**Anthropometric nutritional status, and social and dietary characteristics of African and Indian adolescents taking part in the TALENT (Transforming Adolescent Lives through Nutrition) qualitative study**

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**Ethics statement:** This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the following ethics committees: the Gambia Government/MRC Joint Ethics Committee, The Gambia; the research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg, South Africa; the Ethics Committee of the Institute of Health, Jimma University, Ethiopia; the National Research Ethics Review Board of Côte d’Ivoire; the Institutional Ethics Committee of the CSI Holdsworth Memorial Hospital, Mysore, India; the Intersystem Biomedical Ethics Committee, Mumbai, India; the Institutional Ethics Committee of the BKL Walawalkar Rural Medical College, Dervan, India; the Institutional Ethics Committee of the King Edward Memorial Hospital, Pune, India and the Research Ethics Committee of the University of Southampton, UK. Written informed consent was obtained from all caregivers for their own and their child’s participation; written or verbal assent was obtained from younger adolescent participants.

**Authorship:** CHDF and MEB led the study, which was co-designed with contributions from all members of the TALENT consortium. The quantitative data were analysed by MA, HC, REJ, JJ, CJ, SJ, SHK, GM and KJR. CHDF drafted the manuscript which has been reviewed by all co-authors. PH-J co-ordinated all the manuscripts and contributed to their intellectual content.

**ABSTRACT**

*Objective:* To describe the anthropometry, socio-economic circumstances, diet and screen time usage of adolescents in India and Africa, as context to a qualitative study of barriers to healthy eating and activity.

*Design*: Cross-sectional survey, including measured height and weight and derived rates of stunting, low body mass index (BMI), overweight and obesity. Parental schooling and employment status, household assets and amenities, and adolescents’ dietary diversity, intake of snack foods, mobile/smart phone ownership and TV/computer time were obtained by questionnaire.

*Settings:* Four settings each in Africa (rural villages, West Kiang, The Gambia; low-income urban communities, Abidjan, Cote D’Ivoire; low/middle-class urban communities, Jimma, Ethiopia; low-income township, Johannesburg, South Africa) and India (rural villages, Dervan; semi-rural villages, Pune; city slums, Mumbai; low-middle/middle-class urban communities, Mysore).

*Participants:* Convenience samples (N=41-112 per site) of boys and girls aged 10-12y and 15-17y recruited for a qualitative study.

*Results:* Both undernutrition (stunting and/or low BMI) and overweight/obesity were present in all settings. Rural settings had the most undernutrition, least overweight/obesity and greatest diet diversity. Urban Johannesburg (27%) and Abidjan (16%), and semi-rural Pune (16%), had the most overweight/obesity. In all settings, adolescents reported low intakes of micronutrient-rich fruits and vegetables, and substantial intakes of salted snacks, cakes/biscuits, sweets and fizzy drinks. Smart phone ownership ranged from 5% (West Kiang) to 69% (Johannesburg), higher among older adolescents.

*Conclusions:* The ‘double burden of malnutrition’ is present in all TALENT settings. Greater urban transition is associated with less undernutrition, more overweight/obesity, less diet diversity and higher intakes of unhealthy/snack foods.

**Keywords:** Adolescents, low- and middle-income countries, nutritional status, diet, household assets, mobile phones.

**INTRODUCTION**

The long-term objectives of the TALENT (Transforming Adolescent Lives Through Nutrition) consortium are to: 1) understand what adolescents in low- and middle-income countries (LMICs) are eating, what physical activity they are doing and what drives their diet and activity choices; 2) ascertain the relationship of diet and activity to their nutritional status, growth, development and health; and 3) use this information to develop interventions to optimise adolescent diets and physical activity. The current study was the first stage in this process: through the qualitative research described in the papers in this issue, we aimed to understand adolescent diet and activity behaviour, and the key people and factors that influence that behaviour.

We carried out the study in eight low- and middle-income country (LMIC) settings representing varying stages of ‘urban transition’, the trend away from ‘living off the land’ towards wage-earning in industries or through provision of services, from growing food to buying it, and from living in small remote hamlets to larger more crowded villages, towns and cities. Urbanisation is associated with many nutritional/dietary changes, including greater year-round food availability but less home-cooked and more processed food, and generally lower levels of physical activity due to activity-sparing technologies1. These changes have led to the emergence of ‘a double burden of malnutrition’ in LMICs, with persistent poverty, food insecurity and dietary deficiencies alongside emerging overweight, occurring within the same community, household or individual1,2. There are knowledge gaps about how these transitions impact upon diet and physical activity of adolescents in LMICs, which have in turn limited the development of nutrition policies targeted to this critical age group3,4.

