ORIGINAL RESEARCH

CURRENT DEVELOPMENTS IN NUTRITION

Food and Agricultural Sustainability

Dietary Patterns and Determinants of Changing Diets in Bangladesh from 1985 to 2010

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ABSTRACT

Background: The government of Bangladesh has implemented multiple policies since 1971 to provide the population with more diverse and nutritious diets.

Objective: The aim of this study was to examine the drivers of dietary change over time and the roles agriculture and economic development have played.

Methods: We used principal component analysis to derive dietary patterns from 7 cross-sectional rounds of the Bangladesh Household [Income and] Expenditure Survey. We then used linear probability models to estimate associations of adherence to dietary patterns with socio-economic characteristics of households, and with agricultural production on the household and regional level. For dietary patterns that increased or decreased over time, Blinder–Oaxaca decomposition was used to assess factors associated with these changes.

Results: Seven dietary patterns were identified: modern, traditional, festival, winter, summer, monotonous, and spices. All diets were present in all survey rounds. In 1985, over 40% of households had diets not associated with any identified pattern, which declined to 12% by 2010. The proportion of the population in households adhering to the modern, winter, summer, and monotonous diets increased over time, whereas the proportion adhering to the traditional diet decreased. Although many factors were associated with adherence to dietary patterns in the pooled sample, changes in observed factors only explained a limited proportion of change over time due to variation in coefficients between periods. Increased real per capita expenditure was the largest driver of elevated adherence to dietary patterns over time, whereas changes in the agricultural system increased adherence to less diverse dietary patterns.

Conclusions: These findings highlight the need for both diversified agricultural production and a continued reduction in poverty in order to drive dietary improvement. This study lays the groundwork for further analysis of the impact of changing diets on health and nutrition.
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Keywords: Socio-economic status, agriculture, dietary pattern, dietary change, Bangladesh, Household Consumption and Expenditure Survey

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Supplemental Tables 1–11 and Supplemental Figures 1–3 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/cdn/.

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Abbreviations used: AME, adult male equivalent; CPI, consumer price index; HCES, household consumption and expenditure surveys; H[I]ES, Household [Income and] Expenditure Survey; KMO: Kaiser–Meyer–Olkin test.

Introduction

Article 18(1) of the constitution of Bangladesh states that "the State shall regard the raising of the level of nutrition and improvement of public health as among its primary duties" (1). The government of Bangladesh has implemented multiple policies since 1971 to provide more diverse and nutritious diets to the population. However, the *Nutrition Background Paper to the Seventh Five-year Plan (2016–2020)* finds that the government has not yet ensured the "the right to adequate food", citing a need for a "balance between agriculture for revenue and export, and more nutrition-sensitive actions focused on producing nutritious, affordable, and safe foods for local consumption, and nutritional gain" (2). Indeed, policies for agriculture have largely prioritized economic productivity and poverty reduction over production diversity and increased productivity of nutritionally valuable commodities (3).

In spite of these gaps, diets in Bangladesh are changing (4), with a greater shift among the rich than the poor (5). However, thus far, dietary change at the household level has not been quantified and we lack information regarding how dietary change relates to shifts in agricultural production and to poverty reduction. Dietary patterns have been described in many populations using factor analysis methods (6–8), often in relation to health outcomes such as cancer (9), hypertension (10), arsenic skin lesions (11), and heart disease (12), and in relation to cultural and socio-economic factors (13–15). Though a well-established methodology in clinical nutrition, dietary patterns have been underutilized to examine changes in dietary habits or food systems over time, particularly in low- and middle-income countries (LMICs) (16). One reason for this may be that many LMICs lack data on individual diets, and factor analysis methods have not yet been applied to other types of dietary data.

Household consumption expenditure surveys (HCES) are primarily designed to estimate expenditure patterns of a population (17, 18), but can also be a compelling source of long-term dietary data as they record information on a varying list of food items consumed by the household over a set period. Since 2006, HCES have been increasingly used to assess diets (17, 19), but previous assessments have not examined dietary patterns, and most have used only the most recent datasets (20–23), thus precluding the possibility of examining change over time.

Bangladesh is an ideal setting for using this data source to measure change in diets over time as it has a long series of HCES and relatively robust secondary data that can help to describe the evolution of the food system over time. Bangladesh has experienced large increases in agricultural productivity since independence in 1971 and sizable declines in poverty since the early 1990s (18, 24). Bangladesh has also experienced a rapid reduction in childhood stunting from 51% in 2004 to 35% in 2014, coupled with a doubling of overweight among ever-married women from 18% to 39% (25–27), making it a good setting to help researchers and policymakers better understand the nutritional transition.

We aim to describe dietary change in Bangladesh over 25 years and identify probable causes for this change. As a first step, we examine the feasibility of using household-level consumption data to derive dietary patterns. We then describe pattern content and examine the shift in adherence to patterns over time, as well as socio-economic factors associated with pattern adherence. Finally, we seek to identify plausible drivers of dietary change over time, using decomposition.

Methods

Since 1973, Bangladesh has undertaken a nationally representative HCES every 3 to 5 years, the Household [Income and] Expenditure Surveys (H[I]ES) (18). Data from 7 survey rounds (1985, 1988, 1991, 1995, 2000, 2005, and 2010) were available at the Bangladesh Bureau of Statistics (BBS). Like all HCES, the unit of observation in H[I]ES was the household. All survey rounds include both rural and urban households and data collected over 12 months, enabling diets to be observed seasonally. The sample size increased over time, from 3840 households in 1985 to 12,240 households in 2010 (18, 28), resulting in a total of 52,455 households. More information on the structure of these datasets and data management is available in previously published work (5).

Dietary intake

We obtained dietary data from the list of foods consumed by household members within the H[I]ES reference period (30 days from 1985 until 1995, 14 days from 2000 to 2010). We used these data to estimate the daily consumption (weight in g) of each food category for the average adult male in each household (29). These estimates were made by dividing total household diets by the average energy needs of household members, varying due to differences in age and sex, and adjusting this to the average energy needs of an adult male. This adult male equivalent (AME) method is commonly used to estimate individual nutrient intake from household consumption data. As the number of food items varied across rounds, from 222 in 1991 to 113 in 1995, we combined these food items into the 60 food categories that were consistent across rounds (5). Households were excluded if estimated energy intake (in AME) was above or below certain cut-offs derived from the Goldberg equation (30). Further information regarding the cut-offs used is available in the supplemental information (pg 1, Section 1).

Covariates

As explanatory factors, we considered agricultural production as well as socio-economic factors that were important predictors of adherence to diets in other settings (13–15). Variables were taken from the H[I]ES or derived from national agricultural and population statistics (31–40). Available information varied across survey rounds, thus limiting the number, type, and detail of covariates we could consider across all survey rounds.

Variables derived from H[I]ES.

We categorized the population of households by locality into (*1*) rural areas, (*2*) municipalities, and (*3*) metropolitan areas. The number of municipalities grew from 71 in 1981 to 310 in 2011, whereas the number of metropolitan areas remained stable at 4 throughout this period (31, 33). We used geographic information to create the 7-division structure that was in operation from 2011 to 2015 to have a consistent division variable over time. See the supplemental information for details on the assumptions used to regionally classify the sample in 1985 (pg 1, Section 2).

