The nutrition transition and adolescents’ diets in low- and middle-income countries: a cross-cohort comparison

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Abstract

Objective: To investigate changes in dietary diversity and dietary composition among adolescents in four developing countries.

Design: We analysed dietary diversity and consumption of seven food groups and foods with added sugars as reported by adolescents from two cohorts growing up 8 years apart, when they were aged about 12 years.

Setting: Ethiopia, India (Andhra Pradesh), Peru and Vietnam in 2006 and 2013.

Subjects: Adolescents (n 3659) from the older cohort (OC) born in 1995/96 and adolescents (n 7422) from the younger cohort (YC) born in 2001/02 (N 11 081).

Results: Controlling for other factors, dietary diversity increased in Peru (OC = 4·89, YC = 5·34, P < 0·001) and Ethiopia (OC = 3·52, YC = 3·94, P = 0·001). Dietary diversity was stable in India (OC = 4·28, YC = 4·29, P = 0·982) and Vietnam (OC = 4·71, YC = 4·73, P = 0·814); however, changes in dietary composition were observed. YC adolescents were more likely to consume eggs (India: +32%, P = 0·038; Vietnam: +50%, P < 0·001) and milk and dairy (India: +12%, P = 0·029; Vietnam: +46%, P < 0·001). Other notable shifts included meat consumption in Peru (+72%, P < 0·001) and consumption of fruit and vegetables in Ethiopia (+36%, P < 0·001). Compared with OC, the prevalence of added sugar consumption was greater among the YC in Ethiopia (+35%, P = 0·001) and Vietnam (+44%, P < 0·001). Between 2006 and 2013, disparities in dietary diversity associated with household wealth and place of residence declined, although this varied by country. No marked gender disparities in dietary diversity were evident.

Conclusions: We found significant changes over time in dietary diversity among adolescents in four countries consistent with the hypothesis of the nutrition transition.

Recent studies highlight the increasing prominence of non-communicable diseases in the global burden of disease, and poor dietary quality as a key risk factor(1). Ten per cent of total global disability-adjusted life years lost in 2013 were attributed to dietary risk factors and physical inactivity(2). The widespread shift from communicable to non-communicable diseases is now concentrated in low- and middle-income countries, and has been accompanied by a global trend towards increased consumption of energy-dense, processed foods, known as the nutrition transition(3).

Recently, a study investigated dietary quality and trends among adults both within and across countries, but evidence on evolving dietary patterns for children and adolescents is lacking, particularly for low- and middle-income countries(4–6). Considering the global increase of non-communicable diseases such as type 2 diabetes and hypertension, and of overweight and obesity during childhood and adolescence, this is a critical gap limiting effective policy design(7–9).

Adolescence constitutes a key entry point for interventions aiming to build healthy diets over the life course, as evidence shows that dietary patterns ‘track’ to adulthood(10–14). Such policies could potentially avert the onset of non-communicable diseases. Additionally, as individuals under 15 years of age constitute a quarter of the global population and almost half of the population in sub-Saharan Africa, interventions that reduce non-communicable diseases may entail substantial cost savings for global health systems(2,15).

The limited evidence on adolescents’ diets is mostly attributable to scattered data availability and quality(5). Dietary intake studies are typically confined to one country and based on small cross-sectional samples, usually from urban populations, which limits comparability within and across countries, as well as over time.
A further challenge is the comparability of dietary assessment methods across studies\(^5,16\).

The present study documents changes in dietary diversity and dietary composition among adolescents in Ethiopia, India, Peru and Vietnam between 2006 and 2013. We investigated the degree to which convergence in dietary diversity occurred across countries as well as within countries along three dimensions: gender, urban residence and household wealth. The prevalence in the consumption of foods with added sugars was also assessed.

The study is unique in that it draws from large-scale, cross-country data of the Young Lives study. Two cohorts were sampled and assessed using the same standardized approach in each country. Findings from the analysis can inform our understanding of the changes entailed by the nutrition transition and the speed at which they are taking place among adolescents in developing countries.