Along with the qualitative data, we collected harmonised quantitative data that would enable us to describe some of the anthropometric, dietary and socio-economic characteristics of the adolescents. This was not intended to be representative of adolescents in general in each country, but rather to illustrate the context of the adolescents whose qualitative data we collected, describe nutritional vulnerabilities to inform the development of interventions and, by bringing together information from all the settings, illustrate the contrasts between them.

As described in the qualitative papers, each of the eight TALENT centres had a target to recruit ~80 adolescents, half in the 10-12 year age group (‘young adolescents’), and half aged 15-17 years (‘older adolescents’), and with equal numbers of boys and girls, from whom a sub-set was chosen to participate in focus group discussions. The young adolescent group represents a pre-or early-pubertal stage of development, when adolescents are still largely under parental control for most aspects of their lives, while the older group represents late or completed pubertal development and greater independence from parents in relation to diet and activity. Quantitative data were collected from this larger group, mainly to illustrate the context of their lives. The main objective of the study was to collect qualitative data, and because we were asking the adolescents to spend a considerable amount of time with us for the focus group discussions, the quantitative data collection was kept to a minimum. We therefore limited this to measurements of weight and height, and a questionnaire that would take no more than 15-20 minutes to administer.

**METHODS**

**Study settings and participants**

The communities studied included remote rural villages, urban slums or deprived townships, and urban low-middle-class and middle-class residential areas (Table 1). Most study samples were ‘convenience’ samples, accessed through schools or community health workers; in The Gambia, purposive sampling from a Demographic Surveillance System (DSS) database was used5. Samples ranged from N=41 in Jimma, Ethiopia to N=112 in Dervan India. Data were collected face-to-face by trained and experienced research staff (nutritionists, nurses or social workers) using local language(s) in each setting or French (Abidjan) or English (Mysore) if preferred by participants. All teams were experienced in anthropometry from earlier research; they received additional training for the questionnaire in this study. The questionnaire was administered to the adolescent alone (Abidjan, Jimma, Johannesburg, Dervan, Pune, Mysore) or to the adolescent together with their caregiver (West Kiang and Mumbai) by a researcher, except among older adolescents in Jimma, who self-completed it.

**Questionnaire**

A working group within TALENT, with representation from all eight centres, designed the questionnaire (Supplementary material, Appendix 1). It included questions about family/household possessions, household amenities (drinking water source and toilet facilities), maternal and head-of-household education level and occupational status, the adolescent’s mobile phone ownership and screen time, and frequencies of intake of food groups.

*Family socio-economic status, caregiver education and employment:* We chose household possessions/assets as a measure of socio-economic status. The list of possessions was based upon those in the Standard of Living Index questionnaire, used in the National Family Health Survey (NFHS-4) in India6. We removed electricity, pressure cooker and sewing machine and added water heater; the final list of 21 possessions was as follows: mattress, chair, bed, table, clock/watch, electric fan, bicycle, radio/transistor/music player, television (TV), motorised 2-wheeler (moped/scooter/motorcycle), car, water pump, animal-drawn cart, thresher, tractor, refrigerator, air conditioner, washing machine, computer/laptop, broadband internet connection, water heater. Additional socio-economic questions included caregiver education level (mother’s and head of household’s years of schooling) and employment status (in paid employment, self-employed or not employed), and the household’s drinking water source (categories from ‘piped direct to the house’ to ‘river’) and toilet facilities from ‘private flush toilet’ to ‘open fields’).

*Adolescent diet:* Diet questions were based on the Minimum Dietary Diversity Score for Women produced by the Food and Agriculture Organization and USAID’s Food and Nutrition Technical Assistance III Project (FANTA), which is designed primarily to derive a diet diversity score as an indicator of dietary macro- and micronutrient adequacy7. It has questions about 14 mutually exclusive food groups: 1) grains; 2) vegetables or roots that are orange-coloured inside; 3) white roots and tubers or plantains; 4) dark green leafy vegetables; 5) fruits that are dark yellow or orange inside; 6) any other vegetables; 7) any other fruits; 8) meat made from animal organs; 9) meat and poultry; 10) eggs; 11) fish or seafood (fresh or dried); 12) beans, peas or lentils; 13) nuts or seeds; 14) milk or milk products. As recommended in the use of this questionnaire7, teams were asked to select foods eaten in their population as examples for each food group, and to record whether adolescents had eaten foods in each group within the past 24 hours. We additionally asked how often they ate foods in each group (‘every day’, 5-6 times per week, 2-4 times per week, once a week or less than once a week including never)?

