Type of vegetarian diet, obesity and diabetes in adult Indian population

Sutapa Agrawal1*, Christopher J Millett1,2, Preet K Dhillon1, SV Subramanian3 and Shah Ebrahim1,4

Abstract

Background: To investigate the prevalence of obesity and diabetes among adult men and women in India consuming different types of vegetarian diets compared with those consuming non-vegetarian diets.

Methods: We used cross-sectional data of 156,317 adults aged 20–49 years who participated in India’s third National Family Health Survey (2005–06). Association between types of vegetarian diet (vegan, lacto-vegetarian, lacto-ovo vegetarian, semi-vegetarian and non-vegetarian) and self-reported diabetes status and measured body mass index (BMI) were estimated using multivariable logistic regression adjusting for age, gender, education, household wealth, rural/urban residence, religion, caste, smoking, alcohol use, and television watching.

Results: Mean BMI was lowest in pesco-vegetarians (20.3 kg/m²) and vegans (20.5 kg/m²) and highest in lacto-ovo vegetarian (21.0 kg/m²) and lacto-vegetarian (21.2 kg/m²) diets. Prevalence of diabetes varied from 0.9% (95% CI: 0.8-1.1) in person consuming lacto-vegetarian, lacto-ovo vegetarian (95% CI:0.6-1.3) and semi-vegetarian (95% CI:0.7-1.1) diets and was highest in those persons consuming a pesco-vegetarian diet (1.4%; 95% CI:1.0-2.0). Consumption of a lacto- (OR:0.67;95% CI:0.58-0.76;p < 0.01), lacto-ovo (OR:0.70; 95% CI:0.51-0.96;p = 0.03) and semi-vegetarian (OR:0.77; 95% CI:0.60-0.98; p = 0.03) diet was associated with a lower likelihood of diabetes than a non-vegetarian diet in the adjusted analyses.

Conclusions: In this large, nationally representative sample of Indian adults, lacto-, lacto-ovo and semi-vegetarian diets were associated with a lower likelihood of diabetes. These findings may assist in the development of interventions to address the growing burden of overweight/obesity and diabetes in Indian population. However, prospective studies with better measures of dietary intake and clinical measures of diabetes are needed to clarify this relationship.

Keywords: Vegetarian diets, Diabetes, Obesity, Men, Women, NFHS-3, India

Background

Studies from Western countries suggest that vegetarian diets may have a protective role against the development of obesity and diabetes [1-5]. The European Prospective Investigation Study (EPIC-Oxford) found that mean BMI was highest in meat-eaters, lowest in vegans, and intermediate in fish-eaters and vegetarians [6]. In the Nurses’ Health Study, intake of red meat and processed meats were associated with increased risk of diabetes [7]. In Seventh-day Adventist cohort studies initiated in the 1960s–1970s, diabetes was less prevalent in vegetarian than in semi-vegetarian (those who ate fish and poultry, but <1 time/wk)_ or non-vegetarian church-goers and processed meat eaters [5,7-9]. These observational findings are also supported by experimental data which have shown that the selection of foods found in vegetarian diets may carry metabolic advantages for the prevention of type 2 diabetes [10].

India is experiencing an alarming increase in the prevalence of type 2 diabetes [10-15]. The resulting morbidity, economic costs, reduced quality of life, and risk for complications make preventive strategies imperative. The contribution of the Indian diet to the increasing prevalence of diabetes in the country is not well understood. Within this, there is little information on whether the vegetarian diet confers a similar protective effect

* Correspondence: sutapa.agrawal@phfi.org
1 South Asia Network for Chronic Disease, Public Health Foundation of India, Fourth Floor, Plot no 47, Sector 44, Gurgaon (Haryana)-122002, New Delhi, India
Full list of author information is available at the end of the article

© 2014 Agrawal et al; licensee BioMed Central Ltd. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.
against obesity and diabetes that have been demonstrated in western studies. This is an important question given the ongoing preponderance of vegetarianism in certain social and religious groups in India coupled with an increase in meat eating associated with growth in western-style diets in some section of the Indian society. Moreover, vegetarianism in India is associated with unique characteristics. It is usually a lifelong pattern and adherence crosses multiple generations; it generally comprises high consumption of whole grains, legumes, nuts and seeds and dairy with spices and seasonings unique to the Indian diet. Hence, the combination/or the pattern of vegetarian diet may yield different findings than similar studies conducted in the West and it is thus possible to assess dietary associations with chronic diseases which have been difficult in the West due to low frequency. This study uses data from the third National Family Health Survey (NFHS-3, 2005–06), a survey of 109,041 Indian households which collected information on a wide range of dietary, societal, lifestyle, and environmental determinants of morbidity and chronic ailments including diabetes [16]. The NFHS-3 provides a unique opportunity to examine associations between types of vegetarian diet and diabetes and obesity in a large, nationally representative sample. We hypothesized that exclusively vegetarian diets, such as vegan, lacto- or lacto-ovo vegetarian, are associated with a lower prevalence of diabetes and obesity compared with a non-vegetarian diet.

Methods

Data and study setting

We used cross-sectional data from India's third National Family Health Survey (NFHS-3, 2005-06) conducted in 29 states which comprises more than 99% of the country's population, but excluded the Union Territories. Details of survey objectives and survey methods including sampling frame and questionnaires are provided elsewhere [16]. Briefly, this survey was designed on the lines of the Demographic and Health Surveys (DHS) (available at www.measuredhs.com) that have been conducted in many developing countries since the 1980s and in India the survey was designed to provide estimates of key indicators (except HIV prevalence) for each state by urban and rural areas. The NFHS has been conducted in India for successive three rounds, each at an interval of 5 years. NFHS-3 is the most recent major national health survey in India that collected demographic, socioeconomic and health information from a nationally representative probability sample of 124,385 women (62.6%) aged 15-49 years and 74,369 men (37.4%) aged 15-54 years residing in 109,041 households. The data was obtained at the individual level by face-to-face interviews conducted in the respondents' homes.

The NFHS-3 samples were geo-coded to the primary sampling unit, district, and state to which they belonged. A uniform multistage sampling strategy was adopted in all the states, with separate sampling in urban and rural areas. In rural areas, a two-stage sample was carried out using a list of villages from the 2001 census as the sampling frame. In the first stage, a stratified sample of villages was drawn with probability proportional to the size of the village. In the second stage, a random selection of households was drawn in each village from a complete list of households compiled during field visits carried out in each sampled village. In urban areas, a similar procedure was implemented beginning with a stratified random sample of municipal wards based on the 2001 census. Further, one census enumeration block (about 150–200 households) was selected from within the wards using probability proportional to size sampling frame. Finally, as in rural areas, field enumerators undertook a house listing operation in selected blocks and a random sample of households was made. In both rural and urban areas, 30 households were targeted for selection in each of the sampled units.

The overall household response rate in NFHS-3 was 98%. All women aged 15–49 years in selected households were invited to participate in the National Family Health Survey. Interviews were conducted in one of the 18 Indian languages in the respondent’s home and the response rates were 95% for women and 87% for men. During interviews, the weights and heights of survey respondents were measured and blood sample were drawn by trained field technicians using standardised measuring equipment designed for survey settings in developing country.

The analysis we present here is restricted to 156,317 sample population comprising of 99,574 women and 56,742 men aged 20-49 years living in the sample households. We excluded age below 20 years to avoid any cases of childhood diabetes for which the etiology and risk factors might be different. Age above 50 years is also excluded (for men only) for comparison purpose since information for women age above 50 years is not collected in the survey.

Outcome evaluation

The survey asked participants the question, ‘Do you currently have diabetes?’ However, neither data on physician-reported diagnosis of diabetes nor data on fasting blood glucose was available in the NFHS-3 to verify a self-report.

Assessment of dietary intake

In NFHS-3, consumption of selected food item was assessed by asking, ‘How often do you yourself consume the following food items: daily, weekly, occasionally or never?’
related to the consumption of milk or curd, pulses or beans, dark green leafy vegetables, fruits, eggs, fish, chicken or meat. Based on the frequency of consumption, vegetarian status [8,17,18] was categorized by defining vegans as subjects who reported never consuming animal products (chicken or meat, fish, eggs, milk or curd); lacto-vegetarian as those who reported consuming fruits, vegetables, pulses or beans, milk or curd, either daily, weekly or occasionally but no fish, eggs or chicken or meat; lacto-ovo vegetarian as those who reported consuming fruits, vegetables, pulses or beans, milk or curd, and or eggs either daily, weekly or occasionally but no fish or chicken or meat; pesco-vegetarian: who reported consuming fruits, vegetables, pulses or beans, milk or curd, and or eggs or fish either daily, weekly or occasionally but no chicken or meat; semi-vegetarian: who reported consuming fruits, vegetables, pulses or beans, animal products (chicken or meat, eggs, milk or curd) either daily, weekly or occasionally but no fish; non-vegetarian: who reported consuming fruits, vegetables, pulses or beans, animal products (chicken or meat, fish, eggs, milk or curd) either daily, weekly or occasionally.

Other predictor variables and covariates

The survey collected information on demographic, socio-economic factors, lifestyle factors and anthropometric measurements. Respondents were weighed using a solar powered digital scale (SECA 874 digital scale) with an accuracy of ±100 g [19]. Their height was measured using an adjustable wooden measuring board, specifically designed to provide accurate measurements (to the nearest 0.1 cm) [19]. Indian adult population standard [20-22] categories of Body Mass Index (BMI, kg/m²) were used: ≤18.5 kg/m² (underweight); 18.5 to 22.9 kg/m² (normal), 23.0 to 24.9 kg/m² (overweight), and ≥25.0 kg/m² (obese). The information on exposure to tobacco smoke was—yes—active smoking (person currently smokes) and no smoking (the person has never smoked). Information on past smoking was not available in the dataset. Use of alcohol was quantified as ever drinker (drinks taken almost every day or about once weekly or less than once weekly) and never drinker. 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 behavior. Other covariates in our analysis include: age categories (20–29, 30–39, 40–49 years); gender, education (no education, primary complete, middle complete, higher and above); religion (Hindu, Muslim, Christian, Sikh, Others); caste/tribe (scheduled caste, scheduled tribe, other backward class, others, missing caste); wealth quintiles (based on 33 assets and housing characteristics graded lowest, second, middle, fourth, highest); and place of residence (urban, rural). For detailed definition of some variables and items used for construction of the wealth index, see Table 1.

