Sons Ltd.
30. World Health Organization (2000) *Obesity: Preventing and Managing the Global Epidemic. WHO Technical Report Series* no. 894. Geneva: WHO.
31. Colditz GA, Willett WC, Rotnitzky A *et al.* (1995) Weight gain as a risk factor for clinical diabetes mellitus in women. *Ann Intern Med* **122**, 481–486.
32. Colditz GA, Willett WC, Stampfer MJ *et al.* (1990) Weight as a risk factor for clinical diabetes in women. *Am J Epidemiol* **132**, 501–513.
33. Hu FB, Sigal RJ, Rich-Edwards JW *et al.* (1999) Walking compared with vigorous physical activity and risk of type 2 diabetes in women: a prospective study. *JAMA* **282**, 1433–1439.
34. Lynch J, Helmrich SP, Lakka TA *et al.* (1996) Moderately intense physical activities and high levels of cardiorespiratory fitness reduce risk of non-insulin-dependent diabetes mellitus in middle-aged men. *Arch Intern Med* **156**, 1307–1314.
35. Helmrich SP, Ragland DR, Leung RW *et al.* (1991) Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. *N Engl J Med* **325**, 147–152.
36. Manson JE, Rimm EB, Stampfer MJ *et al.* (1991) Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. *Lancet* **338**, 774–778.
37. Hu FB, Manson JE & Stampfer MJ (2001) Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *N Engl J Med* **345**, 790–797.
38. Manson JE, Ajani UA, Liu S *et al.* (2000) A prospective study of cigarette smoking and the incidence of diabetes mellitus among US male physicians. *Am J Med* **109**, 538–542.
39. Rimm EB, Chan J, Stampfer MJ *et al.* (1995) Prospective study of cigarette smoking, alcohol use, and the risk of diabetes in men. *BMJ* **310**, 555–559.
40. Wei M, Gibbons LW, Mitchell TL *et al.* (2000) Alcohol intake and incidence of type 2 diabetes in men. *Diabetes Care* **23**, 18–22.
41. Ajani UA, Hennekens CH, Spelsberg A *et al.* (2000) Alcohol consumption and risk of type 2 diabetes mellitus among US male physicians. *Arch Intern Med* **160**, 1025–1030.