We also asked about snack and ’fast’ foods, using the same two questions: 1) fried snacks; 2) savoury snacks in packets; 3) bakery items (eg. cakes/biscuits/puffs); 4) sweets; 5) fast food/street food/restaurant food; and 6) fizzy drinks (sugar-sweetened beverages). ‘Restaurant food’ was the term thought to be most understandable to participants to capture eating meals cooked outside the home in a café/restaurant setting, sometimes as takeaway food to eat at home, which tend to be high in fat or sugar. These snack and fast foods did not contribute to the diet diversity score.

*Adolescent’s mobile phone ownership and screen time:* Thinking of future research to develop interventions (including the potential use of digital platforms) to improve adolescent diets and activity in these settings, we wanted to know how many adolescents had access to phones and computers. We asked if adolescents owned their own mobile phone, and specifically whether it was a smart phone, how much time the adolescent spent on a computer each day (for schoolwork or entertainment) and for how many hours they watched television.

*Anthropometry:* The adolescents’ weight (to the nearest 100 grammes) and height (to the nearest millimeter) were measured by standard methods, using portable digital weighing scales and stadiometers.

**Data processing**

A diet diversity score was calculated7 by allotting 1 point if the adolescent reported eating foods from the following groups in the preceding 24 hours, making a maximum possible score of 10: 1) either grains or white roots/tubers; 2) green leafy vegetables; 3) either orange coloured vegetables/roots or orange coloured fruits; 4) other vegetables; 5) other fruits; 6) either meat/poultry or fish/seafood or animal organs; 7) eggs; 8) milk/milk products; 9) beans/peas/lentils; 10) nuts/seeds. Height and weight were used to calculate the prevalence of stunting (<-2 SD height for age), low body mass index (BMI)/thinness (<-2 SD BMI for age), overweight (>1 SD and <2 SD BMI for age) and obesity (>2 SD BMI for age) using the WHO 2007 growth reference8. Each site produced group level metadata using SPSS or STATA (various versions), stratified by sex and age group, according to a common template. The sample size in each setting was small (Table 1), and so we describe gross differences between sub-groups (eg. between sexes and age groups) but did not test these statistically. We pooled data for both sexes and/or age groups in tables and figures if there was no clear evidence of sub-group differences.

**RESULTS**

**Anthropometry**

Figures 1a and 1b show the prevalence of stunting, low BMI, overweight and obesity in younger and older adolescents respectively, by site. Stunting was present in all settings, and was similar in both sexes. The prevalence was higher among older than younger adolescents, and in India compared with the four African settings. The prevalence ranged in young adolescents from 0% in Jimma to 16% in Dervan, India, and in older adolescents from 8% in Jimma to 37% in Mysore, India. In most settings, low BMI was more prominent than overweight and obesity, with the exception of Johannesburg, where 26% of young adolescents and 28% of older adolescents were overweight or obese, while 0% and 5% respectively had a low BMI. The highest prevalence of low BMI was among young adolescents in the two rural settings (West Kiang, The Gambia (18%), Dervan, India (26%)) and in the slum population of Mumbai, India (30%); the same was true for older adolescents. The prevalence of overweight or obesity was low (<5%) in the two rural settings (West Kiang and Dervan), 5-10% in Jimma (10%), Mumbai (8%) and Mysore (9%), and more than 10% in Abidjan (17%), Pune (16%) and Johannesburg (27%). There were no clear differences in the prevalence of overweight or obesity between younger and older adolescents or between the sexes.

**Maternal and head of household education and employment status, house ownership, household possessions, drinking water source and toilet facilities**

The data from younger and older adolescents was pooled for these analyses, because the data related to households rather than individuals.