Statistical analysis

As certain states and certain groups of respondents were oversampled, sample weights were used to restore the representativeness of the sample [16]. Descriptive statistics were calculated with the use of standard methods (such as frequencies and percentages) for the total sample (n = 156,317). Differences in proportions for categorical variables were tested using Pearson’s χ² tests. Trend tests were also carried out scoring the variables in different categories by using likelihood ratio tests. Multivariable logistic regression models were used to estimate the odds ratios of types of vegetarian diet intake on self-reported diabetes after controlling for potential confounders and also examining the independent effects of other risk factors. Both unadjusted and adjusted models were constructed with 95% confidence intervals to account for potential confounders and mediators. Model 1 presents unadjusted results; Model 2 presents results adjusted for BMI, lifestyle factors and socio-demographic factors which may be confounders to exhibit any independent effect of vegetarian diet on diabetes prevalence; Model 3 presents results adjusted for all the above factors except BMI. Results are presented in the form of odds ratios (ORs) with 95% confidence intervals (95% CI). 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 models, we tested for the possibility of multicollinearity between the variables. In the correlation matrix, all pair wise Pearson correlation coefficients are <0.5, suggesting that multicollinearity is not a problem. All the analysis including the logistic regression models were conducted using the SPSS statistical software package, version 19 (IBM SPSS Statistics, Chicago, IL, USA).

As the effect of type of vegetarian diet consumption on the prevalence of diabetes is likely to vary by sex, due to the large gender differences in nutritional status in India, the susceptibility to disease, and access to treatment and care in a developing country in general, an analysis was also carried out for men and women separately.

Ethics statement

The data were analyzed anonymously, using publicly available secondary data, therefore no ethics review is required for this work. The National Family Health Survey was approved by the ethical review boards of the implementing agencies and the Indian government. Participation in the survey was totally voluntary. The survey obtained written informed consent from each respondent (men and women) before asking questions, and separately before obtaining height and weight measurements.
Table 1 Sample distribution and percentage prevalence of diabetes among men (n = 56,742) and women (n = 99,574) age 20–49 years according to intake of specific food items in the national family health survey, India 2005-06

| Frequency of intake | Men | | | Women | | | | Total | | | |
|---------------------|-----|----|----|-------|----|----|----|-------|----|----|----|
|                     | Total N [%] | Diabetes cases N [%] | χ² p value | Subjects N [%] | Diabetes cases N [%] | χ² p value | Total N [%] | Diabetes cases N [%] | χ² p value |
| Milk or curd        | Daily | 26307 [46.4] | 391 [1.5] | <0.0001 | 40366 [40.5] | 492 [1.2] | 66673 [42.7] | 883 [1.3] | <0.0001 |
|                     | Weekly | 11554 [20.4] | 117 [1.0] | | 15071 [15.1] | 138 [0.9] | 26626 [17.0] | 255 [1.0] | |
|                     | Occasionally | 14757 [26.0] | 138 [0.9] | | 32918 [33.1] | 302 [0.9] | 47675 [30.5] | 440 [0.9] | |
|                     | Never | 4114 [7.3] | 74 [1.8] | | 11202 [11.3] | 117 [1.0] | 15317 [9.8] | 191 [1.2] | |
| Pulses and beans    | Daily | 29863 [52.6] | 437 [1.5] | <0.0001 | 52440 [52.7] | 538 [1.0] | 82303 [52.7] | 975 [1.2] | <0.0001 |
|                     | Weekly | 21705 [38.3] | 219 [1.0] | | 36597 [36.8] | 360 [1.0] | 58302 [37.3] | 579 [1.0] | |
|                     | Occasionally | 4660 [8.2] | 51 [1.1] | | 9663 [9.7] | 131 [1.4] | 14323 [9.2] | 182 [1.3] | |
|                     | Never | 505 [0.9] | 13 [2.6] | | 852 [0.9] | 20 [2.3] | 1357 [0.9] | 33 [2.4] | |
| Green leafy vegetables | Daily | 33982 [59.9] | 453 [1.3] | 0.149 | 64095 [64.4] | 674 [1.1] | 98076 [62.7] | 1127 [1.1] | 0.368 |
|                     | Weekly | 19270 [34.0] | 231 [1.2] | | 28606 [28.7] | 286 [1.0] | 47876 [30.6] | 517 [1.1] | |
|                     | Never/ Occasionally | 3480 [6.1] | 35 [1.0] | | 6840 [6.9] | 89 [1.3] | 10321 [6.6] | 125 [1.2] | |
| Fruits              | Daily | 7320 [12.9] | 125 [1.7] | <0.0001 | 12789 [12.9] | 206 [1.6] | 20109 [12.9] | 331 [1.6] | <0.0001 |
|                     | Weekly | 19368 [34.1] | 255 [1.3] | | 26731 [26.9] | 276 [1.0] | 46099 [29.5] | 531 [1.2] | |
|                     | Occasionally | 28484 [50.2] | 296 [1.0] | | 56336 [56.6] | 503 [0.9] | 84820 [54.3] | 800 [0.9] | |
|                     | Never | 1546 [2.7] | 44 [2.8] | | 3631 [3.6] | 63 [1.7] | 5177 [3.3] | 107 [2.1] | |
| Eggs                | Daily | 2931 [5.2] | 56 [1.9] | <0.0001 | 3475 [3.5] | 60 [1.7] | 6405 [4.1] | 115 [1.8] | <0.0001 |
|                     | Weekly | 20682 [36.5] | 317 [1.5] | | 28778 [28.9] | 363 [1.3] | 49460 [31.6] | 680 [1.4] | |
|                     | Occasionally | 19786 [34.9] | 201 [1.0] | | 32635 [32.8] | 287 [0.9] | 52421 [33.5] | 488 [0.9] | |
|                     | Never | 13330 [23.5] | 146 [1.1] | | 34647 [34.8] | 340 [1.0] | 47977 [30.7] | 486 [1.0] | |
| Fish                | Daily | 3706 [6.5] | 90 [2.4] | <0.0001 | 6505 [6.5] | 149 [2.3] | 10211 [6.5] | 240 [2.4] | <0.0001 |
|                     | Weekly | 14414 [25.4] | 238 [1.7] | | 22070 [22.2] | 304 [1.4] | 36484 [23.3] | 542 [1.5] | |
Table 1 Sample distribution and percentage prevalence of diabetes among men (n = 56,742) and women (n = 99,574) age 20–49 years according to intake of specific food items in the national family health survey, India 2005-06 (Continued)

|                   | Occasionally | Never          | <0.0001 | Occasionally | Never          | <0.0001 | Occasionally | Never          | <0.0001 |
|-------------------|--------------|----------------|---------|--------------|----------------|---------|--------------|----------------|---------|
| Chicken or meat   |              |                | <0.0001 |              |                | <0.0001 |              |                | <0.0001 |
| Daily             | 706 [1.2]    | 6 [0.9]        | 839 [0.8]| 14 [1.7]     | 1545 [1.0]     | 20 [1.3]|              |                |         |
| Weekly            | 15609 [27.5]| 269 [1.7]      | 21938 [22.0]| 292 [1.3] | 37548 [24.0]| 561 [1.5]|              |                |         |
| Occasionally      | 26135 [46.1]| 291 [1.1]      | 42222 [42.0]| 423 [1.0] | 68357 [43.7]| 714 [1.0]|              |                |         |
| Never             | 14272 [25.2]| 155 [1.1]      | 34537 [34.7]| 320 [0.9] | 48809 [31.2]| 475 [1.0]|              |                |         |
Results
Types of vegetarian diet consumption in India and states
The sample distribution and percentage prevalence of diabetes among men (n = 56,742) and women (n = 99,574) aged 20–49 years according to intake of specific food items in the National Family Health Survey, India 2005–06 is presented in Table 1. Table 2 gives the percentage consumption of different types of vegetarian diet among adult population (n = 156,317) age 20–49 years in India and states. Overall a majority (two-third- 64%) of the sample population eat a non-vegetarian diet either daily, weekly or at least occasionally where as one-fourth is lacto-vegetarian (Table 1). Other dietary patterns are followed by a relatively smaller percentage of Indian population: semi-vegetarian-5.2%, lacto-ovo vegetarian-3.2%, pesco-vegetarian-2.2% and vegan-1.6%. More than 80% of the population consume a non-vegetarian diet in north-eastern region, in southern region (except the state of Karnataka), most of the states in eastern region (except Bihar), and the western state of Goa. More than half the population in the northern states of Punjab, Haryana, Rajasthan, and in the western state of Gujarat follow a lacto-vegetarian diet. One in five people in Jammu and Kashmir follow a semi-vegetarian diet (without fish) whereas one in ten people in Goa (11.8%) and Manipur (9.0%), 7.8% in Tripura, 7.2% in Orissa, 5.2% in Kerala and 4.1% in West Bengal consume pesco-vegetarian diet (dominated by fish). In the state of Delhi, one out of ten people is a lacto-ovo vegetarian where as the western states of Gujarat (4.9%) and Maharashtra (4.0%) have the highest percentages of vegans.

Distribution of self reported diabetes cases and diabetes prevalence by study covariates
Among those who reported diabetes, three out of five were aged between 40–49 years, a majority (59%) were women, two out of five had a secondary education, three-fourth follow Hindu religion, two out of five belonged to general caste, two out of five belonged to household with a highest wealth status, a majority don’t smoke or drink alcohol, more than half the participants watched TV almost every day and a third were obese (Table 3).