42. Djoussé L, Gaziano JM, Buring JE *et al.* (2009) Egg consumption and risk of type 2 diabetes in men and women. *Diabetes Care* **32**, 295–300.
43. Aune D, Ursin G & Veierød MB (2009) Meat consumption and the risk of type 2 diabetes: a systematic review and meta-analysis of cohort studies. *Diabetologia* **52**, 2277–2287.
44. Steinbrecher A, Erber E, Grandinetti A *et al.* (2010) Meat consumption and risk of type 2 diabetes: the Multiethnic Cohort. *Public Health Nutr* **13**, 1–7.
45. Fung TT, Schulze M, Manson JE *et al.* (2004) Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Arch Intern Med* **164**, 2235–2240.
46. van Dam RM, Willet WC, Rimm EB *et al.* (2002) Dietary fat and meat intake in relation to risk of type 2 diabetes in men. *Diabetes Care* **25**, 417–424.
47. Woudenbergh GJV, Ballegooijen AJV, Kuijsten A *et al.* (2009) Eating fish and risk of type 2 diabetes a population-based, prospective follow-up study. *Diabetes Care* **32**, 2021–2026.
48. Villegas R, Shu Xo, Gao YT *et al.* (2008) Vegetable but not fruit consumption reduces the risk of type 2 diabetes in Chinese women. *J Nutr* **138**, 574–580.
49. Bazzano LA, Li TY, Joshipura KJ *et al.* (2008) Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. *Diabetes Care* **31**, 1311–1317.
50. Villegas R, Gao Y, Yang G *et al.* (2008) Legume and soy food intake and the incidence of type 2 diabetes in the Shanghai Women's Health Study. *Am J Clin Nutr* **87**, 162–167.
51. Venn BJ & Mann JI (2004) Cereal grains, legumes and diabetes. *Eur J Clin Nutr* **58**, 1443–1461.
52. International Institute for Population Sciences & Macro International (2007) *National Family Health Survey (NFHS-3), 2005–06: India: Vol. I.* Mumbai: IIPS.
53. StataCorp. (2003) *STATA Statistical Software Release 8*, p. 24. College Station, TX: StataCorp.
54. Ebrahim S, Kinra S, Bowen L *et al.* (2010) The effect of rural to urban migration on obesity and diabetes in India: cross sectional study. *PLoS Med* **7**, e10000268.
55. Elwood PC, Givens DI, Andrew D *et al.* (2008) The survival advantage of milk and dairy consumption: an overview of evidence from cohort studies of vascular diseases, diabetes and cancer. *J Am Coll Nutr* **27**, issue 6, 723S–734S.
56. van Dam RM, Hu FB, Rosenberg L *et al.* (2006) Dietary calcium and magnesium, major food sources, and risk of type 2 diabetes in US black women. *Diabetes Care* **29**, 2238–2243.
57. Liu S, Choi HK, Ford E *et al.* (2006) A prospective study of dairy intake and the risk of type 2 diabetes in women. *Diabetes Care* **29**, 1579–1584.
58. Choi HK, Willett WC, Stampfer MJ *et al.* (2005) Dairy consumption and risk of type 2 diabetes mellitus in men: a prospective study. *Arch Intern Med* **165**, 997–1003.
59. Villegas R, Gao YT, Dai Q *et al.* (2009) Dietary calcium and magnesium intakes and the risk of type 2 diabetes: the Shanghai Women's Health Study. *Am J Clin Nutr* **89**, 1059–1067.
60. Vang A, Singh PN, Lee JW *et al.* (2008) Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: findings from Adventist Health Studies. *Ann Nutr Metab* **52**, 96–104.
61. Snowdon DA & Phillips RL (1985) Does a vegetarian diet reduce the occurrence of diabetes? *Am J Public Health* **75**, 507–512.
62. Song Y, Manson JAE, Buring JE *et al.* (2004) A prospective study of red meat consumption and type 2 diabetes in middle-aged and elderly women: the women's health study. *Diabetes Care* **27**, 2108–2115.
63. Feskens EJ, Virtanen SM, Rasanen L *et al.* (1995) Dietary factors determining diabetes and impaired glucose tolerance. A 20-year follow-up of the Finnish and Dutch cohorts of the Seven Countries Study. *Diabetes Care* **18**, 1104–1112.
64. Feskens EJ, Bowles CH & Kromhout D (1991) Inverse association between fish intake and risk of glucose intolerance in normoglycemic elderly men and women. *Diabetes Care* **14**, 935–941.
65. Nkondjock A & Receveur O (2003) Fish-seafood consumption, obesity, and risk of type 2 diabetes: an ecological study. *Diabetes Metab* **29**, 635–642.
66. Panagiotakos DB, Zeimbekis A, Boutziouka V *et al.* (2007) Long-term fish intake is associated with better lipid profile, arterial blood pressure, and blood glucose levels in elderly people from Mediterranean islands (MEDIS epidemiological study). *Med Sci Monit* **13**, CR307–CR312.
67. Ruidavets JB, Bongard V, Dallongeville J *et al.* (2007) High consumptions of grain, fish, dairy products and combinations of these are associated with a low prevalence of metabolic syndrome. *J Epidemiol Community Health* **61**, 810–817.
68. Adler AI, Boyko EJ, Schraer CD *et al.* (1994) Lower prevalence of impaired glucose tolerance and diabetes associated with daily seal oil or salmon consumption among Alaska Natives. *Diabetes Care* **17**, 1498–1501.
69. Harding AH, Day NE, Khaw KT *et al.* (2004) Habitual fish consumption and glycated haemoglobin: the EPIC-Norfolk study. *Eur J Clin Nutr* **58**, 277–284.
70. Bjerregaard P, Pedersen HS & Mulvad G (2000) The associations of a marine diet with plasma lipids, blood glucose, blood pressure and obesity among the Inuit in Greenland. *Eur J Clin Nutr* **54**, 732–737.
71. Kaushik M, Mozaffarian D, Spiegelman D *et al.* (2009) Long-chain omega-3 fatty acids, fish intake, and the risk of type 2 diabetes mellitus. *Am J Clin Nutr* **90**, 613–620.
72. Patel PS, Sharp SJ, Robert N *et al.* (2009) Association between type of dietary fish and seafood intake and the risk of incident type 2 diabetes: the European Prospective Investigation of Cancer (EPIC)-Norfolk cohort study. *Diabetes Care* **32**, 1857–1863.
73. Schulze MB, Manson JE, Willett WC *et al.* (2003) Processed meat intake and incidence of type 2 diabetes in younger and middle aged women. *Diabetologia* **46**, 1465–1473.
74. World Health Organization (2003) *Diet, Nutrition and the Prevalence of Chronic Diseases. WHO Technical Report Series* no. 916. Geneva: WHO.
75. Hall JN, Moore S, Harper SB *et al.* (2009) Global variability in fruit and vegetable consumption. *Am J Prev Med* **36**, 402–409.e5.
76. International Agency for Research on Cancer (2001) *Changing Structure of Global Food Consumption and Trade: Agricultural and Trade Report.* Lyon: IARC Press.
77. Kanungsukkasem U, Ng N, Minh HV *et al.* (2009) Fruit and vegetable consumption in rural adults population in INDEPTH HDSS sites in Asia. *Global Health Action Supplement 1*, DOI: 10.3402/gha.v2i0.1988.
78. Pollack SL (2001) *Consumer Demand for Fruits and Vegetables: The US Example.* Washington, DC: Economic Research Service, US Department of Agriculture.
79. Rehm J, Gmel G, Sempos CT *et al.* (2003) Alcohol-related morbidity and mortality. *Alcohol Res Health* **27**, 39–51.
80. English DR, Holman CDJ, Milne E *et al.* (1995) *The Quantification of Drug Caused Morbidity and Mortality in Australia 1995.* Canberra: Commonwealth Department of Human Services and Health.
81. Perry IJ, Wannamethee SG & Walker MK (1995) Prospective study of risk factors for development of non-insulin dependent diabetes in middle aged British men. *BMJ* **310**, 560–564.

