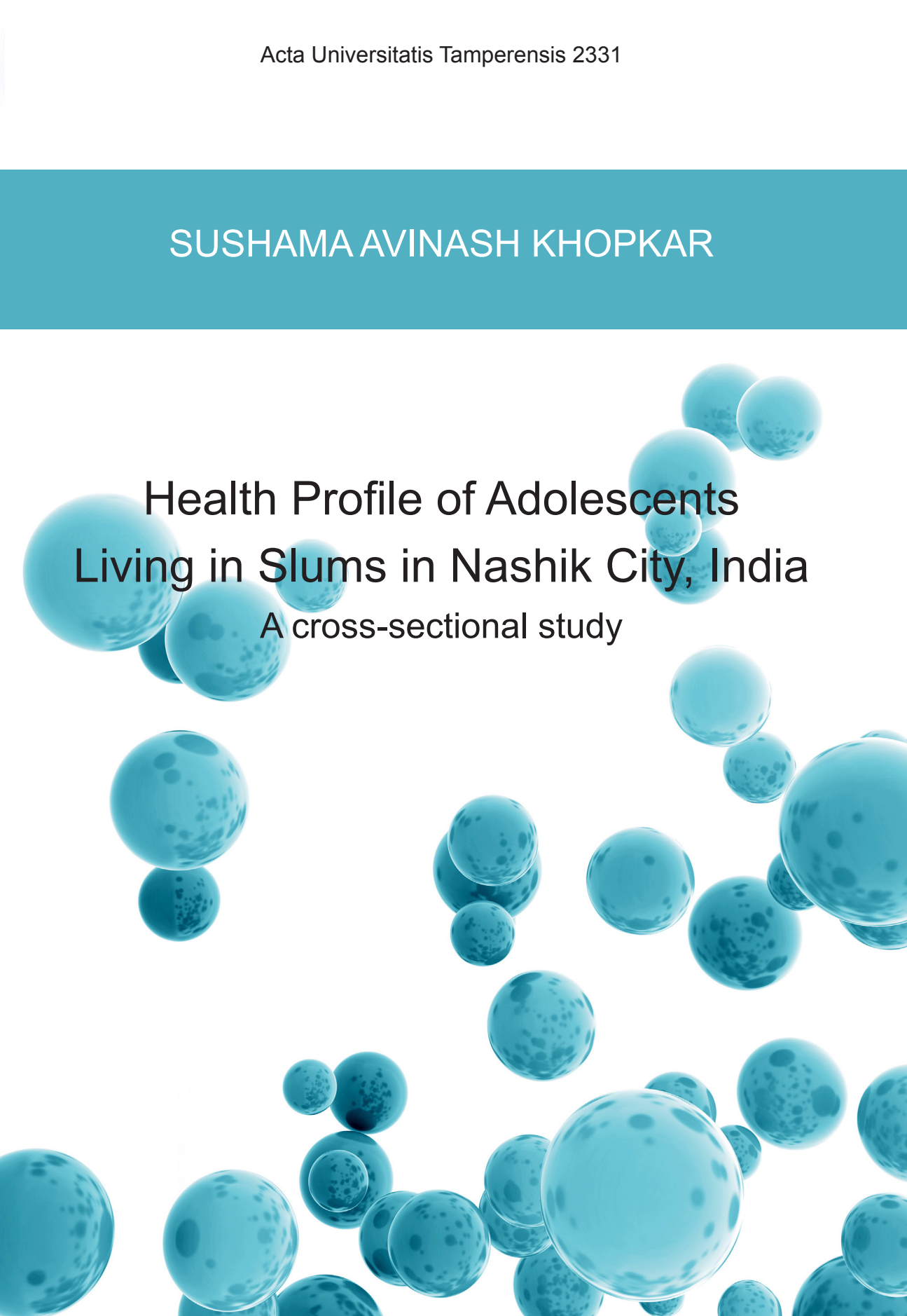# SUSHAMA AVINASH KHOPKAR

Health Profile of Adolescents
Living in Slums in Nashik City, India
A cross-sectional study

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UNIVERSITY OF TAMPERE

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Health Profile of Adolescents Living in Slums in Nashik City, India

A cross-sectional study

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Contents

Summary

Adolescents, young people of 10-19 years of age, constitute 21% of the total population in India. Adolescents of urban slums suffer from adverse living conditions such as unsafe water, poor housing, overcrowding, and limited health facilities, especially when compared to school-going urban adolescents not living in slums. These underprivileged and often understudied young people were the focus of the research here.

This was a descriptive cross-sectional study of the health and well-being of the adolescents living in two randomly selected slums of Nashik City in the state of Maharashtra in Western-central India, and was conducted during 2010-2011. The detailed data on household characteristics, parents, adolescent lifestyle and health were collected through household interviews and measurements, from 276 households and 545 adolescents. The study combined information from five topics, *viz.*, nutrition and growth, mental well-being, blood pressure and lifestyle, reproductive health, socio-demographic variables, and attempted to achieve/answer the following main research questions and aims :

1. How is the growth, as measured by the anthropometric measurements of height and weight of the study subjects and how does it compare to the general Indian and WHO standards? How do the socio-demographic factors such as parental education, income, and diet associate with these measures?

2. What is the prevalence of hypertension in the study population and what roles do stress and mental health play on blood pressure? The secondary aim was to check the association of anthropometric measurements and lifestyle factors on mental health.