We categorized households by demographic characteristics such as nuclear household structure, household size, age of household head, presence of children less than 10 y of age, and presence of a full-time homemaker. A nuclear household was defined as a household with fewer than 2 married women and 2 married men, so households with 1 married couple and an elderly parent were counted as nuclear. Education levels were categorized into 4 groups across survey rounds: none/primary, any secondary, any secondary certificate received, and any university. The education level of household heads was examined using these categories. In addition, we calculated the average level of education for women and men over 15 y in the household separately using these 4 levels as a continuous variable. We also included 3 utility variables that could affect food preparation: piped water, electricity, and natural gas.

Religious affiliation of households was not collected in 1985 but was available in all subsequent rounds. Excluding 1985, all surveys included the month of data collection (1988 to 1995) or the exact dates of recall (2000 to 2010). From this information, we derived variables indicating if a major festival (Eid-ul-Azha, Eid-ul-Fitr, or Durga puja) occurred during the data collection period. These indicators took the value of 1 if both the dates of data collection and religious affiliation of the household matched with the festival. We also divided months of data collection into 3 seasons (January to April, May to August, and September to December), corresponding to the periods following rice harvests in Bangladesh. These indicators were mutually exclusive in the survey rounds from 1985 to 1995 but not in the rounds from 2000 to 2010 if the period of data collection straddled 2 seasons, in which case both seasonal dummy variables were marked.

Household per capita expenditure was available or calculated for each round of data collection (5); however, official standardized poverty lines were only available for the period 1991 to 2010. To convert nominal expenditure into its real value, we used the World Bank's consumer price index (CPI) (41). In addition, to more closely match the poverty line used in Bangladesh, we created a food-only poverty line in each period using the current consumption basket in each of the 11 food groups outlined in Ravallion and Sen (42), upon which the Bangladesh food poverty line is based (see **Supplemental Table 1** for additional details). As expected, real expenditure was positively skewed, so it was log-transformed for regression analysis. We also calculated the percentage of households with per capita expenditure below the food poverty line.

To estimate household agricultural production, we first identified households that reported growing any of 9 common field crops consistently collected across all surveys (rice, wheat, potatoes, lentils, eggplants, other vegetables, oilseeds, spices, and jute). Fruit production could not be included as it was not collected in the 2000 survey. We used the reported production levels of these 9 crop types to measure relative production diversity at the household level and calculated a Simpson's index, i.e., a measure of diversity that quantifies the probability that 2 crop types selected from a defined production basket will be the same (43, 44). The index ranges from 0, when all crop types are produced in the same amounts, to 100 when the production basket is made up of only 1 crop type. We then split this indicator into 3 groups – no diversity, some diversity, and high diversity. We also calculated the overall proportion of the amount produced that was consumed, which we then split into 3 groups – no, some, and high own consumption. Households that did not produce any of the consistently recorded crop types were assigned to the "no diversity" and "no consumption" groups. We also included dummy variables on whether the household produced certain field crop types (starches, vegetables/lentils, oilseeds, spices, and jute) or certain animal source foods (milk and eggs), employing the categories available in all survey rounds.

Variables from other data sources.

To derive regional food production variables, we used existing agricultural statistics for each region. Over the entire period, production statistics were consistently available for 64 crops in 9 production groups (starches, lentils, sugar, vegetables, leafy vegetables, fruits, spices, oilseeds, and nonfood, see **Supplemental Table 2** for the crops included in each group). By region, a Simpson's diversity index was calculated using relative per capita production of the 64 consistently measured crops (43, 44). The production level of these production groups was converted to a per capita amount using population statistics by erstwhile districts that were derived from 1981, 1991, 2001, and 2010 censuses, extrapolated for the intervening years (31, 33, 40, 45). In addition, the quantity of production per capita was summed by production group, creating 9 quantity variables. These variables do not directly measure food supply, merely regional production, as they contain items that could not be expected to be consumed locally (including sugar and nonfood items), were not adjusted for food import and export, and we did not account for other uses of crops such as seeds for the next season and/or livestock feed.

To compare the identified dietary patterns to desirable consumption levels in the country context, we used the *Dietary Guidelines for Bangladesh*, endorsed by the Government of Bangladesh (46).

Statistical analysis

Of the 52,455 households in the overall sample, 651 (1%) were excluded for estimated energy intake above or below cut-offs. Data were population weighted in line with published reports and past work (5, 18, 28, 47–51), although the weights were adjusted to give equal weight to each survey round despite the larger sample sizes in later surveys. All statistical analyses were conducted using Stata version 13.1 (Stata Corp.) and regressions accounted for survey design using the *svy* commands.

In line with past studies, dietary patterns were identified using principal component analysis (PCA), with varimax orthogonal rotation (6, 9, 11, 13), following a Kaiser–Meyer–Olkin test (KMO) to verify that the data were appropriate for PCA. To determine which dietary patterns to retain, we examined the scree plot and the amount of variance explained per factor and selected an eigenvalue cut-off of 1.3 (see **Supplemental Figure 1**). In line with common practice, dietary patterns were described based on the foods with the highest absolute value loadings on each factor, with food items with a positive loading value being characteristic of the dietary pattern and food items with a negative loading value negatively associated with the pattern. The absolute loading value of 0.20 was used to characterize which food items belonged to each dietary pattern (11, 15, 52, 53).

To classify household adherence to dietary patterns, we predicted scores that indicated the alignment between the household's diet and each dietary pattern. For each pattern, we then grouped the scores into population quintiles. To determine the characteristics of adherents to each pattern, we compared households with loadings in the highest quintiles of each dietary pattern to the rest of the sample, as done previously (11, 13, 52). For the few households in which certain variables were not available, such as female education level in households with no adult women, the value was imputed using the overall sample mean, with a dummy variable indicating where this was done (54). Associations were tested using linear probability models with robust standard errors (55). To aid in the interpretation of the findings, we undertook a supplemental dominance analysis to understand which factors were the strongest predictors in these regressions (56), using the *domin* command in Stata (57).

After examining these relations in the pooled sample, we used Blinder–Oaxaca decomposition to identify which set of indicators (all rounds: year, division, locality, demographics, education, utilities, household expenditure, household agriculture, regional agriculture; 1988+: religion and season added) predicted the change in dietary pattern adherence over time (1985/1988/1991 to 2011) (58, 59). Decomposition was performed using the *oaxaca* package in Stata with the 2-fold model, in which coefficients from a pooled model are used as the reference (60).

Compliance with ethical standards

As this is a secondary analysis of publicly available data, obtained from BBS, ethical approval was not required.

Results

The proportion of the population in rural areas fell from 87% in 1985 to 68% in 2010, with the percentage living in municipalities increasing at a slightly faster rate than the percentage living in metropolitan areas (**Table 1**). There was little change in the proportion of the population living in each division, although there was a slight increase in Dhaka division. There were no changes in the religious composition of the sample, with around 90% of the population belonging to Muslim households. As expected, the sample was seasonally balanced.

Household demographics also changed, with nearly 2 fewer household members in 2010 compared with 1985, and the proportion of the population living in households without children under 10 y of age doubled, from 15% to 29% (Table 1). The mean age of household heads did not change dramatically, although the education level of household heads increased over time. Women's education increased somewhat faster than men's education, but parity was not attained by 2010. The proportion of the population in households without full-time homemakers increased slightly as did the proportion living in a nuclear family structure. The percentage of the population with electricity more than tripled from 14% to 56%, whereas the proportion with piped water and natural gas connections increased more gradually.