*Caregiver education and employment:* The median years of schooling was highest (12 years for both mothers and heads of household) in Johannesburg and lowest (0 years) in West Kiang (Figure 2a). It was 8-10 years in Jimma, and in all the Indian settings except Dervan, and 5-7 years in Abidjan and Dervan. Employment status varied between settings (Figure 2b). In Africa, the percentages of mothers in paid employment ranged from 3% in rural West Kiang to 33% in urban Johannesburg, and among the Indian settings from 18% in rural Dervan to 43% in urban Mysore. A high proportion of mothers in West Kiang (29%), Abidjan (67%), Jimma (51%) and Pune (53%) were self-employed and a high proportion were not in paid employment in West Kiang (69%), Johannesburg (53%), Dervan (78%) and Mumbai (71%). Heads of household in paid employment ranged from 17% in West Kiang to 46% in Jimma, and among Indian settings from 23% in Pune to 74% in Dervan. Self-employed heads of household ranged from 15% in Johannesburg to ~40% in West Kiang, Abidjan and Jimma. A substantial proportion of heads of household were not in paid employment in West Kiang (43%) and Johannesburg (52%) but head of household non-employment was minimal in the other settings.

*Household assets/possessions (Supplementary Figure 1):* Television ownership was >90% in Johannesburg, Cote D’Ivoire, Pune, Mumbai and Mysore, and >70% in all other centres except the non-electrified villages of West Kiang (5%). Refrigerator ownership ranged from 0% in West Kiang and 21% in Dervan to 30-60% in most other settings, and 100% in Johannesburg. Washing machine ownership was low (<12%) in the rural settings. Ownership of an animal-drawn cart was mostly limited to rural or semi-rural settings (West Kiang and Pune). The highest ownership of a water pump was in semi-rural Pune, where the villages are electrified and irrigation water is available because of a local dam. Bicycle ownership was highest in rural settings and low in large cities. Ownership of a moped or motorcycle was low in all the African settings, but was substantial in all Indian settings except Mumbai. 57% of families in Johannesburg owned a car (the highest among all settings) while 2-wheeler ownership was negligible. Car ownership was 15-30% in other urban settings, though lower (4%) in Mumbai. It was zero in West Kiang and 8% in Dervan (both rural settings) but as high as 37% in semi-rural Pune. Computer ownership was highest in Johannesburg (44%), 20-30% in Abidjan and Jimma, less than 20% in all other settings, and zero in West Kiang. The items that showed the greatest range in ownership across settings were refrigerators, washing machines and motorised 2-wheelers.

*Household amenities (Figure 3)*: The main drinking water source was a private supply piped directly into the house in the cities (Johannesburg 100%, Jimma 95% and Mysore 88%), around 40% in the other urban settings and rural Dervan with the remainder mainly using a public tap. In West Kiang none had water piped to the house. A private flush toilet within the household was the norm in Johannesburg, and owned by most families in Mysore (Figure 3b). In Dervan, Pune and Abidjan, almost all households had their own pit toilet, while in West Kiang and Mumbai, almost all families used a shared or public pit toilet. Very small numbers of families had no toilet facilities and used open spaces for defaecation.

**Adolescents’ diet**

*Dietary diversity*

Taking all adolescents together in each setting, proportions achieving a DDS of five or more ranged from 41% in Mumbai and 44% in Jimma to 100% in West Kiang (Figure 4a, Supplementary Figure 2). Median diet diversity scores showed a similar pattern, ranging from 4 in Jimma to 9 in West Kiang. Diet diversity was not markedly different between younger and older adolescents (Figure 4b). It was lower in girls than boys in all the Indian settings, though the differences were mostly small; this was due to fewer girls than boys reporting consumption of yellow/orange vegetables/roots and yellow/orange fruits in the past 24 hours, while the opposite was true for white roots/tubers (data not shown). In Dervan, fewer girls than boys also reported eating fish, organ meat and nuts; in Pune and Mumbai fewer girls than boys reported eating beans/peas/lentils and in Mysore, fewer girls than boys reported having milk or milk products (data not shown).

*Frequency of intake of foods*

The frequency of eating eight selected food groups is shown in Supplementary Figure 3; data are missing for Johannesburg and for some foods in West Kiang, due to a misunderstanding about how these questions should be asked (missing data are labelled N/A in these figures). In all settings with data, most adolescents ate micronutrient-rich vegetables and fruits (green leafy vegetables, yellow/orange vegetables/fruits) 2-4 times per week or less, and there were substantial proportions of adolescents who ate them less than once a week, especially in India. Protein-and micronutrient-rich foods of animal origin such as eggs, meat and fish were eaten infrequently in all settings; and although intakes of milk/milk products and beans/peas/lentils were higher than eggs, fish and meat, most adolescents ate them only 2-4 times per week or less.