**Participants and methods**

**Young Lives Study**

The investigation draws on Young Lives, a longitudinal study of childhood poverty conducted in four countries: Ethiopia, India (Andhra Pradesh and Telangana), Peru and Vietnam over 15 years (www.younglives.org.uk)\(^16\). A multistage sampling approach was used to select the study participants. First, within each country, twenty ‘sentinel sites’ were selected in order to reflect the diversity of geographical, socio-economic and cultural contexts of the country, but which were not intended to be necessarily nationally representative. Second, within each sentinel site, about 100 households with a child aged between 6 and 18 months (younger cohort, YC) and about 100 households with a child aged between 7 and 8 years (older cohort, OC) were randomly selected\(^16\). Therefore, the two cohorts are comparable in terms of both sampling approach and the communities in which they live. More information on country-specific sampling procedures have been documented elsewhere\(^17\–20\).

Child, household and community survey data were collected over four rounds (2001/02, 2006–2007, 2009–2010 and 2013–2014); a fifth round is planned. Our analysis focused on Round 2 data from the OC collected between January and July 2006, and Round 4 data from the YC collected between August 2013 and March 2014, when adolescents from both cohorts were about 12 years of age. In each round, informed consent was given by the caregivers and assent obtained from the adolescents\(^16\).

Following the FAO guidelines on individual dietary diversity, a structured questionnaire probing foods eaten during the past 24 h was developed and administered by trained fieldworkers to both the OC and the YC\(^21\). This allowed us to investigate cross-cohort changes in dietary quality in two populations of 12-year-olds living in the same communities at two different points in time.

Attrition in Young Lives is extremely low, both in absolute terms and relative to similar studies conducted in low- and middle-income countries\(^22\), between Rounds 1 and 2, an estimated 1.8% of the OC children were lost to follow up (Ethiopia: 1.9%; India: 1.3%; Peru: 3.6%; Vietnam: 0.7%), while the attrition (excluding deaths) of the YC between Rounds 1 and 4 was 3.7% (Ethiopia: 2.2%; India: 2.6%; Peru: 6.3%; Vietnam: 5.6%)\(^25\–20\). As the present study compares two cohorts at a specific point in time, attrition is only a concern to the degree that it is differential across cohorts and affects their comparability in terms of the sampling. For this reason, attrition patterns were examined for both cohorts by adolescent’s gender, caregiver’s education and household wealth index at Round 1 (see online supplementary material, Supplementary Table 1). Consistent with previous research\(^22\), overall differences between the children who dropped out and the ones who remained in the study were minimal although some non-random patterns of attrition were found in the case of India and Vietnam OC (for which the number of dropped-out children was extremely low).

**Study settings**

The four study countries vary greatly in terms of socio-economic development, urbanization and stage in the nutrition transition. Of the four countries, Ethiopia had the lowest per capita income and experienced the highest rate of economic growth over the period (Table 1). The other countries also underwent significant economic development. Undernutrition and micronutrient deficiencies are widespread in all the countries, while overweight and obesity are emerging concerns, particularly in Peru and in urban areas of India, Ethiopia and Vietnam\(^27\–29\).

**Outcome measures**

Individual dietary diversity and consumption of specific food groups were the outcome measures for the analysis and were derived from the dietary diversity module of the Young Lives study. Dietary diversity was defined as the number of food groups eaten by the adolescent during the past 24 h from a predefined list of food groups\(^30\–33\).

OC and YC adolescents were asked to describe all the meals and snacks they had eaten in the previous 24 h with further probing using country-specific lists of commonly eaten foods in order to determine, for each food group, whether at least one food item had been eaten. Fieldworkers were specifically instructed to ask about the intervals between meals in order to accurately reconstruct the respondent’s dietary diversity during the previous day and limit exclusion of meals, particularly snacks. The specific food items used as examples for the food groups

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* In Peru, fifty or twenty-five OC children were selected depending on the sentinel site.
was vegetarian. These values were recoded as zero if they were missing in the case of vegetarian adolescents. Most replacements were done in India, where forty and fifty-seven vegetarian adolescents were found in the OC and YC, respectively. Three OC and twelve YC adolescents were vegetarian in Vietnam and were therefore replaced. No vegetarian adolescents were identified in Peru.