The middle third of Table 1 provides interquartile ranges for real per capita per month expenditure as calculated using the official CPI as well as author-calculated food poverty cost-based inflation rates. When using the official CPI, real expenditure levels did not change substantially between 1985 and 2005 and only increased in 2010, whereas there was a steady increase in real expenditure from 1991 using food poverty cost-based inflation rates. For both measures, the absolute and relative increase in expenditure was greater at the 75th percentile than at the 25th percentile. The change in the proportion of the population below the food poverty line was largely in line with the change in the official poverty lines, which were available from 1991.

The proportion of the population in households that had not grown any of the specified crops in the year before the survey nearly doubled from 30% to 55% over the period, whereas the proportion that did not produce milk or eggs increased slightly (Table 1, lower third). In line with this, the proportion growing each crop type decreased over time, with the fastest decrease for vegetables/lentils, followed by jute and rice. Over time, the proportion of the population living in households with diverse production declined from 31% to 12%, as did the proportion that consumed most of the crops grown (from 24% to 13%). Using regional data, the diversity of production declined only slightly and the amount of starches produced per capita per day increased by over 300 g (from 520 g to 856 g); there were smaller increases in vegetable and fruit production, and a slight decline in the production of lentils and oilseeds.

Dietary patterns

Dietary patterns were drawn simultaneously from the entire sample across survey rounds. One food item, "wheat and wheat flour," had a KMO coefficient of less than 0.5, and was combined with the "other grains" food group for analysis. In the final model, containing 59 food items, no food item has a KMO coefficient of less than 0.5 and the overall KMO coefficient was 0.78 (Bartlett test $P < 0.001$). Seven dietary patterns were identified that explained 27% of the variance in dietary intake: modern, traditional, winter, festival, summer, monotonous, and spices. Food items that loaded onto the identified dietary patterns and their loadings are given in **Supplemental Table 3**.

The modern dietary pattern is characterized by positive loadings of many items for which consumption has increased over the period under review, and negative loadings of items whose consumption has decreased. It contains items from most food groups. The modern diet has a high level of processed soybean/palm oil with lower levels of mustard oil, the easily pressed, traditional oil of Bangladesh. It is characterized by containing less *khesari dal*, a lower cost traditional pulse, and less rice. The traditional dietary pattern, in contrast, is characterized by positive loadings on many items for which consumption has decreased over time, such as mustard oil. It does not contain any type of fruit but contains a mixture of more traditionally consumed items such as multiple categories of fish and spices along with *masur dal*, a higher cost traditional pulse. No items had negative loadings.

Two food patterns appear to be defined by what produce is available seasonally. The winter dietary pattern is characterized by winter-grown vegetables and potatoes. There were negative loadings on shrimp, summer vegetables (pumpkin/ash gourd and snake/ridge gourd), guava, and nonrice starches (taro and unripe starchy fruit) that are more often grown in summer. In contrast, the summer dietary pattern is characterized by positive loadings on items that negatively loaded on the winter dietary pattern. This pattern is characterized by several varieties of summer vegetables and mango. It is also characterized by greater liquid milk consumption and lower intakes of winter vegetables (fleshy beans, cabbage/cauliflower, bottle gourd) and the striped/spotted snakehead fish.

The festival dietary pattern contains many ingredients of dishes commonly served during festivals in Bangladesh. These include sugar/molasses, liquid milk, prepared sweets, fruit, as well as ingredients for traditional savory items, such as puffed rice and mustard oil that make *jhal muri* – commonly used to break one's fast during Ramadan. The festival pattern also contains purchased soft drinks, which are frequently given to guests, and expensive food ingredients such as fish, meat, and 2 types of lentils. No items had negative loadings on this pattern.

The remaining 2 dietary patterns have both positive and negative loadings. The monotonous diet is characterized by high quantities of starches (rice, processed rice, taro/other starchy crops), accompanied by vegetables, fish, and pea/green gram lentils. It is also characterized by lower amounts of certain higher-cost food items such as bitter gourd, beef, *masur dal*, *hilsha fish*, and biscuits/prepared items. The spices dietary pattern is categorized to a greater degree by what negatively loads onto the pattern than what positively loads. This pattern is characterized by low consumption of many traditional items such as several types of fish, pea/green gram lentils, dried chili, and tea/coffee. The 3 items that load onto this diet are condiment items (green chili, salt, mustard oil) that are common in Bangladesh diets and may also reflect the "rice and spices" diet resorted to during times of food insecurity.

TABLE 1 Descriptive characteristics by H[I]ES survey year and change over time[1]

	1985	1988	1991	1995	2000	2005	2010	All years	Change 2010–1985	
Locality										
Rural	87%	87%	86%	83%	80%	75%	68%	81%	−19%	$P < 0.001$
Municipality	5%	5%	6%	5%	8%	11%	16%	8%	11%	$P < 0.001$
Metropolitan	8%	8%	8%	11%	12%	14%	16%	11%	8%	$P < 0.001$
Division										
Barisal	7%	7%	7%	7%	7%	6%	6%	7%	−1%	$P < 0.001$
Chittagong	20%	19%	20%	20%	20%	19%	19%	20%	−1%	$P = 0.185$
Dhaka	30%	29%	29%	31%	31%	32%	33%	31%	3%	$P < 0.001$
Khulna	13%	13%	12%	12%	12%	12%	12%	12%	−1%	$P = 0.007$
Rajshahi	13%	13%	13%	14%	14%	14%	13%	13%	0%	$P = 0.702$
Rangpur	11%	12%	11%	9%	10%	10%	11%	11%	1%	$P = 0.501$
Sylhet	6%	7%	7%	7%	6%	6%	6%	7%	0%	$P = 0.574$
Household structure										
Members	7.0	6.8	6.6	6.3	6.1	5.7	5.3	6.3	−1.8	$P < 0.001$
No children <10 y	15%	15%	17%	19%	23%	26%	29%	21%	15%	$P < 0.001$
No homemaker	5%	5%	4%	6%	10%	8%	12%	7%	7%	$P < 0.001$
Nuclear family	77%	80%	81%	83%	80%	80%	82%	81%	5%	$P < 0.001$
No adult men	2%	2%	3%	4%	3%	4%	5%	3%	3%	$P < 0.001$
No adult women	1%	2%	1%	0%	0%	0%	0%	1%	0%	$P = 0.003$
Head age, y	45.6	44.7	44.3	44.7	45.7	46.6	46.4	45.4	0.8	$P = 0.015$
Educational level of household head										
None/primary	75%	76%	77%	75%	73%	69%	69%	73%	−6%	$P < 0.001$
Secondary	14%	13%	12%	13%	14%	15%	15%	14%	1%	$P = 0.365$
Certificate	9%	9%	8%	9%	10%	11%	11%	9%	2%	$P = 0.035$
University	2%	3%	4%	3%	4%	5%	6%	4%	4%	$P < 0.001$
Mean level of adult education										
Female	1.1	1.2	1.2	1.2	1.3	1.4	1.5	1.3	0.3	$P < 0.001$
Male	1.4	1.4	1.4	1.5	1.5	1.6	1.7	1.5	0.2	$P < 0.001$
Utilities										
Electricity	14%	11%	16%	20%	33%	57%	56%	29%	43%	$P < 0.001$
Natural gas	3%	3%	3%	6%	8%	9%	14%	7%	11%	$P < 0.001$
Piped water	3%	5%	3%	8%	7%	7%	10%	6%	7%	$P < 0.001$
Religion										
Muslim		87%	90%	89%	91%	88%	88%	89%		
Hindu		13%	10%	10%	9%	10%	10%	10%		
Other		0%	0%	1%	1%	2%	1%	1%		
Season of survey										
Jan to April		33%	34%	34%	33%	32%	33%	33%		
May to Aug		33%	33%	33%	33%	35%	32%	33%		
Sept to Dec		33%	33%	33%	34%	33%	35%	33%		
Real per capita per month expenditure - Consumer Price Index (2010 Bangladeshi Taka)										
25th percentile	1083	1043	1013	1061	981	1090	1425	1082	341	
50th percentile	1403	1366	1377	1410	1332	1459	1940	1453	536	
75th percentile	1909	1868	1866	2007	1905	2097	2777	2059	868	
Real per capita per month expenditure - Cost of food poverty line (2010 Bangladeshi Taka)										
25th percentile	1103	1103	1093	1251	1327	1441	1468	1236	365	
50th percentile	1411	1433	1451	1649	1763	1896	1964	1641	554	
75th percentile	1905	1945	1958	2279	2480	2666	2777	2275	872	
Natural log of real per capita per month expenditure as proportion of food poverty line										
Mean	7.30	7.31	7.31	7.46	7.53	7.62	7.64	7.45	0.34	$P < 0.001$
Proportion of the population above poverty lines										
Food	75%	74%	74%	83%	88%	92%	92%	83%	17%	$P < 0.001$
Official lower			59%	66%	71%	80%	83%			
Official upper			44%	50%	55%	66%	68%			