The overall prevalence of diabetes was significantly higher (p < 0.0001) among men (1.3%) than among women (0.9%) (Table 3). Significant associations between age and diabetes prevalence were observed, diabetes being more prevalent (2.8%) in the highest age group (40–49 years). Diabetes prevalence increased according to household wealth status and was almost double in urban population compared with their rural counterparts (1.6 vs 0.8) and highest among those with a higher secondary and above education (all p < 0.0001). Prevalence of diabetes was also higher among those who were currently smoking tobacco (1.3%) or ever consumed alcohol (1.4%), who were either overweight (2.1%) or obese (3.2%) and those who watched television almost every day (1.4%).

Prevalence of diabetes and obesity according to types of vegetarian diet consumption
Table 4 gives the unadjusted prevalence of diabetes and obesity by types of vegetarian diet consumption. No apparent trend in diabetes prevalence based on type of vegetarian diet was found (p for trend = 0.002). Prevalence of diabetes varied from 0.9% (95% CI:0.8-1.1) each in lacto-vegetarian, lacto-ovo vegetarian (95% CI:0.6-1.3) and semi-vegetarian (95% CI:0.7-1.1) to 1.0% in vegan (95% CI: 0.6-1.7), 1.2% (95% CI:1.1-1.3) in non-vegetarian and highest in pesco-vegetarian diets (1.4%; 95% CI:1.0-2.0). The range between the lowest and highest BMIs for all groups were reasonably low (less than 1 kg/m²). Mean BMI was 20.3 kg/m² in pesco-vegetarians and 20.5 kg/m² in vegans, 20.6 kg/m² in semi-vegetarians, 20.7 kg/m² in non-vegetarians, 21.0 kg/m² in lacto-ovo vegetarians and 21.2 kg/m² in lacto-vegetarians. For BMIs ≥23 kg/m², the prevalence of diabetes was 1.7% in lacto-ovo vegetarians, 2.0% in semi-vegetarians, 2.1% in lacto-vegetarians, 2.6% in pesco-vegetarians, 2.8% in vegans, and 2.9% in non-vegetarians (data not shown). For BMIs ≥30 kg/m², the prevalence of diabetes was 2.1% in lacto-ovo vegetarians, 3.7% in lacto-vegetarians, 3.8% in semi-vegetarians, 5.2% in vegans, 5.3% in pesco-vegetarians and 5.4% in non-vegetarians (data not shown).

Vegetarian diet consumption according to non-dietary variables
Table 5 shows the vegetarian diet consumption by non-dietary variables. Socioeconomic demographic and lifestyle characteristics differed substantially (p < 0.001) among the dietary groups but overall non-vegetarian diet was predominant in all socio economic and demographic categories followed by lacto-vegetarian diet.

Association between type of vegetarian diet and diabetes
In multivariable logistic regression analysis (Table 6), after adjustment for age, gender, education, household wealth, rural/urban residence, religion, caste, smoking, alcohol use, television watching and body mass index, consumption of lacto-vegetarian (AOR:0.67; 95% CI:0.58-0.76), lacto-ovo vegetarian (AOR:0.69; 95% CI:0.50-0.95) and semi-vegetarian (AOR:0.76; 95% CI: 0.60-0.98) diets were associated with a lower likelihood of diabetes than non-vegetarian diet. The association remained almost unchanged when BMI was removed from the analyses.

Association between type of vegetarian diet and diabetes stratified by sex
To examine the sex differences in the adjusted effect of vegetarian diet on diabetes prevalence, we also carried
out separate analyses for men and women (Table 7). The likelihood of having a positive diabetes status was significantly lower among men following a lacto-vegetarian (AOR:0.66; 95% CI:0.52-0.82; p < 0.0001) and semi-vegetarian diet (AOR:0.45; 95% CI:0.29-0.71; p = 0.001) while only lacto-vegetarian diet (AOR:0.70; 95% CI:0.59-0.82; p < 0.0001) consumption was associated with a lower likelihood of diabetes among women.

Discussion
This cross-sectional, population-based study adds to the limited data on associations between type of vegetarian

| India/States         | Vegan N [%] | Lacto-vegetarian N [%] | Lacto-ovo vegetarian N [%] | Pesco-vegetarian N [%] | Semi-vegetarian N [%] | Non-vegetarian N [%] | Total N |
|----------------------|------------|------------------------|-----------------------------|------------------------|-----------------------|----------------------|---------|
| India                | 2560 [1.6] | 37797 [24.2]          | 5002 [3.2]                  | 3446 [2.2]             | 8140 [5.2]            | 99372 [63.6]        | 156317  |

Northern region

Jammu & Kashmir      | 9 [0.6]   | 276 [18.4]            | 18 [1.2]                    | 9 [0.6]                | 297 [19.8]           | 891 [59.4]           | 1500    |

Himachal Pradesh     | 17 [1.8]  | 429 [45.6]            | 76 [8.1]                    | 13 [1.4]               | 137 [14.6]           | 269 [28.6]           | 941     |

Punjab               | 138 [3.4] | 2149 [52.3]           | 275 [6.7]                   | 13 [0.3]               | 420 [10.2]           | 1112 [27.1]          | 4107    |

Uttaranchal          | 20 [1.6]  | 324 [26.6]            | 84 [6.9]                    | 15 [1.2]               | 108 [8.9]            | 669 [54.8]           | 1220    |

Haryana              | 107 [3.3] | 2099 [68.9]           | 205 [6.7]                   | 6 [0.2]                | 148 [4.9]            | 482 [15.8]           | 3047    |

Delhi                | 43 [2.1]  | 645 [30.9]            | 222 [10.6]                  | 25 [1.2]               | 192 [9.2]            | 963 [46.1]           | 2090    |

Rajasthan            | 236 [2.9] | 5060 [62.1]           | 393 [4.8]                   | 62 [0.8]               | 869 [10.7]           | 1528 [18.8]          | 8148    |

Central region

Uttar Pradesh        | 264 [1.2] | 8458 [37.7]           | 1227 [5.5]                  | 336 [1.5]              | 835 [3.7]            | 11343 [50.5]         | 22463   |

Chhattisgarh         | 69 [2.1]  | 484 [14.5]            | 101 [3.0]                   | 60 [1.8]               | 57 [1.7]             | 2574 [77.0]          | 3345    |

Madhya Pradesh       | 294 [3.1] | 3975 [42.2]           | 479 [5.1]                   | 223 [2.4]              | 463 [4.9]            | 3980 [42.3]          | 9414    |

Eastern region

Bihar                | 50 [0.5]  | 1812 [17.3]           | 66 [0.6]                    | 382 [3.6]              | 120 [1.1]            | 8037 [76.8]          | 10467   |

West Bengal          | 43 [0.3]  | 183 [1.4]             | 16 [0.1]                    | 554 [4.1]              | 94 [0.7]             | 12548 [93.4]         | 13438   |

Jharkhand            | 49 [1.3]  | 214 [5.5]             | 37 [1.0]                    | 80 [2.1]               | 81 [2.1]             | 3395 [88.0]          | 3856    |

Orissa               | 50 [0.8]  | 225 [3.8]             | 19 [0.3]                    | 432 [7.2]              | 66 [1.1]             | 5168 [86.7]          | 5960    |

Northeastern region

Sikkim               | 0 [0.0]   | 9 [9.6]               | 1 [1.1]                     | 1 [1.1]                | 6 [6.4]              | 77 [81.9]            | 94      |

Arunachal Pradesh    | 0 [0.0]   | 2 [1.3]               | 1 [0.6]                     | 2 [1.3]                | 2 [1.3]              | 152 [95.6]           | 159     |

Nagaland             | 0 [0.0]   | 1 [0.5]               | 0 [0.0]                     | 1 [0.5]                | 2 [1.0]              | 204 [98.1]           | 208     |

Manipur              | 1 [0.3]   | 1 [0.3]               | 0 [0.0]                     | 31 [9.0]               | 3 [0.9]              | 307 [89.5]           | 343     |

Mizoram              | 0 [0.0]   | 0 [0.0]               | 1 [0.7]                     | 1 [0.7]                | 6 [43]               | 131 [94.2]           | 139     |

Tripura              | 1 [0.2]   | 4 [0.7]               | 1 [0.2]                     | 46 [7.8]               | 2 [0.3]              | 536 [90.8]           | 590     |

Meghalaya            | 0 [0.0]   | 3 [0.8]               | 1 [0.3]                     | 9 [2.3]                | 5 [1.3]              | 371 [95.4]           | 389     |

Assam                | 5 [0.1]   | 72 [1.6]              | 13 [0.3]                    | 132 [3.0]              | 12 [0.3]             | 4135 [94.6]          | 4369    |

Western region

Gujarat              | 400 [4.0] | 4546 [55.6]           | 342 [4.2]                   | 159 [1.9]              | 399 [4.9]            | 2330 [28.5]          | 8176    |

Maharashtra          | 643 [4.0] | 3614 [22.7]           | 529 [3.3]                   | 1.35 [0.8]             | 912 [5.7]            | 10068 [63.3]         | 15901   |

Goa                  | 3 [1.2]   | 10 [3.9]              | 2 [0.8]                     | 30 [11.8]              | 2 [0.8]              | 207 [81.5]           | 254     |

Southern region

Andhra Pradesh       | 45 [0.4]  | 579 [4.7]             | 222 [1.8]                   | 78 [0.6]               | 1129 [9.1]           | 10299 [83.4]         | 12352   |

Karnataka            | 41 [0.4]  | 2126 [22.2]           | 385 [4.0]                   | 134 [1.4]              | 979 [10.2]           | 5932 [61.8]          | 9597    |

Kerala               | 11 [0.2]  | 81 [1.8]              | 37 [0.8]                    | 234 [5.2]              | 54 [1.2]             | 4045 [90.7]          | 4462    |