Dietary diversity scores could not be computed for adolescents who did not respond to any of the questions in the module. After these exclusions and the above-mentioned cleaning, data on dietary diversity and consumption of food groups were available for 978, 994, 683 and 990 adolescents in the OC and YC, respectively. Three OC and twelve YC adolescents were vegetarian in Ethiopia, while fifteen YC adolescents were vegetarian in Vietnam and were therefore replaced. No vegetarian adolescents were identified in Peru.

Descriptive statistics and the differences in covariates by cohort and country were assessed using t tests. Covariates included the following: adolescent’s gender and age in months; main caregiver’s age, gender and years of schooling; head of the household’s age and gender; household size and place of residence (urban/rural); and a wealth index constructed on the basis of the household’s access to services (sanitation, water, electricity, cooking fuel), quality of housing (number of rooms, quality of roofing, walls and floors) and ownership of durable assets. The wealth index ranges from 0 to 1. Similar indices have been used in other studies from low-resource settings as a proxy for socio-economic status.

Descriptive statistics and the differences in the outcome variables by cohort were estimated for each country using t tests. For each country, multivariate linear regression models on pooled cohort data were fitted by adjusting for...
Are there cross-cohort differences in dietary diversity and consumption of food groups? 

Results

How do the two cohorts compare in terms of background characteristics?

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Descriptive statistics for covariates used in the analysis and P values of differences in mean values, by country and cohort, Young Lives study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ethiopia</td>
</tr>
<tr>
<td></td>
<td>OC - 2006 (n 980)</td>
</tr>
<tr>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>sd</td>
<td>sd</td>
</tr>
<tr>
<td>P value</td>
<td>P value</td>
</tr>
<tr>
<td>Adolescent’s age (months)</td>
<td>144.64 3.81 145.49 3.89 0.000</td>
</tr>
<tr>
<td>Adolescent is male</td>
<td>0.51 0.50 0.53 0.50 0.401</td>
</tr>
<tr>
<td>Main caregiver’s age (years)</td>
<td>39.33 9.52 42.05 9.55 0.000</td>
</tr>
<tr>
<td>Main caregiver is male</td>
<td>0.04 0.19 0.25 0.43 0.000</td>
</tr>
<tr>
<td>Main caregiver’s years of education</td>
<td>213.34 3.76 237.37 3.76 0.087</td>
</tr>
<tr>
<td>Household head’s age (years)</td>
<td>46.58 11.41 46.79 10.60 0.063</td>
</tr>
<tr>
<td>Household head is male</td>
<td>0.74 0.44 0.73 0.44 0.609</td>
</tr>
<tr>
<td>Household size</td>
<td>6.50 2.05 8.22 2.63 0.000</td>
</tr>
<tr>
<td>Wealth index†</td>
<td>0.30 0.17 0.38 0.18 0.000</td>
</tr>
<tr>
<td>Urban‡</td>
<td>0.40 0.49 0.40 0.49 0.867</td>
</tr>
</tbody>
</table>

[OC, older cohort (born 1994/95); YC, younger cohort (born 2001/02).
†Wealth index is a composite asset index which ranges from 0 to 1.
‡The definition of urban/rural is based on each country’s National Statistical Office definition.
§A substantively larger proportion of the OC in Peru is urban, because only twenty-five children were recruited in some of the provincial sites towards the end of the enrolment in the first round of the study.]
While dietary diversity was stable across cohorts in India and Vietnam, some significant changes by individual food groups occurred. As compared with the OC, a larger proportion of YC adolescents consumed eggs (India: +32%, \( P = 0.038 \); Vietnam: +50%, \( P < 0.001 \)) and milk and dairy products (India: +12%, \( P = 0.029 \); Vietnam: +46%, \( P < 0.001 \)). The YC in Vietnam was less likely to consume foods cooked in oil (−68%, \( P < 0.001 \)), while in India YC consumption of pulses, legumes and nuts decreased by 57% (\( P = 0.02 \)).