(continued)

TABLE 1 *(continued)*

	1985	1988	1991	1995	2000	2005	2010	All years	Change 2010–1985	
Household production (H[I]ES sample)										
No milk	83%	86%	88%	82%	86%	85%	88%	86%	4%	$P < 0.001$
No eggs	60%	56%	55%	49%	61%	53%	64%	57%	4%	$P = 0.003$
No listed field crops	30%	35%	34%	30%	50%	54%	55%	41%	25%	$P < 0.001$
No starches	38%	43%	41%	40%	52%	57%	60%	47%	22%	$P < 0.001$
No vegetables/lentils	42%	53%	49%	50%	85%	86%	81%	64%	39%	$P < 0.001$
No oilseeds	80%	87%	90%	87%	95%	95%	96%	90%	15%	$P < 0.001$
No spices	73%	78%	78%	80%	91%	92%	90%	83%	17%	$P < 0.001$
No jute	64%	81%	84%	85%	93%	92%	91%	84%	27%	$P < 0.001$
Crop production diversity (H[I]ES sample)										
Not producing/no diversity	43%	52%	50%	50%	75%	78%	76%	61%	33%	$P < 0.001$
Low production diversity	26%	26%	18%	29%	14%	13%	12%	20%	−14%	$P < 0.001$
High production diversity	31%	21%	32%	21%	11%	9%	12%	20%	−19%	$P < 0.001$
Consumption of produced crops (H[I]ES sample)										
Not producing/no consumption	46%	53%	54%	49%	74%	75%	73%	61%	27%	$P < 0.001$
Moderate consumption	30%	22%	22%	21%	15%	13%	14%	20%	−16%	$P < 0.001$
High consumption	24%	26%	24%	30%	11%	11%	13%	20%	−11%	$P < 0.001$
Regional agricultural production in g (national statistics, population weighted, n = 23 in each year)										
Starches	516.1	506.2	565.0	504.3	627.7	657.0	853.2	604.2	337.1	$P < 0.001$
Pulses	15.1	13.4	13.0	12.5	8.4	6.6	4.7	10.5	−10.4	$P < 0.001$
Vegetables	29.3	29.5	33.4	32.0	36.4	52.4	70.9	40.5	41.6	$P < 0.001$
Leafy vegetables	0.7	0.8	0.8	0.9	1.0	1.4	2.3	1.1	1.6	$P < 0.001$
Fruits	40.6	33.7	32.4	35.7	31.4	101.3	80.3	50.8	39.7	$P < 0.001$
Oilseeds	11.2	8.4	9.4	9.3	6.5	6.1	6.6	8.2	−4.5	$P < 0.001$
Sugarcane	195.3	191.1	196.7	168.7	144.2	136.4	95.3	161.1	−100.0	$P < 0.001$
Spices	3.2	2.9	2.9	2.9	2.7	5.9	9.8	4.3	6.6	$P < 0.001$
Non-food crops	49.2	25.1	27.0	20.8	21.6	20.2	39.7	29.1	−9.5	$P < 0.001$
Simpson's diversity index	62.1	59.3	56.6	57.9	57.5	60.1	57.4	58.7	−4.7	$P < 0.001$

[1]H[I]ES, Household [Income and] Expenditure Survey.

Diet quantity, food group composition, and cost of dietary patterns also varied between patterns (Table 2 and **Supplemental Figure 2**). The most expensive dietary patterns were the festival and modern, followed closely by the traditional and summer. All dietary patterns contained more energy than the poverty food basket and the dietary guidelines, and all dietary patterns contained, on average, more rice than the dietary guidelines. Even in the modern diet, on which rice negatively loaded, starches made up slightly more than half the diet by weight. Households that did not adhere to any dietary pattern had the least expensive, lowest weight, and lowest energy diets. Their diets had over 70% of dietary weight derived from starches. Among the identified dietary patterns, the mean composition of the modern diet adheres most closely to the dietary guidelines, though sizable gaps remain. The modern diet contains 151 g more starches, 102 g fewer vegetables, and 57 g fewer fruits than the guidelines recommend. In addition, it contains 11 g less fish, 22 g less egg, 7 g less meat, and 73 g less milk than stated in the dietary guidelines, with only the festival pattern being higher in animal-sourced foods.

Characteristics associated with household dietary patterns

All diets were present in all survey rounds, although the proportion of the population in households adhering to these patterns changed over time. Households with adherence to the modern, winter, summer, and monotonous dietary patterns increased over time, whereas those adhering to the traditional and with no identified dietary pattern declined over time (Figure 1). The most dramatic changes were for the modern (1985: 1% to 2010: 62%) and no pattern (1985: 41% to 2010: 12%) diets. There were no consistent trends over time for adherence to the festival and spices patterns.