*Snack foods*

There were no obvious differences between boys and girls or younger and older adolescents in the consumption of snacks. Proportions of adolescents who reported eating savoury snacks in packets, bakery foods (eg cakes, biscuits, puffs) and sweets in the past 24 hours were consistently high (70-90%) in urban Johannesburg and rural Dervan (Figure 5, Supplementary Figure 4). In semi-rural Pune, 86% of adolescents reported eating savoury snacks in packets in the last 24 hours, while only 7.5% reported this in rural West Kiang. Otherwise, between 30% and 60% of adolescents reported eating these foods in the past 24 hours. Across the African sites there was a consistent pattern suggesting that intakes of savoury snacks, bakery items and sweets were higher in more urbanised or affluent settings; there was no clear pattern in India. Consumption of fizzy drinks varied widely across sites (Figure 5). Over 80% of adolescents in West Kiang, Johannesburg and Dervan reported drinking these in the past 24 hours. In contrast, fewer than 20% of adolescents in Jimma, Pune, Mumbai and Mysore did so. In West Kiang and Dervan adolescents were probably reporting locally produced drinks, made from fruit juices/cordials/syrups with added bicarbonate to make them appear fizzy, which have less added sugar than branded sugar-sweetened beverages.

**Mobile phones, smart phones and screen time**

Ownership by adolescents of a mobile phone was higher among older than younger adolescents (Figure 6). It was highest in Johannesburg and Abidjan (~60-70% among older adolescents and 30-40% among younger adolescents) and among older adolescents in Jimma (68%). It was negligible in West Kiang in both age groups, among young adolescents in Jimma, and all the Indian centres. Most adolescents who owned a mobile phone had a smart phone (except in Jimma). Median hours of TV watching for leisure/entertainment ranged from 1-4 hours in Africa and 1-2 hours in India, with large variation everywhere, and were generally higher among older adolescents (Table 2). Median time spent playing computer games was less than an hour in most places, but was as high as 2 hours among young adolescents in Abidjan and Johannesburg. A striking finding was that there was very little computer use for school work (median values 0-1 everywhere and in both age groups).

**DISCUSSION**

We collected quantitative data in order to describe the context of the qualitative data collection, illustrate the contrast between settings, and inform our thinking about the future development of interventions to improve adolescent diet and physical activity levels in these settings. Although we included a middle-class area in one Indian setting (Mysore), we targeted mainly deprived neighbourhoods.

**Anthropometry**

Undernutrition (stunting and low BMI) were more prominent than overweight or obesity in most of the settings in our study. Undernutrition was most prevalent in the least transitioned, rural settings and in slums in Mumbai, where obesity was uncommon. Johannesburg had the highest prevalence of overweight/obesity (27% overall) and yet more than 5% of adolescents were stunted. The semi-rural Pune setting has experienced substantial economic improvement over the past 20 years due to electrification, irrigation, better roads and small industries, and here there were approximately equal prevalence rates of stunting, low BMI and overweight/obesity. There is an upward shift in BMI in most LMICs, and overweight and obesity are increasing while underweight and thinness are decreasing9. Within populations the prevalence of thinness is inversely correlated with the prevalence of overweight/obesity2,9. However, inequalities in transition mean that both are often present, with persistent stunting and/or thinness in some individuals alongside emergent overweight/obesity in others, the ‘double burden of malnutrition’. South Asia and sub-Saharan Africa stand out as having a high prevalence of both undernutrition and overweight9,10. Few, if any, LMICs seem to have both escaped from hunger and avoided the emergence of overweight/obesity9,10. This has important implications for later health, because accelerated weight gain during adolescence is associated with a higher risk of type 2 diabetes, hypertension and the metabolic syndrome11,12.

Consistent with published data, stunting was more prevalent in India than Africa13. Within each of the TALENT settings, the prevalence of low BMI was similar in both age groups, while stunting was more prominent in older adolescents. This illustrates the difficulty of comparing adolescent growth in different settings. Stunting in LMICs has its onset pre-natally and in infancy14 and height Z-scores tend to be stable through childhood15. Thus higher stunting rates at 15-17 years do not necessarily reflect the appearance of new cases of stunting but could be an artefact resulting from a different *tempo* of growth during adolescence compared with the WHO reference. Because of variation in the onset and duration of pubertal growth there is limited population-based data from LMICs that documents the entire period, which can start from any age from 10 to 15 years and continue until the age of 20 years or more16-18. Information on how nutrition before and during puberty influence the pubertal growth spurt and final height, as well as other aspects of human capital such as cognitive function, is needed.