Tamil Nadu           | 21 [0.2]  | 416 [4.5]             | 249 [2.7]                   | 243 [2.6]              | 740 [8.0]            | 7619 [82.0]          | 9288    |
Table 3: Percentage distribution of participants by self-reported diabetes status and prevalence of diabetes according to non-dietary variables, India NFHS 2005-06

| Characteristics          | Total participants | Diabetes cases | $\chi^2$ P values | Diabetes prevalence | $\chi^2$ P values |
|--------------------------|--------------------|----------------|-------------------|---------------------|-------------------|
|                          | N [%]*             | Reported N [%] | Not reported N [%]| N [%]               |                   |
| N [%]                    | 156,317            | 1,769 [1.1]    | 154,501 [98.9]    |                     |                   |
| Age                      | <0.0001            | <0.0001        |                   |                     |                   |
| 20-29 y                  | 66,038 [42.2]      | 204 [11.5]     | 65807 [42.6]      | 0.3                 |                   |
| 30-39 y                  | 52,567 [33.6]      | 520 [29.4]     | 52038 [33.7]      | 1.0                 |                   |
| 40-49 y                  | 37,711 [24.1]      | 1045 [59.1]    | 36656 [23.7]      | 2.8                 |                   |
| Sex                      | <0.0001            | <0.0001        |                   |                     |                   |
| Men                      | 56,742 [36.3]      | 994 [40.7]     | 73367 [36.3]      | 1.3                 |                   |
| Women                    | 99,574 [63.7]      | 1096 [59.3]    | 123244 [63.7]     | 0.9                 |                   |
| Education a              | <0.0001            | <0.0001        |                   |                     |                   |
| No education             | 56,720 [36.3]      | 529 [27.3]     | 63709 [36.4]      | 0.8                 |                   |
| Primary                  | 24,493 [15.7]      | 350 [17.1]     | 30593 [15.7]      | 1.1                 |                   |
| Secondary                | 58,448 [37.4]      | 909 [42.6]     | 84284 [37.3]      | 1.1                 |                   |
| Higher and above         | 16,639 [10.6]      | 302 [13.0]     | 18001 [10.6]      | 1.7                 |                   |
| Caste/tribe b            | <0.0001            | <0.0001        |                   |                     |                   |
| Scheduled caste          | 29831 [18.5]       | 350 [17.2]     | 36736 [18.5]      | 0.9                 |                   |
| Scheduled tribe          | 12734 [8.1]        | 75 [3.1]       | 16105 [8.2]       | 0.5                 |                   |
| Other backward class     | 60977 [39.0]       | 728 [35.3]     | 77187 [39.0]      | 0.9                 |                   |
| General                  | 48854 [31.3]       | 840 [39.9]     | 60489 [31.2]      | 1.4                 |                   |
| Missing caste            | 4821 [3.1]         | 90 [4.6]       | 5450 [3.1]        | 1.6                 |                   |
| Religion c               | <0.0001            | <0.0001        |                   |                     |                   |
| Hindu                    | 127375 [81.5]      | 1616 [77.3]    | 159511 [81.5]     | 1.0                 |                   |
| Muslim                   | 19781 [12.7]       | 311 [15.1]     | 25806 [12.6]      | 1.2                 |                   |
| Christian                | 3816 [2.4]         | 86 [4.2]       | 4657 [2.4]        | 1.8                 |                   |
| Sikh                     | 2845 [1.8]         | 48 [2.1]       | 3334 [1.8]        | 1.3                 |                   |
| Others                   | 2500 [1.6]         | 28 [1.2]       | 3104 [1.6]        | 0.8                 |                   |
| Wealth quintiles d       | <0.0001            | <0.0001        |                   |                     |                   |
| Lowest                   | 26389 [16.9]       | 171 [8.0]      | 33269 [17.0]      | 0.5                 |                   |
| Second                   | 28751 [18.4]       | 270 [13.6]     | 36780 [18.4]      | 0.7                 |                   |
| Middle                   | 31232 [20.0]       | 272 [13.1]     | 39975 [20.1]      | 0.7                 |                   |
| Fourth                   | 33560 [21.5]       | 490 [24.2]     | 42082 [21.4]      | 1.2                 |                   |
| Highest                  | 36385 [23.3]       | 887 [41.0]     | 44505 [23.1]      | 2.0                 |                   |
| Place of residence       | <0.0001            | <0.0001        |                   |                     |                   |
| Urban                    | 54134 [34.6]       | 1068 [50.8]    | 66879 [34.4]      | 1.6                 |                   |
| Rural                    | 102183 [65.4]      | 1022 [49.2]    | 129732 [65.6]     | 0.8                 |                   |
| Body Mass Index (kg/m²)  | <0.0001            | <0.0001        |                   |                     |                   |
| ≤18.5 kg/m²              | 46021 [30.9]       | 694 [14.6]     | 85097 [31.1]      | 0.8                 |                   |
| 18.5-22.9 kg/m²          | 67836 [45.5]       | 295 [33.2]     | 64754 [45.7]      | 0.5                 |                   |
| 23.0-24.9 kg/m²          | 15089 [10.1]       | 347 [16.4]     | 16537 [10.1]      | 2.1                 |                   |
| ≥25.0 kg/m²              | 20050 [13.5]       | 691 [35.8]     | 20858 [13.2]      | 3.2                 |                   |
diet intake and diabetes prevalence in developing countries. Our finding suggest that persons consuming a lacto vegetarian, lacto-ovo vegetarian or semi-vegetarian diet had a lower likelihood of diabetes compared with those consuming non-vegetarian diet after adjustment for a number of socioeconomic and lifestyle factors. These findings may be explained by adverse effects of meat and fish, protective effects of typical constituents of lacto-vegetarian and lacto-ovo vegetarian diet which have been demonstrated elsewhere [23-26]. Our study indicates that the body mass index of Indian vegetarian diet consumers did not differ significantly from their non-vegetarian counterparts, but the male vegetarians appeared to be significantly (p < 0.0001) uniformly leaner than female vegetarians. This association between vegetarianism and non-leanness is in line with a health study

Table 3 Percentage distribution of participants by self reported diabetes status and prevalence of diabetes according to non-dietary variables, India NFHS 2005-06 (Continued)

| Characteristic                  | No (%) | Yes (%) | Alcohol consumption | Male | Frequency of watching TV |
|--------------------------------|--------|---------|----------------------|------|-------------------------|
| Current Tobacco smoking        | <0.0001| <0.0001 | 0.015                |      | <0.0001                 |
| Tobacco smoking                |        |         |                      |      |                         |
| No                             | 13316 [85.2] | 1736 [83.7] | 170086 [85.2] | 1.0  | 355 [16.3] | 26525 [14.8] | 1.3  |
| Yes                            | 23156 [14.8] | 355 [16.3] | 26525 [14.8] | 1.3  | 26177 [14.9] | 1.4  |
| Alcohol consumption            |        |         |                      |      |                         |
| Never                          | 133067 [85.1] | 1705 [83.3] | 170416 [85.2] | 1.0  | 385 [16.7] | 26177 [14.9] | 1.4  |
| Ever                           | 23250 [14.9] | 1.0     | 26177 [14.9] | 1.4  |                         |
| Frequency of watching TV       |        | <0.0001 | <0.0001              |      |                         |
| Not at all                     | 45916 [29.4] | 403 [20.7] | 55562 [29.5] | 0.7  |
| Less than once a week          | 21859 [14.0] | 232 [10.8] | 27442 [14.0] | 0.8  |
| At least once a week           | 20033 [12.8] | 257 [12.0] | 26059 [12.8] | 1.0  |
| Almost everyday                | 68480 [43.8] | 1198 [56.5] | 87516 [43.7] | 1.4  |

*Total participants varies slightly for individual variables depending on the number of missing values.

**Education:** illiterate (0 years of education), literate but less than middle school complete (1–5 years of education), middle school complete (6–8 years of education), high school complete or more (9+ years of education).

**Scheduled castes and scheduled tribes** are identified by the Government of India as socially and economically backward and needing protection from social injustice and exploitation. Other backward class is a diverse collection of intermediate castes that were considered low in the traditional caste hierarchy but are clearly above scheduled castes. Others is thus a default residual group that enjoys higher status in the caste hierarchy.

*Others include Buddhist, Jain, Jewish, Zoroastrian.

The wealth index is based on following assets in the household: household electrification, type of windows, drinking water source, type of toilet facility, type of flooring, material of exterior walls, type of roofing, house ownership, 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 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 tractor.

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.

Table 4 Unadjusted prevalence (% with CI) of diabetes and obesity according to types of vegetarian diet consumption in adult Indian population (n = 156,317) aged 20–49 years, NFHS 2005-06

| Characteristics | Vegan | Lacto-vegetarian | Lacto-ovo vegetarian | Pesco-vegetarian | Semi-vegetarian | Non-vegetarian | P for trend values* |
|-----------------|-------|------------------|----------------------|------------------|-----------------|----------------|-------------------|
| Diabetes        | 26 [1.0] | 356 [0.9] | 46 [0.9] | 48 [1.4] | 71 [0.9] | 1223 [1.2] | 0.002 |
| N, [%, 95% CI]  | 0.6-1.7 | 0.8-1.1 | 0.6-1.3 | 1.0-2.0 | 0.7-1.1 | 1.1-1.3 |                   |
| BMI ≥23 kg/m²   | 534 [21.5] | 9722 [26.9] | 1163 [24.9] | 650 [19.5] | 1690 [21.8] | 21380 [22.6] | <0.001 |
| N, [%, 95% CI]  | 19.5-23.7 | 26.3-27.5 | 23.4-26.5 | 17.8-21.3 | 20.7-23.0 | 22.3-23.0 |                   |
| BMI ≥25 kg/m²   | 286 [11.5] | 5861 [16.2] | 697 [14.9] | 334 [10.0] | 877 [11.3] | 11996 [12.7] | <0.001 |
| N, [%, 95% CI]  | 10.0-13.2 | 15.7-16.7 | 13.7-16.3 | 8.0-11.3 | 10.5-12.2 | 12.4-13.0 |                   |
| BMI ≥30 kg/m²   | 58 [2.3] | 1311 [3.6] | 140 [3.0] | 56 [1.7] | 156 [1.6] | 2269 [2.4] | <0.001 |
| N, [%, 95% CI]  | 1.7-3.2 | 3.4-3.9 | 2.5-3.7 | 1.2-2.4 | 1.2-2.4 | 2.3-2.5 |                   |
| BMI mean [±SD]  | 20.5 [±4.2] | 21.2 [±4.5] | 21.0 [±4.1] | 20.3 [±3.8] | 20.6 [±4.0] | 20.7 [±4.1] |                   |