Bivariable associations of dietary patterns with characteristics are available in **Supplemental Table 4**. In Table 3, we present predictors of adherence to dietary patterns from multivariable pooled regression models (due to the omission of seasonal variables in the earliest round, the 2 seasonal diets were predicted over the period 1988 to 2010 instead of the complete period to improve model fit). Higher expenditure, presence of children, and smaller households were associated with adherence to every dietary pattern, and negatively associated with adherence to no dietary pattern. Modern diets were associated with urban locality, whereas festival, spices, and monotonous dietary patterns were associated with rural locality. Adherence to the traditional dietary pattern was associated with residence in the northeast, whereas the spices pattern was more common in the west. We found significant change in patterns over time despite controlling for changes in demography, expenditure, agricultural production, and other variables, indicating that unobserved factors associated with time

TABLE 2 Average composition and cost of diets (in grams per adult male equivalent per day)

	Among households with high adherence								Simulated diet	
	Modern	Traditional	Winter	Festival	Summer	Monotonous	Spices	No pattern	Poverty basket	Dietary guidelines
Food groups (g)										
Starches	651	788	776	765	739	811	788	663	464	500
Pulses	24	33	18	31	24	21	21	18	40	50
Fish	49	56	38	54	37	45	36	25	48	60
Eggs	8	8	5	9	6	4	5	2	0	30
Meat	33	16	18	25	17	9	13	7	12	40
Vegetables	198	190	216	201	192	210	209	108	150	300
Fruits	43	27	16	48	68	31	23	7	20	100
Dairy	57	40	38	80	58	31	51	16	58	130
Oil	30	22	18	22	19	17	19	9	20	30
Spices	50	59	47	43	44	47	56	28	0	20
Sweets	20	18	18	37	15	14	14	7	20	20
Beverages	45	27	34	34	31	27	12	12	0	0
Energy (kcal)										
Mean	2777	3185	2967	3204	2937	3118	3030	2468	2109	2429
25^{th} percentile	2371	2697	2517	2742	2499	2683	2588	2110	2095	2408
50^{th} percentile	2729	3102	2908	3111	2854	3033	2944	2431	2105	2426
75^{th} percentile	3103	3610	3336	3605	3299	3472	3397	2780	2118	2446
Weight (g)										
Mean	1207	1283	1242	1348	1249	1267	1250	903	832	1280
25^{th} percentile	1007	1074	1053	1148	1049	1077	1058	783		
50^{th} percentile	1170	1245	1201	1314	1210	1230	1214	894		
75^{th} percentile	1363	1450	1392	1509	1408	1413	1400	1013		
Monthly cost (BDT)[1]										
Mean	3121	2314	2189	2876	2328	2031	2129	1395	1163	1880
25^{th} percentile	1899	1449	1391	1770	1463	1398	1372	995	1086	1750
50^{th} percentile	2539	1911	1830	2319	1930	1775	1800	1250	1152	1860
75^{th} percentile	3625	2638	2531	3295	2703	2324	2427	1603	1228	1987

[1]BDT, Bangladesh taka in 2010. ~80 BDT to 1 USD.

periods (e.g., market characteristics, underlying social norms related to diet) may have contributed to adherence to dietary patterns over time.

A number of household demographic factors were associated with certain dietary patterns. Notably, the absence of a full-time homemaker was associated with a lower probability of adhering to the modern pattern and with a higher probability of adhering to the traditional and winter patterns. Households with no adult men had a higher probability of adhering to the modern, traditional, monotonous, and spices dietary patterns. At the same time, households with no adult women had a greater probability of adherence to no dietary pattern and a lower probability of adherence to the modern dietary pattern. Adherence to the modern, traditional, spices, summer, and winter patterns was associated with a younger household head and adherence to no dietary pattern with an older head.

Beyond demographics, other household factors also affected adherence to dietary patterns. All indicators of higher education increased the probability of adherence to the modern and festival patterns and decreased the probability of adherence to the traditional, monotonous, and winter patterns. Hindu religious affiliation was associated with a lower probability of adherence to the modern and traditional dietary patterns and increased the probability of adherence to the festival and monotonous dietary patterns (**Supplemental Tables 5** and **6**). Presence of each "modern" utility – electricity, natural gas, and piped water – increased the probability of adherence to the modern dietary pattern and decreased the probability of adherence to the monotonous pattern. Season of survey also influenced many dietary patterns, particularly the seasonal winter and summer patterns. The probability of adherence to diets during holidays was higher for the modern, festival, and no pattern, and lower for the traditional, winter, spices, and monotonous dietary patterns.

Few clear patterns emerged with respect to household agricultural production. The production of starches and jute was associated with a higher probability of adherence to the monotonous diet. Households that produced milk had a lower probability of adherence to the modern and traditional diets and a greater probability of adherence to the festival, spices, and summer dietary patterns. Production of oilseeds was associated with a lower probability of adherence to the modern dietary pattern and a greater probability of adherence to the festival and spices pattern. Greater production diversity was associated with a higher probability of adherence to the modern diet and a lower probability of adherence to the monotonous diet. The consumption of own crops was associated with a higher probability of adherence to the modern diet and to no dietary pattern, and a lower probability of adherence to the monotonous and spices dietary patterns.

Regional production was associated with all dietary patterns, but to a lesser extent with adherence to no dietary pattern. Greater levels of regional starches production were associated with a lower probability of adherence to the modern dietary pattern and greater