**Household-level information**

The household assets data give a snapshot of the material wealth of the adolescents’ families, and illustrate the marked contrasts in material wealth between the settings. Refrigerator ownership was one of the most varied between settings. There is little data on how refrigerator ownership influences diet. Nigerian children whose families owned a refrigerator had higher intakes of micronutrient-rich foods; the authors attributed this to greater access to perishable foods including fruit and vegetables19. On the other hand, a study in South Africa found that refrigerator ownership was associated with greater intake by adolescents of sugar-sweetened beverages and greater adiposity which, the authors suggested, reflected more disposable wealth20.

Parents’ educational attainment varied from 0 years in West Kiang to 12 years in Johannesburg, reflecting large differences between LMICs in the recent past in availability of universal education. There was also large variation in the employment status of mothers and heads of household. Other studies, mostly from high-income settings, have shown complex relationships of parental education level, occupation, income and work patterns with adolescent diet, nutritional status and physical activity. These factors have been related to adolescents’ food security, body mass index, diet quality and opportunities for choice in terms of diet and physical activity, as well as to family meal patterns, and parental control of adolescents’ food intake.21-25. In future work in TALENT settings, it will be important to develop an understanding of how the education and employment of parents influence adolescent nutrition. Few adolescents had no access to safe drinking water and or were using open spaces for urination and defaecation. Almost all had access to at least a shared pit or flush toilet, and substantial numbers had a toilet in their house. This reflects recent improvements in water and sanitation facilities in LMICs, with India having one of the best improvement records26. Arguably the worst situation was in Mumbai slums, where most adolescents use public pit toilets, which are often poorly maintained. Apart from being an infection risk, lack of privacy can be a special problem for girls coping with menstruation. It seems unlikely that, with the population densities seen in the slums of ‘megacities’ like Mumbai, universal private toilet facilities are achievable, and current efforts are directed at improving the quality of shared facilities.

**Diet**

Diet diversity was greatest in the two most rural and least transitioned settings, which also had the most undernutrition. This may be because of local agriculture and opportunities for home gardening and/or foraging, but food quantities were not assessed in our study and so, although diets were diverse they may not meet other dietary requirements. Diet diversity was lower in girls than boys in India. Given our small sample size, this should be interpreted with caution, but it is consistent with evidence that, especially in rural Indian communities, there is a tendency for boys to eat before girls, and/or to have access to a greater range of foods27. The data indicate that adolescents’ intakes of micronutrient-rich fruits and vegetables, and protein source foods, are sub-optimal in all of our study settings. This is consistent with previous data, and, since these are costly foods, it is likely to at least partly reflect affordability of these foods in all settings28,29. At the same time, adolescents, even in rural communities, were able to obtain, and were frequently eating, unhealthy snacks and drinks, often locally made and sold extremely cheaply near schools by informal roadside vendors. As reported from other LMICs, intake of these often exceeded that of nutritious foods30. Finding sustainable ways of improving diet quality among adolescents should be a research priority.

**Screen time and mobile phone ownership**

Screen time varied across settings, but adolescents in urban Abidjan and Johannesburg were spending on average of 2 or more hours a day watching television and 1 or more hours playing digital games. Displacement of physical activity by screen time was a major concern reported by caregivers in the qualitative work reported in other papers in this issue. Television ownership was almost universal among the families studied, except in The Gambia. TV time has been robustly linked to BMI in adolescents, through a combination of sedentariness, snacking, exposure to food advertisements, and reduced sleep time31,32. Ownership of computers, home access to the internet, and the use of computers for schoolwork were all markedly low. The investigators in all settings report that school equipment remains fairly basic (mainly blackboard and chalk) though school students use internet centres and smart phones for school projects. Smart phone ownership was negligible in most settings, but ~20-40% of young adolescents and >50% of older adolescents in Abidjan and Johannesburg had smart phones. We did not collect data on this, but we are aware anecdotally that smart phones owned by family members are frequently shared with adolescents. There is evidence that smart phone usage can be associated with reduced physical activity, a risk factor for obesity, and with mental health problems, possibly because of sleep impairment and/or exposure to harmful online material or bullying33-35. However, they are also potentially valuable platforms from which to provide health information and engage adolescents in interventions to improve health36,37. Smart phone ownership among adults was estimated in 2017 at 22% in India and 51% in South Africa; and ownership in LMICs increased by 10-20% between 2015 and 201738, but there are few data specifically from adolescents.