*P for trend values has been obtained from Likelihood ratio test for no difference between the groups for types of vegetarian diet ignoring the correlated data. As the non-vegetarian group was expected to have the highest and the rural group the lowest levels of diabetes and BMI, trend tests were carried out scoring the groups 1 to 5 and using likelihood ratio tests.
Table 5 Percentage distribution of non-dietary variables according to types of vegetarian diet consumption in adult Indian population (n = 156,317) aged 20–49 years, NFHS 2005-06

| Characteristics          | Type of diets | Chi sq p values |
|--------------------------|---------------|-----------------|
|                          | Vegan         | Lacto-vegetarian| Lacto-ovo vegetarian| Pesco-vegetarian| Semi-vegetarian| Non-vegetarian |
| Age                      |               |                 |                  |                |               |               |
| 20-29 y                  | 1097 [1.7]    | 14846 [22.5]    | 2535 [3.8]       | 1234 [1.9]     | 3772 [5.7]    | 42533 [64.4]  |
| 30-39 y                  | 856 [1.6]     | 12758 [24.3]    | 1553 [3.0]       | 1203 [2.3]     | 2550 [4.9]    | 33648 [64.0]  |
| 40-49 y                  | 609 [1.6]     | 10196 [27.0]    | 913 [2.4]        | 1005 [2.7]     | 1817 [4.8]    | 23172 [61.4]  |
| Sex                      |               |                 |                  |                |               |               |
| Men                      | 406 [0.7]     | 10683 [18.8]    | 2226 [3.9]       | 955 [1.7]      | 3465 [6.1]    | 39009 [68.7]  |
| Women                    | 2156 [2.2]    | 27118 [27.2]    | 2775 [2.8]       | 2487 [2.5]     | 4675 [4.7]    | 60364 [60.6]  |
| Education                |               |                 |                  |                |               |               |
| No education             | 1207 [2.1]    | 4343 [15.0]     | 836 [2.9]        | 731 [2.5]      | 2018 [7.0]    | 20545 [71.0]  |
| Primary                  | 455 [1.9]     | 5645 [20.6]     | 599 [2.4]        | 628 [2.6]      | 1304 [5.3]    | 16462 [67.2]  |
| Secondary                | 755 [1.3]     | 14505 [24.8]    | 2199 [3.8]       | 1185 [2.0]     | 2967 [5.1]    | 36817 [63.0]  |
| Higher and above         | 125 [0.8]     | 5355 [32.2]     | 1087 [6.5]       | 265 [1.6]      | 686 [4.1]     | 9120 [54.8]   |
| Caste/tribe              |               |                 |                  |                |               |               |
| Scheduled caste          | 456 [1.6]     | 4343 [15.0]     | 836 [2.9]        | 731 [2.5]      | 2018 [7.0]    | 20545 [71.0]  |
| Scheduled tribe          | 311 [2.4]     | 1603 [12.6]     | 271 [2.1]        | 264 [2.1]      | 709 [5.6]     | 9576 [75.2]   |
| Other backward class     | 1019 [1.7]    | 16614 [27.2]    | 2160 [3.5]       | 1319 [2.2]     | 3026 [5.0]    | 36839 [60.4]  |
| General                  | 761 [1.6]     | 15087 [30.9]    | 1692 [3.5]       | 1014 [2.1]     | 2110 [4.3]    | 28189 [57.7]  |
| Missing caste            | 9 [0.2]       | 109 [2.6]       | 31 [0.7]         | 92 [2.2]       | 222 [5.2]     | 3808 [89.2]   |
| Religion                 |               |                 |                  |                |               |               |
| Hindu                    | 2358 [1.9]    | 35337 [27.7]    | 4522 [3.6]       | 3069 [2.4]     | 6192 [4.9]    | 75897 [59.6]  |
| Muslim                   | 78 [0.4]      | 272 [1.4]       | 196 [1.0]        | 260 [1.3]      | 1417 [7.2]    | 17558 [88.8]  |
| Christian                | 6 [0.2]       | 27 [0.7]        | 32 [0.8]         | 65 [1.7]       | 102 [2.7]     | 3585 [93.9]   |
| Sikh                     | 75 [2.6]      | 1561 [54.9]     | 170 [6.0]        | 10 [0.4]       | 286 [10.1]    | 742 [26.1]    |
| Others                   | 45 [1.8]      | 602 [24.1]      | 81 [3.2]         | 38 [1.5]       | 143 [5.7]     | 1591 [63.6]   |
| Wealth quintiles         |               |                 |                  |                |               |               |
| Lowest                   | 586 [2.2]     | 4777 [18.1]     | 427 [1.6]        | 789 [3.0]      | 1051 [40]     | 18759 [71.1]  |
| Second                   | 509 [1.8]     | 6225 [21.7]     | 735 [2.6]        | 741 [2.6]      | 1515 [5.3]    | 19026 [66.2]  |
| Middle                   | 468 [1.5]     | 6768 [21.7]     | 846 [2.7]        | 725 [2.3]      | 1997 [6.4]    | 20428 [65.4]  |
| Fourth                   | 516 [1.5]     | 7760 [23.1]     | 1167 [3.5]       | 667 [2.0]      | 1944 [5.8]    | 21506 [64.1]  |
| Highest                  | 483 [1.3]     | 12270 [33.7]    | 1826 [5.0]       | 521 [1.4]      | 1633 [4.5]    | 19653 [54.0]  |
| Place of residence       |               |                 |                  |                |               |               |
| Urban                    | 757 [1.4]     | 12685 [23.4]    | 2259 [4.2]       | 904 [1.7]      | 2964 [5.5]    | 34565 [63.9]  |
| Rural                    | 1804 [1.8]    | 25116 [24.6]    | 2741 [2.7]       | 2538 [2.5]     | 5176 [5.1]    | 64808 [63.4]  |
| Current Tobacco smoking  |               |                 |                  |                |               |               |
| No                       | 2388 [1.8]    | 34150 [25.6]    | 4258 [3.2]       | 3026 [2.3]     | 6687 [5.0]    | 82651 [62.1]  |
| Yes                      | 173 [0.7]     | 3651 [15.8]     | 742 [3.2]        | 416 [1.8]      | 1453 [6.3]    | 16721 [72.2]  |
| Alcohol consumption      |               |                 |                  |                |               |               |
| Never                    | 2496 [1.9]    | 36605 [27.5]    | 4320 [3.2]       | 3102 [2.3]     | 6707 [5.0]    | 79745 [60.0]  |
| Ever                     | 66 [0.3]      | 1196 [5.1]      | 681 [2.9]        | 339 [1.5]      | 1431 [6.1]    | 19611 [84.1]  |
Table 5 Percentage distribution of non-dietary variables according to types of vegetarian diet consumption in adult Indian population (n = 156,317) aged 20–49 years, NFHS 2005–06 (Continued)

| Frequency of watching TV | <0.001 |
|-------------------------|--------|
| Not at all              | 1177 [2.6] | 12046 [26.2] | 937 [2.0] | 1269 [2.8] | 2170 [4.7] | 28318 [61.7] |
| Less than once a week   | 245 [1.1] | 4789 [21.9] | 588 [2.7] | 467 [2.1] | 884 [4.0] | 14886 [68.1] |
| At least once a week    | 314 [1.6] | 4639 [23.2] | 663 [3.3] | 476 [2.4] | 1128 [5.6] | 12814 [64.0] |
| Almost everyday         | 824 [1.2] | 16322 [23.8] | 2812 [4.1] | 1230 [1.8] | 3956 [5.8] | 43336 [63.3] |
| Total                   | 2560 [1.6] | 37797 [24.2] | 5002 [3.2] | 3446 [2.2] | 8140 [5.2] | 99372 [63.6] | 156317 |

among the Barbados Seventh-Day Adventists which found self-reported vegetarians of less than 5 years did not differ significantly from the non-vegetarians [27].

Our results are in consistent with those of previous studies among various seventh-Day Adventist churchgoers [1,2,5,6,28,29], several other studies conducted in western countries [10,30–37] and an Indian study [38] which showed that increased conformity to vegetarian diets is protected against risk of type 2 diabetes and hypertension. Findings from an accumulating number of studies have also shown evidence that most vegetarian diets are not only nutritionally adequate but also associated with lower risk of certain chronic diseases, when compared with the effects of a more typical western diets [36]. Evidence from a number of other observational studies shows that certain dietary constituents are associated with protection against diabetes through the pathway of insulin sensitivity which is also confirmed by the small sample size in the vegan group, which constituted only 1.6% of the sample, might have influenced the study results. However, though the more recent official statements from American Diabetes Association has clearly described vegetarian diets as healthful [53] and some studies [1,2] shows that vegans have a least risk of type 2 diabetes, still the association between vegan diet and diabetes risk is open to question.

The notion that animal protein stimulates insulin secretion and possibly insulin resistance was proposed decades ago [54]. Red and processed meat consumption has been associated with increased risk of type 2 diabetes in a large number of cohort studies in the west [6,55–57]. Meat intake was associated with a higher risk of diagnosed diabetes in a study in Seventh-Day Adventists [8]. Several other studies around the globe have also reported an increased risk of diabetes or type 2 diabetes with a higher intake of processed meat [7,9,58–62], red meat [7,58,59,62–64] and total meat [7,9,65], but in some studies the results have been inconsistent [55,61].