During the period considered, the intake of added sugars grew substantially in Ethiopia (+35%, \( P < 0.001 \)) and Vietnam (+44%, \( P < 0.001 \)). Compared with these countries, the prevalence of consumption was higher in Peru and India and stable across the cohorts.

Are there subgroup differences in dietary shifts?
Figures 1 to 3 present predicted values of dietary diversity by gender, household wealth, place of residence and cohort. There were no marked disparities by gender (Fig. 1). In contrast, dietary diversity varied significantly by tertile of household wealth for both cohorts (Fig. 2). In 2006, Ethiopia and Vietnam exhibited the widest difference between the top and the lowest wealth tertiles in dietary diversity (inter-tertile gap, Ethiopia: 0.72, \( P < 0.001 \); Vietnam: 0.61, \( P < 0.001 \)), followed by India (inter-tertile gap: 0.31, \( P = 0.004 \)). Over the 2006–2013 period, inequalities in food consumption based on household wealth tertiles disappeared in Ethiopia and India, and decreased in the case of Vietnam (inter-tertile gap: 0.26, \( P = 0.029 \)). Finally, Fig. 3 presents disparities by place of residence. Urban/rural gaps in dietary diversity were not apparent in India and Ethiopia at either point in time. By contrast, pro-urban differences were evident in 2006 and waned over time in Peru and Vietnam. In Peru, this result was driven by an increase in dietary diversity in both urban and rural areas (\( P < 0.001 \), result not shown).

Which food groups drove within-country variation over time in dietary diversity?
We investigated whether these overall shifts occurred homogeneously across socio-economic groups within countries. Figure 4 illustrates uneven trends in the consumption of the food groups that represent the principal sources of protein (pulses, legumes and nuts; meat and fish; eggs; and milk and dairy products) by wealth tertiles for the four countries(5). In Ethiopia, predicted consumption of pulses, legumes and nuts among adolescents from less wealthy households converged over time to the prevalence exhibited by adolescents from more affluent households, which remained relatively stable. Convergence was also noted in India for the same food group, but to a lower prevalence across all wealth tertiles for the YC (OC: 0.108, \( P = 0.025 \); YC: 0.05, \( P = 0.839 \)). In Peru, the consumption of meat and fish increased homogeneously across wealth tertiles although a small gap between children belonging to the top and the lowest wealth tertiles was evident for the YC (OC: 0.114, \( P = 0.105 \); YC: 0.067, \( P = 0.011 \)). In Vietnam, the inter-tertile disparity

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**Fig. 1** Differences in dietary diversity by adolescent gender (girls; boys), country and cohort (OC, older cohort (born 1994/95); YC, younger cohort (born 2001/02)). Young Lives study. Predicted margins, with their standard errors represented by vertical bars, adjusted for adolescent’s gender and age in months, caregiver’s age, gender and educational level, head of the household’s age and gender, household size, wealth tertile, urban residence, cohort, and interactions between cohort and gender, cohort and wealth tertiles, and cohort and urban residence. *\( P < 0.1 \), **\( P < 0.05 \).
in milk consumption widened in favour of adolescents in the least poor tertile (OC: 0.15, \(P=0.016\); YC: 0.199, \(P<0.000\)).

Figure 5 presents differing patterns in the prevalence of consumption of added sugars by place of residence. In Ethiopia, consumption increased in both rural and urban areas while the urban-rural gap was maintained (OC: 0.18, \(P=0.041\); YC: 0.197, \(P<0.000\)). A striking convergence was observed in Vietnam where added sugar consumption in rural
areas was low relative to urban areas in 2006, but comparable to urban areas in 2013 (OC: 0.26, \( P = 0.003 \); YC: 0.037, \( P = 0.477 \)). In India and Peru, prevalence of sugar consumption decreased in urban areas while it increased in rural areas, resulting in narrower disparities based on location.