**Strengths and limitations**

The strength of our data is the harmonised approach across eight settings, providing valuable contextual information about the pool of adolescents from which the focus groups were derived and for whom we have qualitative data. Data were collected by trained staff fluent in languages used by the participants. A limitation was that, except for West Kiang, the adolescents studied were convenience samples, recruited in schools or by health workers, and not population-based. A further limitation was that, by design, the sample size in each setting was small, limiting robust sub-group comparisons. One site (Jimma, Ethiopia) did not reach the target sample for recruitment to the quantitative survey; this could reduce the generalisability of their data, but remains useful for contextualising their qualitative work. Two centres (South Arica and The Gambia) did not have data on the frequency of intake of all foods, due to a misunderstanding about how to ask the questions (they asked about the frequency of intake of foods only if the adolescent reported eating that food within the past 24 hours); the frequency data was therefore incomplete for these two sites. The other data collected in these sites was, however, useful. Finally, we could not verify the information recorded, and therefore the possibility of under- or over-reporting (eg. social desirability bias).

**Conclusions**

The quantitative data captured considerable diversity in anthropometry, socio-economic parameters, diet and mobile phone usage and screen time across the TALENT settings. The implication of our results is that there is a need to address the ‘double burden of malnutrition’ seen across the settings and that improving nutrition, particularly increasing diet diversity and reducing intakes of unhealthy snack foods and sugar-sweetened beverages may be important approaches. Next steps include working with adolescents in these communities, and other stakeholders to co-create solutions that are feasible, acceptable and scalable to improve the nutrition of young people.

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**Figure titles**

**Figure 1:** Prevalence (%) of stunting, low body mass index, overweight and obesity among a) young adolescents and b) older adolescents

**Figure 2:** Attained education level (a) and employment status (b) of mothers and heads of household

**Figure 3:** Main source of drinking water (a) and toilet facilities (b) by setting (percentages, sexes and age groups pooled)

**Figure 4:** Proportions of adolescents achieving a diet diversity score of 5 or more (a) and median diet diversity scores (b) by setting, stratified by sex and age group

**Figure 5:** Proportions of adolescents who had eaten selected snack foods in the past 24 hours, by setting (sexes and age groups pooled)

**Figure 6:** Ownership by adolescents of any mobile phone (solid bars) and a smart phone (hatched bars), stratified by age group, sexes pooled

**Figure legends**

Figure 2 legend: If a caregiver was both a mother and a head of household, she was included in both analyses (5% in West Kiang, 17% in Cote D’Ivoire, 7% in Ethiopia, 0% in Johannesburg, 10% in Dervan, 5% in Pune, 9% in Mumbai and 11% in Mysore).

**Supplementary figure titles**

**Supplementary Figure 1:** Proportions of adolescents in each setting whose households owned the following assets (sexes and age groups pooled)

**Supplementary Figure 2:** Proportions of adolescents in each setting who had eaten foods from selected food groups in the past 24 hours (sexes and age groups pooled)