The categories that we have used to distinguish different types of diet in our study is internationally recognized [2,8,17,18] and have also proven to be categories that have markedly different risks of common diseases.
Table 6 Multivariable logistic regression analysis (odds ratio with 95% confidence interval) of the relation between types of vegetarian diet and self reported diabetes, in adult Indian population aged 20–49 years, NFHS-3 2005-06

| Characteristics                  | Unadjusted OR [95% CI] | P values | Adjusted* OR [95% CI] | P values | Adjusted ψ OR [95% CI] | P values |
|----------------------------------|------------------------|----------|------------------------|----------|------------------------|----------|
| Types of vegetarian diet         |                        |          |                        |          |                        |          |
| Non-vegetarian (ref)             | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Semi-vegetarian                  | 0.71 [0.56-0.90]        | 0.005    | 0.77 [0.60-0.98]        | 0.034    | 0.76 [0.59-0.96]        | 0.024    |
| Pesco-vegetarian                 | 1.13 [0.84-1.51]        | 0.426    | 1.15 [0.85-1.54]        | 0.365    | 1.09 [0.81-1.46]        | 0.589    |
| Lacto-ovo vegetarian             | 0.74 [0.55-1.00]        | 0.047    | 0.70 [0.51-0.96]        | 0.025    | 0.73 [0.54-0.99]        | 0.044    |
| Lacto-vegetarian                 | 0.76 [0.68-0.86]        | <0.001   | 0.67 [0.58-0.76]        | <0.001   | 0.66 [0.58-0.75]        | <0.001   |
| Vegan                            | 0.81 [0.55-1.20]        | 0.289    | 0.91 [0.61-1.36]        | 0.643    | 0.89 [0.59-1.33]        | 0.553    |
| Age                              |                        |          |                        |          |                        |          |
| 20-29y (ref)                     | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| 30-39y                           | 3.23 [2.74-3.80]        | <0.001   | 2.83 [2.39-3.35]        | <0.001   | 3.32 [2.82-3.91]        | <0.001   |
| 40-49y                           | 9.20 [7.91-10.69]       | <0.001   | 7.78 [6.64-9.12]        | <0.001   | 9.39 [8.05-10.95]       | <0.001   |
| Sex                              |                        |          |                        |          |                        |          |
| Men (ref)                        | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Women                            | 0.83 [0.75-0.91]        | <0.001   | 0.87 [0.76-0.99]        | 0.029    | 0.94 [0.83-1.06]        | 0.298    |
| Education                        |                        |          |                        |          |                        |          |
| No education (ref)               | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Primary                          | 1.46 [1.27-1.69]        | <0.001   | 1.20 [1.03-1.40]        | 0.022    | 1.23 [1.06-1.44]        | 0.008    |
| Secondary                        | 1.53 [1.36-1.71]        | <0.001   | 1.22 [1.05-1.41]        | 0.008    | 1.28 [1.11-1.47]        | 0.001    |
| Higher and above                 | 1.63 [1.39-1.91]        | <0.001   | 1.05 [0.85-1.28]        | 0.672    | 1.11 [0.91-1.36]        | 0.300    |
| Caste/tribe                      |                        |          |                        |          |                        |          |
| Scheduled caste (ref)            | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Scheduled tribe                  | 0.40 [0.30-0.54]        | <0.001   | 0.47 [0.34-0.63]        | <0.001   | 0.47 [0.35-0.63]        | <0.001   |
| Other backward class             | 0.98 [0.85-1.12]        | 0.714    | 0.84 [0.73-0.98]        | 0.022    | 0.86 [0.75-0.99]        | 0.039    |
| General                          | 1.38 [1.21-1.58]        | <0.001   | 0.95 [0.81-1.10]        | 0.459    | 0.98 [0.84-1.13]        | 0.751    |
| Missing caste                    | 1.61 [1.26-2.06]        | <0.001   | 1.18 [0.90-1.55]        | 0.244    | 1.20 [0.91-1.59]        | 0.199    |
| Religion                         |                        |          |                        |          |                        |          |
| Hindu (ref)                      | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Muslim                           | 1.26 [1.11-1.44]        | <0.001   | 1.14 [0.98-1.33]        | 0.100    | 1.16 [0.99-1.35]        | 0.062    |
| Christian                        | 1.85 [1.46-2.33]        | <0.001   | 1.31 [1.02-1.68]        | 0.035    | 1.36 [1.07-1.74]        | 0.014    |
| Sikh                             | 1.25 [0.91-1.73]        | 0.173    | 0.85 [0.61-1.19]        | 0.333    | 0.96 [0.69-1.33]        | 0.787    |
| Others                           | 0.83 [0.54-1.26]        | 0.375    | 0.70 [0.44-1.10]        | 0.119    | 0.74 [0.48-1.13]        | 0.159    |
| Wealth quintiles                 |                        |          |                        |          |                        |          |
| Lowest (ref)                     | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Second                           | 1.56 [1.27-1.92]        | <0.001   | 1.40 [1.13-1.73]        | 0.002    | 1.42 [1.15-1.76]        | 0.001    |
| Middle                           | 1.38 [1.12-1.71]        | 0.002    | 1.05 [0.84-1.32]        | 0.654    | 1.16 [0.93-1.44]        | 0.201    |
| Fourth                           | 2.39 [1.98-2.90]        | <0.001   | 1.53 [1.22-1.93]        | <0.001   | 1.80 [1.44-2.25]        | <0.001   |
| Highest                          | 3.77 [3.15-4.51]        | <0.001   | 1.87 [1.45-2.41]        | <0.001   | 2.50 [1.96-3.19]        | <0.001   |
| Place of residence               |                        |          |                        |          |                        |          |
| Urban                            | 1.96 [1.79-2.16]        | <0.001   | 1.20 [1.07-1.35]        | 0.002    | 1.24 [1.10-1.39]        | <0.001   |
| Rural (ref)                      | 1                      | 1        | 1                      | 1        | 1                      | 1        |
| Body Mass Index (kg/m²)          |                        |          |                        |          |                        |          |
| ≤18.5 kg/m²                      | 0.56 [0.49-0.64]        | <0.001   | 0.75 [0.65-0.88]        | <0.001   | -                      | -        |
| 18.5-22.9 kg/m² (ref)            | 1                      | 1        | 1                      | 1        | 1                      | 1        |
such as diabetes and hypertension in cohort [1,2,66] and observational studies in UK [37] but it is possible that the more-refined categories may provide better comparability.

The strengths of our study include the use of large nationally representative study sample which allows comparisons to be made between men and women and the ability to examine this association in adult Indian population. Also rigorous efforts were made in the NFHS-3 to obtain reliable self-reported data: the survey used local terminology and commonly understood terms to describe the disease, rigorously trained interviewers, supervisors and standard quality checks [16] (also see www.dhsprogram.com).

The prevalence of diabetes in this large nationally representative survey was comparatively low (1.1%) than studies conducted in selected geographical areas or cities in India [11,14,67-71]. The low diabetes prevalence in our study reflects the young age of this population, the use of self-reports rather than biochemical assessments and sampling from the general population that included a high proportion of respondents in rural areas [72]. Our study has added to this literature using a national population health survey with good coverage in rural areas across India. 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 [72]. 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 [74]. However, this ascertainment bias is unlikely to have been differential with respect to types of vegetarian diet consumption. In other words, although we clearly have sub-set of disease, it’s unlikely to be systematically different from entire group in terms of dietary patterns.

Previous research has shown a good agreement for self-reported diabetes when compared with medical records in a US population [75] and that self-reported health conditions demonstrate the expected relationship with socioeconomic status in India [76]. Studies in India also have shown that the difference between self reports and objective measurements according to education and awareness levels does not preclude the use of self-reports [72,76]. On the contrary to the prevailing view that there is a positive (or null) association between measures of socio economic status and self-reported poor health/morbidities in less-developed countries, and that any potential “under-reporting” is not only smaller than the difference in prevalence of illness between the socially disadvantaged and the advantaged, the study by Subramanian et al. [76] showed that the same is even true within groups with the same objective diagnosis. In addition, our analyses considering respondents who reported ‘unknown’ for diabetes status were nearly identical to the main analyses (data not shown). Although our sample was relatively young (<50 years for women and men both), it is representative of the young population profile of India; 84% of the Indian adult population (18–69 years) and 47% of the total Indian population at all ages fall within the ages covered by this study [77]. Our study does exclude approximately 14% of the Indian population (men and women over age 50) due to the sample design of the NFHS. The prevalence of diabetes

| Table 6 Multivariable logistic regression analysis (odds ratio with 95% confidence interval) of the relation between types of vegetarian diet and self reported diabetes, in adult Indian population aged 20–49 years, NFHS-3 2005-06 (Continued) |
|---|---|---|---|---|---|
| 23.0-24.9 kg/m² | 2.57 [2.26-2.93] | <0.001 | 1.64 [1.42-1.91] | <0.001 | - |
| ≥25.0 kg/m² | 4.06 [3.65-4.52] | <0.001 | 2.21 [1.95-2.51] | <0.001 | - |

Current tobacco smoking

| No (ref) | 1 | 1 | 1 |
|---|---|---|---|

Yes

| 1.13 [0.99-1.28] | 0.069 | 0.98 [0.84-1.15] | 0.803 | 0.93 [0.80-1.09] | 0.379 |

Alcohol consumption

| Never (ref) | 1 | 1 | 1 |
|---|---|---|---|
| Ever | 1.15 [1.01-1.30] | 0.029 | 1.01 [0.87-1.19] | 0.870 | 1.05 [0.90-1.23] | 0.519 |

Frequency of watching TV

| Not at all (ref) | 1 | 1 | 1 |
|---|---|---|---|
| Less than once a week | 1.10 [0.92-1.31] | 0.307 | 0.89 [0.74-1.07] | 0.202 | 0.92 [0.76-1.10] | 0.345 |
| At least once a week | 1.34 [1.13-1.58] | 0.001 | 0.95 [0.79-1.14] | 0.594 | 1.00 [0.84-1.20] | 0.975 |
| Almost everyday | 1.84 [1.63-2.08] | <0.001 | 0.91 [0.78-1.07] | 0.258 | 1.04 [0.89-2.21] | 0.652 |

*Adjusted for all factors; Ψ Adjusted for all factors except BMI; OR- indicates odds ratios; ref- indicates reference category.
increases with age and whether a similar socioeconomic status–diabetes relationship exists among middle and older age groups in all parts India is not clear [72], although our findings are consistent with the previous studies that have included older ages.