**Discussion**

The present study documents dramatic and rapid shifts in diets among two comparable cohorts of adolescents in Ethiopia, India, Peru and Vietnam that took place between 2006 and 2013. For example, dietary diversity among 12-year-olds increased in Ethiopia and Peru while inter-country disparities in overall dietary quality remained, reflecting different stages of economic development and nutrition transition. Our results also provide some indications that adolescents’ dietary diversity is converging across population subgroups within countries, particularly with respect to household wealth.

While the dietary diversity score provides a good indication of shifting diets across and within countries, it is important to note the limitations of such an approach. For instance, the use of gross calorific intake may not fully capture the nutritional quality of diets, and it is possible that improvements in dietary diversity may not translate into improved health outcomes. Future research should aim to develop more robust measures of dietary quality and to examine the long-term implications of these shifts in diet on health and well-being.
Table 3 Predicted margins (multi-adjusted means) and unconditional standard errors in outcome variables, and pairwise comparisons of cross-cohort differences in predicted margins, by country, Young Lives study

<table>
<thead>
<tr>
<th></th>
<th>OC</th>
<th>YC</th>
<th>P value</th>
<th>OC</th>
<th>YC</th>
<th>P value</th>
<th>OC</th>
<th>YC</th>
<th>P value</th>
<th>OC</th>
<th>YC</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary diversity, seven food groups</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1: Grains, roots &amp; tubers</td>
<td>3.52</td>
<td>0.11</td>
<td>3.94</td>
<td>0.08</td>
<td>0.001</td>
<td></td>
<td>4.28</td>
<td>0.09</td>
<td>4.29</td>
<td>0.08</td>
<td>0.982</td>
<td></td>
</tr>
<tr>
<td>Group 2: Fruits &amp; vegetables</td>
<td>0.97</td>
<td>0.01</td>
<td>0.99</td>
<td>0.00</td>
<td>0.007</td>
<td></td>
<td>0.96</td>
<td>0.01</td>
<td>0.98</td>
<td>0.01</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>Group 3: Meat &amp; fish</td>
<td>0.67</td>
<td>0.04</td>
<td>0.91</td>
<td>0.03</td>
<td>0.000</td>
<td></td>
<td>0.96</td>
<td>0.01</td>
<td>0.98</td>
<td>0.01</td>
<td>0.119</td>
<td></td>
</tr>
<tr>
<td>Group 4: Eggs</td>
<td>0.16</td>
<td>0.03</td>
<td>0.12</td>
<td>0.02</td>
<td>0.269</td>
<td></td>
<td>0.16</td>
<td>0.02</td>
<td>0.16</td>
<td>0.02</td>
<td>0.869</td>
<td></td>
</tr>
<tr>
<td>Group 5: Pulses, legumes &amp; nuts</td>
<td>0.13</td>
<td>0.01</td>
<td>0.08</td>
<td>0.01</td>
<td>0.864</td>
<td></td>
<td>0.18</td>
<td>0.02</td>
<td>0.24</td>
<td>0.02</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Group 6: Milk &amp; dairy products</td>
<td>0.02</td>
<td>0.01</td>
<td>0.72</td>
<td>0.04</td>
<td>0.148</td>
<td></td>
<td>0.41</td>
<td>0.05</td>
<td>0.23</td>
<td>0.03</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>Group 7: Foods cooked in oil</td>
<td>0.76</td>
<td>0.04</td>
<td>0.90</td>
<td>0.03</td>
<td>0.002</td>
<td></td>
<td>0.92</td>
<td>0.01</td>
<td>0.97</td>
<td>0.01</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>0.40</td>
<td>0.06</td>
<td>0.54</td>
<td>0.04</td>
<td>0.001</td>
<td></td>
<td>0.73</td>
<td>0.03</td>
<td>0.72</td>
<td>0.03</td>
<td>0.773</td>
<td></td>
</tr>
</tbody>
</table>

OC, older cohort (born 1994/95); YC, younger cohort (born 2001/02).