82. Rimm EB, Chan J & Stampfer MJ (1995) Prospective study for cigarette smoking, alcohol use, and the risk of diabetes in men. *BMJ* **310**, 555–559.
83. Bowman SA (2006) Television-viewing characteristics of adults: correlations to eating practices and overweight and health status. *Prev Chronic Dis* **3**, A38.
84. Hu FB, Li TY, Colditz GA *et al.* (2003) Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *JAMA* **289**, 1785–1791.
85. Maty SC, James SA & Kaplan GA (2010) Life-course socioeconomic position and incidence of diabetes mellitus among blacks and whites: The Alameda County Study, 1965–1999. *Am J Public Health* **100**, 137–145.
86. Reddy KS, Prabhakaran D & Jeemon P (2007) Educational status and cardiovascular risk profile in Indians. *Proc Natl Acad Sci USA* **104**, 16263–16268.
87. Bhopal R, Hayes L & White M (2002) Ethnic and socio-economic inequalities in coronary heart disease, diabetes and risk factors in Europeans and South Asians. *J Public Health Med* **24**, 95–105.

Appendix

Items comprising the wealth index in the third National Family Health Survey

Household electrification; type of windows; drinking water source; type of toilet facility; type of flooring; material of exterior walls; type of roofing; cooking fuel; house ownership; number of household members per sleeping room; ownership of a bank or post-office account; and ownership of a mattress, a pressure cooker, a chair, a cot/bed, a table, an electric fan, a radio/transistor, a black and white television, a colour television, a sewing machine, a mobile telephone, any other telephone, a computer, a refrigerator, a watch or clock, a bicycle, a motorcycle or scooter, an animal-drawn cart, a car, a water pump, a thresher and a tractor.