The current national estimate for diabetes prevalence in India is about 7% of the adult population aged 20–79 years [72]; estimates being based on three relatively recent and large scale studies using a combination of oral glucose tolerance testing and self-reports of diabetes [11,78]. There continues to be considerable uncertainty in estimates of diabetes for the whole of India due to the limited study locations (with a focus on urban areas), wide variation in survey sampling methodology, differences in diabetes diagnostic criteria and age groups studied [72]. These differences in study design have hindered direct comparison of the prevalence between studies, across regions and over time. The NFHS-3 provides an important benchmark because it is the first nationally representative survey of diabetes in India. Even if the prevalence estimates of diabetes have been underestimated in the NFHS-3, the observed diet–diabetes associations are reasonable and significant, and can be comparable to cohort and prospective studies on similar association in the west. Previous studies have largely overlooked the importance of modifiable dietary factors, which may be a key determinant of diabetes in Indians, given the varied nature of Indian diets. Further large-scale population-based surveys can be strengthened by using simple finger-prick blood glucose measurements in addition to self-reports.

In our analyses, the cross-sectional design precludes causal inferences and we were limited to the questions

| Predictors                          | Unadjusted OR [95% CI] | P values | Adjusted* OR [95% CI] | P values | Adjusted Ψ OR [95% CI] | P values |
|-------------------------------------|------------------------|----------|-----------------------|----------|------------------------|----------|
|                                    | Men                    |          |                       |          |                        |          |
|                                    | Types of vegetarian diet |         |                       |          |                        |          |
| Non-vegetarian (ref)                | 1                      | 1        | 1                     | 1        | 1                      | 1        |
| Semi-vegetarian                    | 0.47 [0.31-0.72]       | <0.001   | 0.45 [0.29-0.71]       | 0.001    | 0.48 [0.32-0.73]        | 0.001    |
| Pesco-vegetarian                   | 0.78 [0.42-1.44]       | 0.426    | 0.80 [0.43-1.50]       | 0.488    | 0.77 [0.41-1.43]        | 0.047    |
| Lacto-ovo vegetarian               | 0.74 [0.49-1.13]       | 0.165    | 0.63 [0.39-1.00]       | 0.050    | 0.72 [0.47-1.11]        | 0.134    |
| Lacto-vegetarian                   | 0.79 [0.64-0.96]       | 0.020    | 0.66 [0.52-0.82]       | <0.001   | 0.65 [0.52-0.81]        | <0.001   |
| Vegan                              | 0.67 [0.24-1.85]       | 0.438    | 0.70 [0.25-1.96]       | 0.498    | 0.66 [0.24-1.83]        | 0.424    |
| Body Mass Index (kg/m²)            |                        |          |                       |          |                        |          |
| ≤18.5 kg/m²                        | 0.75 [0.60-0.93]       | 0.009    | 0.85 [0.68-1.06]       | 0.147    |                        |          |
| 18.5-22.9 kg/m² (ref)              | 1                      | 1        | 1                     |          |                        |          |
| 23.0-24.9 kg/m²                    | 2.29 [1.85-2.83]       | <0.001   | 1.63 [1.30-2.03]       | <0.001   |                        |          |
| ≥25.0 kg/m²                        | 3.06 [2.53-3.71]       | <0.001   | 1.80 [1.46-2.23]       | <0.001   |                        |          |
|                                    | Women                  |          |                       |          |                        |          |
|                                    | Types of vegetarian diet |         |                       |          |                        |          |
| Non-vegetarian (ref)                | 1                      | 1        | 1                     | 1        | 1                      | 1        |
| Semi-vegetarian                    | 0.92 [0.68-1.23]       | 0.561    | 1.09 [0.81-1.47]       | 0.582    | 1.03 [0.77-1.39]        | 0.842    |
| Pesco-vegetarian                   | 1.33 [0.96-1.86]       | 0.090    | 1.33 [0.95-1.87]       | 0.101    | 1.24 [0.88-1.74]        | 0.220    |
| Lacto-ovo vegetarian               | 0.72 [0.47-1.10]       | 0.128    | 0.77 [0.50-1.19]       | 0.238    | 0.75 [0.49-1.14]        | 0.176    |
| Lacto-vegetarian                   | 0.78 [0.67-0.90]       | 0.001    | 0.70 [0.59-0.82]       | <0.001   | 0.69 [0.59-0.81]        | <0.001   |
| Vegan                              | 0.89 [0.58-1.37]       | 0.606    | 1.01 [0.65-1.56]       | 0.984    | 0.98 [0.64-1.52]        | 0.931    |
| Body Mass Index (kg/m²)            |                        |          |                       |          |                        |          |
| ≤18.5 kg/m²                        | 0.60 [0.49-0.74]       | <0.001   | 0.68 [0.56-0.84]       | <0.001   |                        |          |
| 18.5-22.9 kg/m² (ref)              | 1                      | 1        | 1                     |          |                        |          |
| 23.0-24.9 kg/m²                    | 2.23 [1.83-2.71]       | <0.001   | 1.63 [1.34-2.00]       | <0.001   |                        |          |
| ≥25.0 kg/m²                        | 4.32 [3.72-5.01]       | <0.001   | 2.44 [2.07-2.87]       | <0.001   |                        |          |

*Adjusted for age, education, caste/tribe, religion, wealth quintiles, place of residence, BMI, current tobacco smoking, alcohol consumption and frequency of watching TV. Ψ Adjusted for all factors except BMI OR; odds ratios. ref- reference category.
used to elicit lifestyle and dietary information. Given the high proportion of undiagnosed diabetes in developing countries including India (www.worlddiabetesfoundation.org) where less than half of people with diabetes are diagnosed, there is a possibility that the exposure was associated with the likelihood of testing for diabetes, which may result in detection bias. Importantly the entire study may be with known diabetic subjects who would have altered diet and hence might have increased or decreased vegetarian diet consumption due to the dietary advice based on diabetes control and complications of diabetes like nephropathy. General dietary advice given to diabetic subjects is to include more whole grains, legumes, fruits and green leafy and other vegetables as this is evident in our data where more than 90% of the self-reported diabetes did report ‘daily’ or ‘weekly’ consumption of legumes, vegetables and fruits--all suggest that the dietary choices of self-reported diabetic subjects might have been modified to manage diabetes. However, 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.

Nevertheless, our study has some other limitations. Misclassification of dietary information, although unavoidable, would most likely be non-differential and thus may attenuate the true association. There were relatively small numbers in some of the dietary categories, which should be considered when interpreting the findings in relation to these diets. There might be limitation of the dietary assessment method in NFHS-3 as well since there may be other foods that are associated with diabetes that are not asked to the respondents. We were also unable to distinguish between Type 1 and 2 diabetes diagnoses. Since the NFHS-3 questionnaire is interviewer administered, information on the inter rater compatibility, reproducibility and validity of questionnaire would be critical to evaluate the ability of such questionnaire to measure true dietary intake. But NFHS-3 being a part of Demographic and Health Surveys (available at www.dhsprogram.com) which is conducted in more than 80 countries with similar questionnaire seems to be fairly valid to get an overall picture of frequency of dietary intake in a population [79]. However, under- and over-reporting could lead to a biased estimation of the association between dietary factors and diabetes. Although we adjusted for several confounding variables, we cannot exclude the possibility of residual confounding. However, if this was the case, similar effects would be expected for dietary components that are related to greater affluence, which was not observed.

Another limitation of our study is reliance on self-reports of diabetes which has resulted in a marked underestimation of prevalence, and its focus on people <60 years in whom diabetes is less common [74]. Self-reported data, especially in rural areas, can be flawed owing to several factors such as lack of awareness, low educational status, limited access to health services and hesitation to disclose diagnosed diseases. But in developing countries, self-reporting should not be a prohibitive limitation as medically diagnosed and/or biomarker-confirmed prevalence estimates are nearly impossible for nationwide prevalence estimates in low-resource and low-access settings such as India. Also since, the low and middle income countries has only very limited nutrition and health outcomes data, NFHS-3 is therefore the best available dataset to examine the relationship.

Valid data on physical activity were not available in NFHS-3 which is a limitation of this study since persons with healthier diets may be physically more active than other persons [80]. Therefore the lack of physical activity data may have confounded the results. Moreover, assessment of sedentary habits in this study was based on hours of TV watching. However, physical activity has in part been accounted for, indirectly, by adjusting for body mass index. In the present study, adjustment for socioeconomic and demographic factors, residential location, religion and caste/tribe status of the respondents did not markedly modify the adjusted result, suggesting that the associations are not completely explained by non-dietary lifestyle factors. Further studies are needed to determine whether the association between diet and diabetes is mediated by assumed nutrients or by lifestyle and socioeconomic and demographic factors related to frequency of food consumption.

The rising burden of diabetes in India requires a rapid response that integrates policies and programmes which enable effective prevention and control across diverse geographical and low-resource settings. Our findings on inverse association between types of vegetarian diet consumption and diabetes prevalence can be considered by policy-makers to promote healthy vegetarian diet consumption in Indian population and to discourage unhealthy non-vegetarian diets. There is, therefore, an opportunity to modify the direction and dimensions of this national epidemic through policy interventions (at the state level), which promote the availability, affordability and acceptability of vegetarian diets more specifically lacto vegetarian and lacto-ovo vegetarian diets and restrain the marketing and consumption of unhealthy non-vegetarian foods. This requires coordinated action at the level of governments, civil society and responsible sections of the food industry.

Conclusions
In conclusion, our findings are important for public health interventions in diabetes care in India which shows that,
in a large sample of adult men and women in India, vari-
nants of vegetarian diets such as lacto-vegetarian and lacto-ovo vegetarian were associated with at least a 30%
lower risk of diabetes. These results add to the limited
evidence in developing countries that shows potential
benefits of consuming vegetarian diets to reduce the de-
velopment of diabetes. These findings need further val-
idation by longitudinal and clinical studies but may well
have public health significance for the Indian popula-
tion. These findings, if replicated using objective and
comprehensive methods of dietary intake and diabetes,
may inform the development of interventions to address
the growing burden of overweight and diabetes in India.