Estimations adjusted for adolescent's gender and age in months, caregiver's age, gender and educational level, head of the household's age and gender, household size, wealth tertiles, place of residence (urban/rural), cohort, and interactions between cohort and gender, cohort and wealth tertiles, and cohort and place of residence.

The noted changes in dietary diversity and dietary composition may reflect the consequences of global dietary transitions as well as the rise in the supply of protein from animal sources. The rise in the supply of protein from animal sources may reflect the consequences of global dietary transitions as well as the rise in the supply of protein from animal sources. The rise in the supply of protein from animal sources may reflect the consequences of global dietary transitions as well as the rise in the supply of protein from animal sources. The rise in the supply of protein from animal sources may reflect the consequences of global dietary transitions as well as the rise in the supply of protein from animal sources.
economic forces on food systems\textsuperscript{(37)}. Within-country disparities however may be exacerbated or reduced, depending on how these forces interact with the socio-economic and political context\textsuperscript{(37)}. Changes and convergence in diets can be particularly pronounced for adolescents, who may be more exposed to and influenced by food environmental factors related to the nutrition transition such as food advertising and promotion\textsuperscript{(4,37)}. The results suggest that the four countries could be placed along the continuum of the nutrition transition as follows: Ethiopia (earlier stage), India (intermediate stage), Vietnam (intermediate stage) and Peru (later stage). This assessment can inform the design of policies and strategies to avert the negative consequences of the nutrition transition\textsuperscript{(38)}.

Some limitations merit discussion. Individual dietary diversity is considered a proxy for the macro- and micronutrient adequacy of the diet for different age groups including adolescents and is associated with individual nutrient adequacy\textsuperscript{(30,32,33,53)}. Nevertheless, research in this area is still ongoing and, except for women of reproductive age and infants and young children, there are no definite guidelines on which food groups should be included in the score for different sex/age groups\textsuperscript{(21,39,40)}. In contrast to nutrient intake assessments, this measure is less burdensome to collect and simpler to analyse. However, the measure did not include quantities or nutritional quality of the reported foods, including consumption of ultra-processed foods which can have significant impacts on energy and nutrient intakes\textsuperscript{(41)}. Other shortcomings of the data were as follows. The data are based on a description of meal content over 24 h. There may have been some inaccuracy and possible recall bias in reporting all foods consumed but care was taken to reconstruct everything eaten from waking in the morning to sleeping at night in order to avoid missing snacks between meals. Alternatively, willingness to report from adolescents may be affected by psychosocial factors relevant to this age group, such as concerns related to body image\textsuperscript{(5)}.

The covariate analysis in Table 2 illustrates sociodemographic differences between the two cohorts, an issue that has been highlighted in other cross-cohort studies\textsuperscript{(42)}. The multivariate estimation of predicted margins sought to uncover trends that could not be ascribed to the differing sociodemographic profiles of the cohorts. More research on other factors that may underlie changing diets, such as changes in preferences, tastes and food environments, is needed. Finally, the data were not nationally representative. Despite this, analysis of key living standards indicators from Young Lives suggests that the type of variation found in Young Lives data is comparable with nationally representative surveys from the same countries\textsuperscript{(36)}.

Conclusions

The current study presents new evidence regarding the nutrition transition and dietary composition among adolescents in four very different low- and middle-income countries. Dietary diversity increased for most countries while indications of intra-country convergence by household wealth and place of residence were observed. However, care should be taken in drawing general conclusions given significant heterogeneity of diets both across and within countries. Regardless of this, the speed in which diets are transforming clearly signals the urgent need for global, regional and context-specific policies to avert negative and costly consequences for health-care systems and societal well-being. For children and adolescents in particular, school-based policies and interventions hold promise for promoting healthy diets over the life course.

Acknowledgements

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Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1368980016001865

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