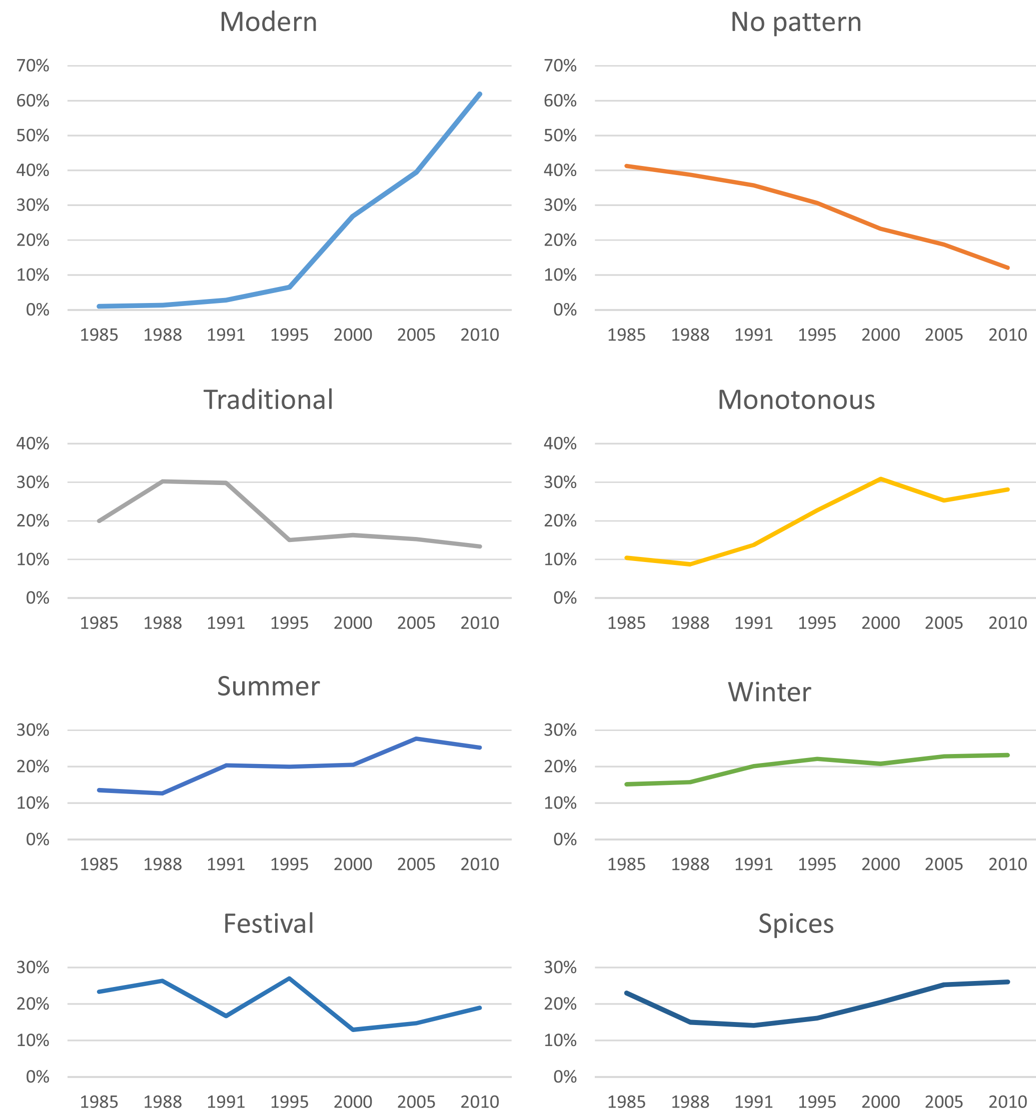

FIGURE 1 Change in adherence to dietary patterns over time. Dietary patterns are shown in the order of most dynamic change over time to the lowest level of change. By definition, 20% of the sample has "high adherence" to each dietary pattern. "No pattern" refers to the 29% of the population across all survey rounds who were residing in households that adhere to no identified dietary pattern.

probability of adherence to the traditional, spices, winter, and summer dietary patterns. Regional vegetable production was associated with lower probability of adherence to the modern, traditional, and festival patterns, and greater probability of adherence to the spices pattern. In contrast, regional production of dark green leafy vegetables was associated with much greater adherence to the modern dietary pattern. Regional spices production was associated with a greater probability of adherence to the traditional and monotonous dietary patterns and a lower probability of adherence to the festival and spices dietary patterns. Regional production diversity was associated with a greater probability of adherence to the modern, spices, and summer dietary patterns and lower probability of adherence to the monotonous and no dietary patterns.

The results of the dominance analysis undertaken to determine the overall importance of the various indicators in predicting dietary adherence are available in the supplemental material (see Supplemental Figure 2 and **Supplemental Table 7**). In summary, dominance analysis indicated that household expenditure was a key predictor for 4 dietary patterns (festival, absence of a dietary pattern, modern, and traditional), whereas regional agricultural production explained over 10% of the variance of 4 patterns (spices, monotonous, traditional, and modern). Utilities and education were also important predictors of adherance to the modern dietary pattern.

Decomposition results

After examining the trends in the proportion of the population adhering to dietary patterns over time (Figure 1), we undertook decomposition to identify drivers of change, studying the 5 dietary patterns for which adherence had changed over time as well as those not adhering to any dietary pattern (**Table 4**). We compared the relative contribution of change in all observed variables over time (explained change) to the overall change over time in the proportion of the population residing

TABLE 3 Factors associated with high adherence to identified dietary patterns (pooled multivariable regression results)[1]

	1985 to 2010						1988 to 2010	
	Modern	Traditional	Festival	Monotonous	Spices	No pattern	Winter	Summer
Year (Reference = 2000)								
1985	−21.7%***	11.3%***	16.2%***	−18.7%***	1.6%	9.0%***		
1988	−20.0%***	19.7%***	19.5%***	−21.4%***	−3.5%**	6.8%***	−3.7%**	−2.8%
1991	−18.4%***	19.1%***	10.2%***	−16.7%***	−4.6%***	3.6%**	−0.1%	4.8%***
1995	−19.1%***	0.8%	14.8%***	−8.0%***	−3.5%**	4.3%**	2.1%	2.8%*
2005	8.3%***	−1.8%	−0.6%	−6.6%***	3.7%***	−0.6%	1.2%	3.6%**
2010	29.2%***	−5.0%***	3.7%***	−5.7%***	2.8%*	−6.6%***	3.0%*	−1.1%
Locality (Reference = rural)								
Municipality	5.7%***	−1.7%*	−2.5%***	−9.6%***	−5.3%***	3.7%***	0.1%	1.8%
Metropolitan area	7.9%***	2.3%	−5.7%***	−11.8%***	−6.0%***	0.5%	2.6%	3.1%*
Division (Reference = Dhaka)								
Barisal	−0.6%	6.1%***	1.5%	−6.0%***	−12.8%***	1.6%	−2.6%	−4.6%*
Chittagong	5.9%***	4.0%**	0.9%	6.3%***	−9.9%***	−7.9%***	8.9%***	2.8%*
Khulna	−2.5%*	−11.6%***	1.6%	5.3%**	11.6%***	−2.2%	1.8%	−3.6%
Rajshahi	0.1%	−12.6%***	0.5%	−5.0%***	13.0%***	0.4%	−4.4%**	0.4%
Rangpur	−6.7%***	−18.9%***	1.9%	3.8%*	7.3%***	−4.4%**	6.7%***	0.6%
Sylhet	7.0%***	21.4%***	−1.2%	1.0%	−0.8%	−13.3%***	4.4%	−2.5%
Household structure								
Members	−0.7%***	−2.5%***	−0.5%***	−1.1%***	−1.7%***	2.2%***	−0.6%***	−0.5%***
No children <10 y	−3.8%***	−5.3%***	−8.6%***	−2.3%***	−3.0%***	8.3%***	−2.8%***	−2.8%***
No homemaker	−2.6%***	1.6%*	−1.4%*	1.5%	−0.6%	−0.5%	2.3%***	−1.3%
Nuclear family	−1.1%**	−0.7%	0.8%	0.5%	−0.9%	1.1%	0.3%	−0.1%
No adult men	3.7%***	7.0%***	0.7%	4.1%***	6.1%***	−1.6%	1.1%	1.1%
No adult women	−2.3%**	−0.1%	−3.1%	−2.6%	1.3%	6.4%**	1.1%	2.9%*
Head age (decade)	−0.2%**	−1.0%***	−0.2%	−0.2%	−0.5%***	1.0%***	−0.4%**	−0.4%**
Education of household head (Reference = None/primary)								
Secondary	0.4%	−1.6%**	2.9%***	−0.1%	−1.9%**	1.1%	−0.8%	−0.5%
Certificate	−0.4%	−0.4%	3.7%**	0.3%	−0.2%	0.2%	0.0%	−1.4%
University	−1.4%	−0.3%	6.1%***	3.4%*	−0.8%	0.5%	−3.6%**	0.0%
Mean level of adult education								
Adult women	5.3%***	−2.8%***	1.2%**	−3.4%***	−0.2%	0.5%	−1.4%**	1.0%*
Adult men	1.2%**	−1.0%*	−0.3%	−2.9%***	−0.3%	0.4%	0.0%	0.1%
Utilities								
Electricity	5.6%***	−3.2%***	0.5%	−4.3%***	−1.3%*	0.7%	0.0%	0.0%
Natural gas	7.8%***	−4.9%***	−2.5%*	−3.4%***	−3.4%***	0.1%	−4.0%**	−2.3%*
Piped water	6.1%***	−1.5%	−3.8%***	−3.9%***	−3.7%***	1.2%	−2.3%	−4.1%**
Religion (Reference = Muslim)								
Hindu							0.8%	0.5%
Other							7.0%**	1.7%
Season of survey (Reference = January to April)								
May to Aug							−44.2%***	39.0%***
Sep to Dec							−39.1%***	−7.1%***
Holiday							−6.2%***	2.1%**
Household per capita expenditure								
Above food poverty	−7.9%***	4.5%***	−3.4%***	7.0%***	5.8%***	−17.4%***	3.2%***	3.3%***
Log of expenditure	22.6%***	17.5%***	36.9%***	5.2%***	8.5%***	−26.0%***	8.5%***	10.6%***
Household agricultural production (Reference = producing)								
No milk	1.3%***	1.4%**	−4.9%***	−0.4%	−2.9%***	0.2%	1.1%	−2.9%***
No eggs	0.7%*	0.0%	−0.5%	0.7%	0.6%	−0.5%	0.6%	1.7%***
No field crops	1.2%	−1.2%	1.3%	−0.9%	−2.2%	1.4%	−0.9%	−1.9%
No starches	4.2%***	1.2%	−1.8%	−2.8%**	−1.3%	−0.4%	0.3%	−0.2%
No vegetables/lentils	−0.3%	2.4%**	−0.5%	−1.9%*	0.8%	−1.8%*	1.3%	−0.1%
No oilseeds	3.2%***	0.5%	−2.5%**	−1.5%	−4.5%***	1.2%	−0.8%	0.9%
No spices	1.2%**	−2.6%***	−1.7%*	−0.4%	0.5%	1.8%	0.4%	0.3%
No jute	−0.5%	0.8%	1.9%*	−3.6%***	−1.6%	−0.6%	−0.8%	1.1%