**Supplementary Figure 3:** Frequencies of intake of selected food groups in each setting (sexes and age groups pooled)

**Supplementary Figure 4:** Frequencies of intake of snack foods in each setting (sexes and age groups pooled)

**Table 1: Description of study settings, selection method for the quantitative survey, data collection dates and sample size**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | **Final sample**  |
| **Setting** | **Population characteristics** | **Sample selection** | **Dates of data collection** | **Boys, 10-12y****(N)** | **Girls****10-12y****(N)** | **Boys****15-17y****(N)** | **Girls****15-17y****(N)** | **TOTAL** **(response rate (%))Ϯ****(N)** |
| **West Kiang, The Gambia**(see Janha RE *et al*. in this issue) | Poor rural subsistence farming villages, non-electrified and connected by earth roads. Some commercial farming (groundnuts). Nutrition and workload strongly influenced by season. Households comprise extended family compounds. High rates of adult illiteracy. Food is predominantly from home gardening and farming, local markets and small shop outlets. | Purposive selection from demographic surveillance system (DSS), avoiding Keneba village (site of MRC Unit) | July 2018 | 21 | 19 | 22 | 18 | 80(96%) |
| **Abidjan, Cote D’Ivoire**(see Jesson J et al. in this issue) | 3 districts of Abidjan city. Low-income families. Dwellings have solid walls and roofing but limited space and access to electricity, and poor sanitation. Food mainly purchased from roadside market stalls. | Convenience sampling through schools and community associations | June 2018 | 29 | 38 | 18 | 24 | 109(N/A) |
| **Jimma, Ethiopia**(see Abera M et al. in this issue) | Low and middle socio-economic classes in Jimma City. Small rapidly growing and industrialising city, population ~200,000. Main local industry is coffee growing. Food purchased from informal vendors, shops, markets and supermarkets. | Convenience sampling, through CHWs | June-July 2018 | 7 | 9 | 10 | 15 | 41(82%) |
| **Johannesburg, South Africa**(see Wrottesley S et al. in this issue) | Disadvantaged urban township (Soweto) in Johannesburg (population 7.9 million). Good infrastructure (roads, electricity) due to post-apartheid investment. Recent rapid emergence of shopping malls and fast-food chains. | Convenience sampling through CHWs | July 2018 | 22 | 20 | 20 | 19 | 81(100%) |
| **Dervan, Maharashtra, India**(see Banavali U et al. in this issue) | Villages in deprived rural region f Konkan. Main livelihood farming (rice) but land quality poor; many men earn by working in cities. Earth roads. Erratic electricity. Food purchased in local markets. Sample included ‘tribals’ (historically hunter-gatherers). | Convenience sampling in government schools  | June-September 2018 | 25 | 25 | 35 | 27 | 112(100%) |
| **Pune, Maharashtra, India**(see Joshi-Reddy K et al. in this issue) | Rural villages, previously a subsistence farming community, now transformed by improved roads, electrification and irrigation, enabling cash crops (eg. sugar cane) and small industries, with greatly increased local wealth.  | Convenience sample, recruited through CHWs | May-August 2018 | 20 | 20 | 20 | 21 | 81(88%) |
| **Mumbai, Maharashtra, India**(see Chopra H et al. in this issue) | City slums in India’s commercial capital. Multiple occupation groups represented (labourers through professionals). Mostly 1-room closely packed concrete dwellings, and public toilet facilities. Most have access to electricity. Food sources: abundant vendors and markets. | Convenience sample, recruited through CHWs | June-August 2018 | 20 | 20 | 20 | 20 | 80\*(98%) |
| **Mysore, Karnataka, South India**(see Joseph S et al. in this issue) | Low middle-/middle-class neighbourhoods in one of the best developed cities in India. Mainly detached houses or apartments. Several parks for public recreation and physical activity. Food sources: abundant food shops and markets. | Convenience sampling via schools and the community;  | July-November 2018 | 19 | 20 | 20 | 21 | 80(N/A) |

Footnote: \*Dietary data were collected for 67 adolescents in Mumbai; Ϯ Percentage of adolescents approached who agreed to participate; not available for Cote D’Ivoire and Mysore, where community meetings were held and participants asked to volunteer; CHW=community health worker

**Table 2: Screen Time**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Setting** | **Younger or older age group** | **Watching entertainment (TV, computer, phone)****Hours per day****Median (range)** | **Playing games****(computer, phone)****Hours per day****Median (range)** | **Doing schoolwork on a computer****Hours per day****Median (range)** |
| **West Kiang, Gambia** | Younger | **1** | (0-3) | **0** | (0-0) | **0** | (0-0) |
| Older | **1** | (0-3) | **0** | (0-0) | **0** | (0-0) |
| **Abidjan,** **Cote D’Ivoire** | Younger | **2** | (0-11) | **2** | (0-6) | **0** | (0-2) |
| Older  | **3** | (0-10) | **1** | (0-6) | **0** | (0-4) |
| **Jimma, Ethiopia** | Younger | **1** | (0-11) | **1** | (0-14) | **0** | (0-0) |
| Older | **4** | (1-6) | **0** | (0-6) | **0** | (0-6) |
| **Jo’burg,** **S Africa** | Younger | **3** | (2-5) | **2** | (0-3) | **1** | (0-3) |
| Older | **3** | (2-4) | **1** | (0-3) | **0** | (0-1) |
| **Dervan,** **India** | Younger | **1** | (0-3) | **0** | (0-2) | **1** | (0-4) |
| Older | **1** | (0-4) | **0** | (0-4) | **1** | (0-6) |
| **Pune,** **India** | Younger | **1**  | (0-4) | **0.5** | (0-3.5) | **0** | (0-0) |
| Older | **1.5** | (0-6.5) | **0.25** | (0-2) | **0** | (0-0) |
| **Mumbai,****India** | Younger | **1** | (0-4) | **0.4** | (0-2) | **0** | (0-0.05) |
| Older | **2** | (0-5) | **0.5** | (0-3) | **0** | (0-3) |
| **Mysore,** **India** | Younger | **1** | (0-6) | **0.5** | (0-3) | **0** | (0-5) |
| Older | **2** | (0-6) | **0** | (0-5) | **0** | (0-2) |