Endnotes

1The scale has a 200 kg capacity and weighs in 0.01 kg
crmonents. The scale is powered by six AA batteries
and has an “ON-OFF” switch located at the side of the
scale. The SECA 874 digital floor scale is manufactured
by Seca gmbh & co. kg. Hammer Steindamm 9 – 25,
22089 Hamburg, Germany. The scale can be procured
directly from Seca. These instructions were adapted
from instructions that accompany the scale and revised
by Irwin J. Shorr, MPH, MPS.

1The state of a person’s health in terms of the nutri-
ents in his or her diet. In Indian context, it also means
inadequate and poor diet and repeated exposure to dis-
ease and illness, may or may not be based on any clinical
test or measurement.

Competing interests

Authors declare that they have no competing interests.

Authors’ contributions

SA conceived the article. SA conducted and CM and SE supervised the
statistical analysis. SA wrote the paper and CM and SE revised it for
important intellectual content. SA is the guarantors of this work and, as such,
had full access to all the data in the study and take responsibility for the
integrity of the data and the accuracy of the data analysis. All authors gave
final approval.

Acknowledgements

An earlier version of the paper was accepted as a poster at the IUNS 20th
International Congress of Nutrition, Granada (Spain), September 15–20, 2013. SA is
supported by a Wellcome Trust Strategic Award Grant No WT084674. The data for
this research were collected by The Demographic and Health Surveys Program
(www.dhsprogram.com), under a contract from the U.S. Agency for International
Development. The authors acknowledge the support of International Institute for
Population Sciences and Macro International for providing access to the 2005–06
Indian National Family Health Survey data. The authors are also thankful to the
editor and the reviewers for their immensely helpful comments and suggestions
and edits on the earlier draft of this paper.

Author details

1South Asia Network for Chronic Disease, Public Health Foundation of India,
Fourth Floor, Plot no 47, Sector 44, Gurgaon (Haryana)–122002, New Delhi,
India. Department of Primary Care and Public Health, School of Public
Health, Imperial College, London, UK. 2Department of Society, Human
Development and Health, Harvard School of Public Health, Harvard
University, Boston, USA. 3Department of Non-communicable Disease
Epidemiology, London School of Hygiene and Tropical Medicine, London,
UK.

Received: 9 April 2014 Accepted: 28 August 2014
Published: 5 September 2014

References

1. Tonstad S, Stewart K, Oda K, Batech M, Herring RP, Fraser GE: Vegetarian
diets and incidence of diabetes in the Adventist health study-2.
Nutr Metab Cardiovasc Dis 2013, 23(4):292–299.

2. Tonstad S, Butler T, Yan R, Fraser GE: Type of vegetarian diet, body weight,
and prevalence of type 2 diabetes. Diabetes Care 2009, 32:791–796.

3. Rosell M, Appleby P, Spencer E, Key T: Weight gain over 5 years in 21,966
meat eating, fish-eating, vegetarian, and vegan men and women in
EPIC-Oxford, Int J Obes 2006, 30:1389–1396.

4. Phillips F, Hackett A, Billington D, Stratton G: Effects of changing from a
mixed to self-selected vegetarian diet on anthropometric measurements
in UK adults. J Hum Nutr Diet 2004, 17:245–255.

5. Fraser GE: Associations between diet and cancer, ischemic heart disease,
and all-cause mortality in non-Hispanic white California Seventh-day
Adventists. Am J Clin Nutr 1999, 70(Suppl):S532–S538.

6. Appleby PN, Thorogood M, Mann J, Key TJ: Low body mass index in
non-meat eaters: the possible roles of animal fat, dietary fibre and
alcohol. Int J Obes Relat Metab Disord 1998, 22:454–460.

7. Fung TT, Schulze MB, Manson JE, Willett WC, Hu FB: Dietary patterns, meat
intake, and the risk of type 2 diabetes in women. Arch Intern Med 2004,
164:2235–2240.

8. Snowden DA, Phillips RL: Does a vegetarian diet reduce the occurrence
of diabetes? Am J Public Health 1985, 75:507–512.

9. Vang A, Singh PN, Lee JW, Haddad EH, Brinegar CH: Meats, processed
meats, obesity, weight gain and occurrence of diabetes among adults:
findings from Adventist health studies. Ann Nutr Metab 2008, 52(6):104–109.

10. Jenkins DJA, Kendall CWC, Marchie A, Jenkins AL, Augustin LSA, Ludwig DS,
Barnard ND, Anderson JW: Type 2 diabetes and the vegetarian diet. Am J
Clin Nutr 2007, 83(Suppl):610S–616.

11. Ramachandran A, Snehathala C, Kapur A, Vijay V, Mohan V, Das AK, Rao PV,
Yajnik CS, Prasanna Kumar KM, Nair JD: Diabetes Epidemiology Study Group
in India (DESi): Diabetes Epidemiology Study Group in India (DESi):
high prevalence of diabetes and impaired glucose tolerance in India: national
urban diabetes survey. Diabetologia 2001, 44:1094–1101.

12. Wild S, Roglic G, Green A, Sicree R, King H: Global prevalence of diabetes:
estimates for the year 2000 and projections for 2030. Diabetes Care 2004,
27:1047–1053.

13. Yoon KH, Jin HL, Ji-Won K, Cho JH, Choi YH, Ko SH, Zimmer P, Son HY:
Epidemic obesity and type 2 diabetes in Asia. Lancet 2006, 368:1681–1688.

14. Ramachandran A, Snehathala C: Current scenario of diabetes in India.
J Diabetes 2009, 1:8–28.

15. Diamond JED: Diabetes in India. Nature 2011, 469:478.

16. International Institute for Population Sciences, Macro International: National
Family Health Survey (NFHS-3), 2005–06 India, Volume I: Mumbai; IIPS, 2007.

17. Key TJ, Davey GK, Appleby PN: Health benefits of a vegetarian diet.
Proc Nutr Soc 2006, 59(Pt 2):271–275.

18. Farnodu AA, Osilesi O, Makinde YO, Osonuga OA: Blood pressure and
blood lipid levels among vegetarian, semi-vegetarian, and nonvegetarian
Native Africans. Clin Biochem 1998, 31(5):545–549.

19. ICF International: MEASURE DHS Biomarker Field Manual. Calverton, Maryland,
USA: ICF International, 2012.

20. Indian Consensus Group: Indian consensus for prevention of
hypertension and coronary heart disease: a joint scientific statement of
Indian society of hypertension and international college of nutrition.
J Nutr Environ Med 2009, 163–170.

21. WHO expert consultation: Appropriate body-mass index for Asian
populations and its implications for policy and intervention strategies.
Lancet 2004, 363(9403):157–163.

22. Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, Joshi SR,
Sadikot S, Gupta R, Gulati S, Murlidhar S, Consensus Group: Consensus
statement for diagnosis of obesity, abdominal obesity and the metabolic
syndrome for Indian Indians and recommendations for physical activity,
medical and surgical management. J Assoc Physicians India 2009,
57:163–170.

23. Liu S, Choi HK, Ford E, Song Y, Klevak A, Buring JE, Manson JE: A
prospective study of dairy intake and the risk of type 2 diabetes in women.
Diabetes Care 2006, 29(7):1579–1584.
71. Vijayakumar G, Arun R, Kutty VR: High prevalence of type 2 diabetes mellitus and other metabolic disorders in rural Central Kerala. J Assoc Physicians India 2009, 57:563–567.
72. Corsi DJ, Subramanian SV: Association between socioeconomic status and self-reported diabetes in India: a cross-sectional multilevel analysis. BMJ Open 2012, 2:e000895. doi:10.1136/bmjopen-2012-000895, 2012.
73. Ebrahim S, Kinsa S, Bowen L, Andersen E, Ben-Shlomo Y, Lyngdoh T, Ramakrishnan L, Ahuja RC, Joshi P, Mohan Das S, Mohan M, Davey Smith G, Prabhakaran D, Reddy KS, for the Indian Migration Study group: The effect of rural-to-urban migration on obesity and diabetes in India: a cross-sectional study. PLoS Med 2010, 7(4):e1000268. doi:10.1371/journal.pmed.1000268.
74. Agrawal S, Ebrahim S: Prevalence and risk factors for self-reported diabetes among adult men and women in India: findings from a national cross-sectional survey. Publ Health Nutr 2011, 15:1065–1077.
75. Okura Y, Urban LH, Mahoney DW, Jacobsen SJ, Rodeheffer RJ: Agreement between self-report questionnaires and medical record data was substantial for diabetes, hypertension, myocardial infarction and stroke but not for heart failure. J Clin Epidemiol 2004, 57:1096 e103.
76. Subramanian SV, Subramanyam MA, Selvaraj S, Kawachi I: Are self-reports of health and morbidities in developing countries misleading? Evidence from India. Soc Sci Med 2009, 68:260 e5.
77. Registrar General of India: Census of India: C-13 Single Year Age Returns by Residence and Sex. 2001. http://www.censusindia.gov.in/Tables_Published/C-Series/c_series_tables_2001.aspx, 2001.
78. Mohan V, Mathur P, Deepa R, Deepa M, Shukla DK, Menon GR, Anand K, Desai NG, Joshi PP, Mahanta J, Thakkan KP, Shah B: Urban rural differences in prevalence of self-reported diabetes in India—the WHO-ICMR Indian NCD risk factor surveillance. Diabetes Res Clin Pract 2008, 80:159–168.
79. Pullum TW: An Assessment of the Quality of Data on Health and Nutrition in the DHS Surveys, 1993–2003. Methodological Reports No. 6. Calvewood, MD: Macro International Inc; 2008.
80. Patel PS, Sharp SJ, Luben RN, Khaw KT, Bingham SA, Wareham NJ, Forouhi NG: 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 2009, 32:1857–1863.

doi:10.1186/1475-2891-13-89
Cite this article as: Agrawal et al.: Type of vegetarian diet, obesity and diabetes in adult Indian population. Nutrition Journal 2014 13:89.