(continued)

TABLE 3 *(continued)*

	1985 to 2010						1988 to 2010	
	Modern	Traditional	Festival	Monotonous	Spices	No pattern	Winter	Summer
Household agricultural production diversity (Reference = no production/no diversity)								
Some diversity	1.7%**	1.0%	1.7%	−1.4%	−1.6%	−0.8%	1.8%*	0.3%
High diversity	2.5%***	1.4%	−0.3%	−2.9%**	0.9%	−1.1%	1.8%	0.5%
Household consumption of agricultural production (Reference = no production/no consumption)								
Some consumption	2.9%***	0.6%	−0.3%	−0.3%	−1.1%	0.1%	0.0%	−0.8%
High consumption	3.2%***	−0.7%	0.0%	−2.5%***	−3.3%***	2.7%***	−1.6%*	−1.3%
Regional agricultural production per capita								
Starches (100 g)	−0.5%***	0.3%**	0.1%	0.3%	0.7%***	−0.2%	0.8%***	1.0%***
Lentils (10 g)	−0.1%	−1.0%**	0.3%	−0.5%	2.1%***	0.3%	−0.7%	−0.1%
Vegetables (10 g)	−0.7%***	−0.9%***	−0.5%**	0.3%	0.9%***	0.3%	0.1%	0.4%
DGLV (10 g)	19.3%***	6.7%	9.8%*	5.4%	−9.0%	−8.4%	−4.2%	−4.5%
Fruits (10 g)	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%*	0.0%	0.0%
Oilseeds (10 g)	0.4%	−1.1%	2.0%**	−2.0%**	0.5%	0.0%	−3.1%***	−1.4%
Sugars (10 g)	0.0%	−0.1%***	0.0%	0.0%	0.0%	0.0%	0.2%***	0.0%
Spices (10 g)	−0.8%	2.6%***	−1.3%**	3.6%***	−2.7%***	−0.2%	1.1%	0.5%
Non-food (10 g)	0.4%***	−0.2%	0.0%	−0.3%	0.6%***	0.1%	−0.3%	0.1%
Diversity index	0.2%***	0.0%	0.0%	−0.2%***	0.2%***	−0.2%***	0.1%	0.2%***
Constant	−40.8%***	3.6%	−55.5%***	48.9%***	1.4%	88.3%***	26.2%***	−29.3%***
n	51,804	51,804	51,804	51,804	51,804	51,804	48,005	48,005
Model fit (AUC)	0.92	0.81	0.82	0.73	0.79	0.78	0.87	0.87

[1] *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. DGLV, dark green leafy vegetables.

in households with adherence to the listed dietary pattern. In contrast, unexplained change is due to differences in response to the observed variables over time. Most of the increase in the summer pattern was explained by changes in observed variables, as was nearly one-third of the increase in the monotonous dietary pattern, and about half of the decrease in those with no pattern. The increase in the modern pattern over time remained largely unexplained. Whereas adherence to the traditional pattern decreased by 7% over time, changes in observed variables predicted an 11% increase in adherence, leaving even more to be explained after the analysis than before. The ability of the decomposition to explain the 7% increase over time in the winter dietary pattern was very low (nonsignificant and near zero coefficient), with few variables significant. (Detailed results are available in **Supplemental Tables 8** to **11**.)

Figure 2 shows the decomposition results summarized by the category of indicator. As indicated, the explained portion of the change is the net sum of explanatory factors moving in the direction of change and moving in the opposite direction. The increase in adherence to the modern pattern was driven by rural to urban migration, changing household demographics, increased education, increasing expenditure, and improved access to utilities. At the same time, changes in regional production patterns (towards more rice) predicted reduced adherence to the modern pattern over time. The increase in the monotonous pattern was largely driven by changes in

TABLE 4 Explained and unexplained change in dietary patterns over time

		Two-group decomposition				
		Explained		Unexplained		
Dietary Pattern	Observed change	Coef.	*p*-value	Coef.	*p*-value	% explained
1985 to 2010						
Modern	61%	8%	<0.001	53%	<0.001	12%
Traditional	−7%	11%	<0.001	−17%	<0.001	−163%
Monotonous	18%	5%	0.008	13%	<0.001	28%
No pattern	−29%	−14%	<0.001	−15%	<0.001	48%
1988 to 2010						
Winter	7%	2%	0.392	5%	0.051	29%
Summer	13%	11%	<0.001	2%	0.555	88%

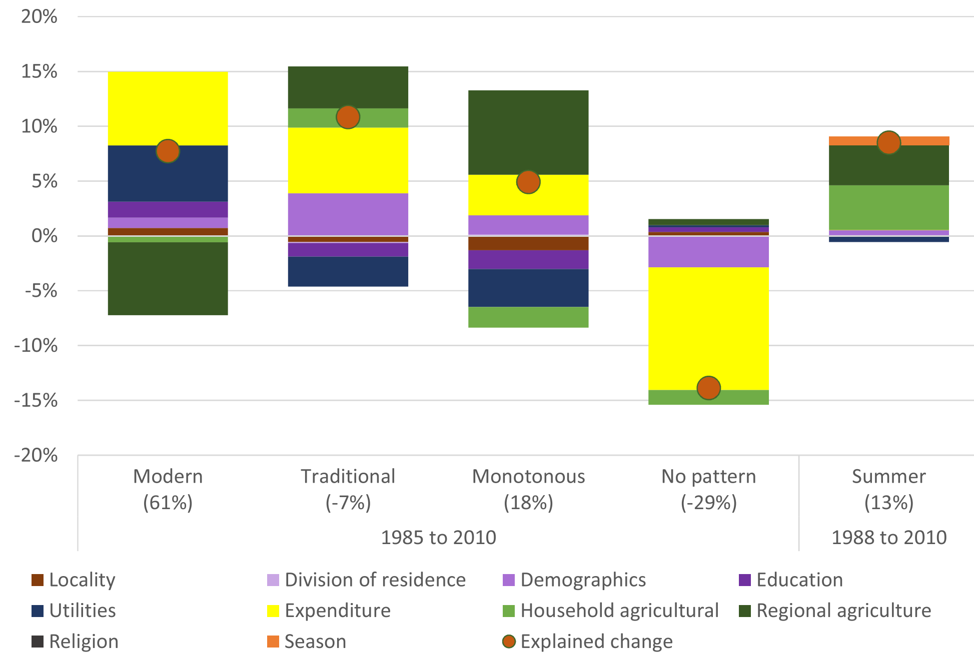

FIGURE 2 Direction and size of change in adherence to dietary patterns explained by differences in indicators, by indicator set. The change over time in the proportion of the household with high adherence to a dietary pattern is given in parenthesis under the label in the horizontal axis. The colored stacked boxes show the size and direction of explained change by each indicator set from the decomposition models, and the overall sum of the explained change is indicated by the orange dot.

agriculture and to a lesser extent by changing household demographics and increasing household expenditure. Working against the increase in the monotonous pattern were urbanization, increasing education, declining household agriculture, and improved utilities. The increase in the summer dietary pattern was largely explained by changes in household and regional agricultural production. The decline in adherence to the traditional diet was predicted by increased education and improved utilities. However, changing household demographics, increasing household expenditure, and changes in regional and household agricultural production predicted a large increase in this pattern that was not observed. The decline in the proportion of population in households with no dietary pattern was explained by increasing household expenditure and, to a lesser extent, changing household demographics and a decline in household agriculture.

Discussion

Utilizing 7 large, seasonally variable, nationally representative household datasets spanning 25 years, we identified 7 dietary patterns and examined household and regional characteristics associated with change in adherence to these patterns over time. We observed a dramatic increase in adherence to the modern dietary pattern, from 1% in 1985 to 62% in 2010, associated most strongly with urban locality, absence of adult men in the household, higher education, and the presence of modern utilities (i.e., electricity, natural gas, and piped water) in the household. Although the predictive power of these models was relatively high, the relation between observed factors and adherence to identified patterns varied across survey rounds. Blinder–Oaxaca decomposition indicated that only a limited amount of the observed change in prevalence over time was due to changes in the underlying characteristics that we could include in our models. Of the factors driving dietary change overall, agricultural production patterns and increased household real expenditure were the most important.

With economic growth, a greater proportion of households adhered to 1 or more dietary patterns: 40% of the overall decrease of households adhering to no dietary pattern from 1985 to 2010 was due to increase in household expenditure. As the "no pattern" diet was the least expensive and of lower cost than even the poverty food basket (Table 2), it seems reasonable that its decline over time was driven by economic growth. This shift implied a large increase in the proportion of nonstarch items in the diet, from 27% of dietary weight in households with no dietary pattern to between 36% and 46% among identified dietary patterns. In absolute numbers, the shift from no pattern to any pattern increased the amount of vegetables in the diet from slightly over 100 g/day/AME to nearly 200 g/day/AME, as well as increasing total dietary energy from just below 2500 kcal to around 2800—3200 kcal (corresponding to a 13% to 30% increase in dietary energy). Similar dietary transitions from a starch-dominated diet to more diversified diets have been documented in many countries (61).

Inflation rates of nonstarch items have greatly outstripped those of starches (3), limiting the gains in dietary diversification that could otherwise be expected from increasing real income. Features of the agricultural system both predicted dietary pattern adherence (Table 3 and **Supplemental Figure 3**) and explained observed changes in adherence over time (Figure 2). However, predicted changes were contrary to the observed increase in the modern and decrease in the traditional pattern, perhaps due to modern diets being more market-based and thereby linked to more aggregate levels of availability and local market quality for which we did not have indicators available. Notably, the increase in adherence to the starch-heavy monotonous diet from 1985 to 2010 appears to be driven by rural households, which experienced an increase in income but slower increases in education and electrification and still relied on subsistence agriculture. To enable these households to obtain a more diversified diet, there is a clear need for agricultural production to be diversified through agricultural policy that is more closely linked to nutrition policy.

This study indicates that household data could be used in other countries with similarly rich datasets to explore the relation between changes in agriculture and diets, and subsequently, to link agricultural change to health outcomes. Dietary patterns identified from household consumption data were similar to those obtained from individual data in number and amount of variance explained (13, 15, 16, 62–65). In comparison to previous studies in Bangladesh, the amount of dietary variance explained per dietary pattern was similar, although more patterns were identified in this study (11, 52).

Our novel approach of using HCES to identify and examine trends in adherence to dietary patterns over time has certain limitations. The data did not contain information on intra-household food distribution and thereby on individual diets. This precluded us from examining differences in dietary patterns and their change over time between women and men or between individuals of different ages within the household. In addition, as our dataset was drawn from 7 rounds of HCES with somewhat different methodologies, some of the observed change over time could be due to changes in the survey system.

Changes in the available data over time placed limitations on our analyses. Official poverty lines only exist for the period 1991 to 2010 and therefore we had to calculate our own conversion from nominal to real expenditure. In addition, the number and types of agricultural products varied over time in both the H[I]ES and agricultural statistics, resulting in fewer variables available for inclusion in the pooled models. Even for variables consistently collected over time, round-to-round changes in the way questions were asked may have resulted in systematic error in the estimates. We sought to reduce such errors by examining trends in all variables over time and simplifying the production variables from H[I]ES. Another data limitation is the lack of regional production variables for animal-sourced foods.

Dietary pattern analyses usually focus on the path from diets to health, however, we expanded their scope by examining drivers of change in adherence to dietary patterns over time. We have sought to understand relations between the agricultural and economic system and dietary change and, through this, the implications of policy on dietary change. Bangladesh first codified a holistic plan for food and nutrition policy in 1997 (66, 67), followed by *The National Food Policy* in 2006 (68), *the Country Investment Plan: A Roadmap Towards Investment in Agriculture, Food Security and Nutrition* in 2011 (69), and the recently released *Second Country Investment Plan: Nutrition Sensitive Food Systems (2016–2020)* (70). A consistent theme throughout these plans was the need to diversify agricultural production beyond rice, and this goal has been achieved in part with real increases in per capita production of vegetables and fruits and decreases in per capita production of nonfood crops and sugarcane. However, these increases have only kept pace with the increased total per capita production of starches, due to both continued gains in the productivity of rice and the increase in production of potato, a nonrice starchy crop. Investments in agricultural research for rice continue to outstrip that for other foods (3). These findings highlight the need for both continued poverty reduction as well as realigning agricultural production patterns to support healthy diets. With this analysis, we lay the groundwork for further work on health and nutrition impacts of changing diets, including on how changing dietary patterns relate to changing nutritional status in Bangladesh.

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The authors' contributions were as follows—JLW, SSS, and SG: drafted the study plan. MA contributed to data acquisition and processing. JLW undertook the quantitative analysis design and execution, including data management. JLW created all tables and figures and wrote the manuscript with support from SSS and SG. SHT provided inputs on policy aspects and AES on nutrition aspects. All authors critically reviewed and approved the final manuscript.

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