3. At what age do the girls living in slums attain menarche and is this age associated with the nutritional status and different types of oils and fat in the diet?

4. What is the prevalence of reproductive tract infections, observed using the self-reported symptoms suggestive of reproductive tract infections, and how does it associate with the mental health?

The growth was assessed by stunting and nutrition status. The stunting was measured using the height-for-age score and the nutritional status using the body mass index-for-age score. The diet data considered were related to food items rich in protein, energy and fat. Mother's education, household per capita income and the size of household were the main socioeconomic variables used in the analysis. A mental well-being score was developed and

used in various analyses. The different types of fat, vegetable oil, ghee (clarified butter), meat/fish/eggs and dairy products, were segregated for the analysis. The data were summarised using descriptive statistics and graphical tools, and were analysed using logistic and multivariate linear regression models, taking into account household effects. The latter was necessary because some adolescents might be from the same household. The key study findings were the following:

1. Stunting was more prevalent than thinness in the study subjects, and more common among boys (ranges of stunting 13%-41%, thinness 0%-18%, and overweight 0%-8%) than girls (ranges of stunting 4%-31%, thinness 4%-19%, and overweight 0%-10%). Mother's higher education significantly lowered the prevalence of stunting among boys and girls and thinness in girls. In addition, having more than five household members reduced stunting, and increasing household income reduced thinness among girls. However, consumption of protein- and energy-rich food did not show any significant association.

2. The overall prevalence of prehypertension among the study subjects was 20%. Both systolic and diastolic blood pressure were significantly higher among those with worse mental status. Both types of blood pressure were significantly lower among stunted and thin adolescents while higher among overweight adolescents. The diastolic blood pressure was higher among girls and it also increased with father's education among the adolescents. It was also observed that adolescents with worse mental status were more stunted and reported having general health-related problems.

3. The average age at menarche was 13.7 years. Height was positively associated with the consumption of ghee, and the consumption of vegetable oil was negatively associated with the age at menarche. However, consumption of dairy products, meat, fish and eggs were not associated with the age at menarche.

4. The results indicated that the symptoms suggestive of reproductive tract infection were reported by almost half of the post-menarcheal girls. Having these symptoms and low height (stunted) both negatively associated with the mental well-being.

This study has brought out the important areas of health of adolescents living in challenging slum conditions. The research also calls for larger studies focusing on the role of mental status and blood pressure, knowledge, attitude and practice of sexual and reproductive health, and dietary habits so that proper interventions can be planned to bring about behavioural changes in these vulnerable people. The girls and women of India have gathered increasing

attention in recent years, however boys and men may also be in a precarious position. This study has brought out that the health and well-being of both boys and girls need to be investigated. The mother's role is crucial in children's growth and educating mother about children's needs might have long-term positive effect. However, the father's role, even though not very prominent on the surface in Indian culture, in caring for children and their well-being should not be neglected.

Tiivistelmä

Nuoruus on siirtymävaihe lapsuuden ja aikuisuuden välillä jota leimaa kasvun nopeutuminen. Nuoret ovat yhteiskunnan rakennuspalikoita ja näin ollen terve nuorisoväestö on osa valtion vaurautta. Suuri osa Itä- ja Kaakkois-Aasian nuorista kärsii kroonisesta aliravitsemuksesta ja anemiasta mikä haittaa heidän kehitystään. Ravitsemuksellisia puutostiloja, riippuvuuksia tupakkaan ja alkoholiin sekä muuta päihteidenkäyttöä, mielenterveyden häiriöitä, suojaamatonta seksuaalikäyttäytymistä ja sukuelininfektioita tavataan nuorten keskuudessa. Useamman kuin yhden tällaisen ongelman samanaikainen esiintyminen yksilöllä tekee hänet alttiiksi vakaville terveysongelmille. 10–19-vuotiaat muodostavat 21 % Intian väestöstä. Urbaanien slummien nuoret kärsivät haitallisista elinolosuhteista, epäpuhtaasta juomavedestä, heikoista asuintiloista, liikakansoituksesta ja rajallisista terveyspalveluista verrattuna koulua käyviin urbaaneihin nuoriin, jotka eivät asu slummeissa. Tutkimuksia Intian urbaanien alueiden ja maaseudun nuorten terveysongelmista on julkaistu aiemmin, mutta vähemmän tutkimustietoa on tarjolla urbaanien slummien nuorista. Näiden huono-osaisten nuorten pituuskasvuun, verenpaineeseen, mielenterveyteen ja seksuaaliterveyteen liittyviin yleisiin terveysongelmiin tarttuminen voisi olla merkittävä askel katkaistaessa sukupolvienvälistä noidankehää, johon kuuluu aliravitsemusta, kroonisia sairauksia ja köyhyyttä.

Tämä tutkimus suoritettiin poikkileikkaavana havainnointitutkimuksena kahdessa satunnaisesti valitussa slummissa Nashikin kaupungissa, intialaisessa Maharashtran osavaltiossa, marraskuun 2010 ja huhtikuun 2011 välisenä aikana. Päätavoitteena oli selvittää urbaaneissa slummeissa elävien nuorten terveydentilaa suhteessa tutkittavien ravitsemuksen tilaan, verenpaineeseen, ruokatottumuksiin, mielenterveyteen, seksuaaliterveyteen ja elintapaan. Tätä tarkoitusta varten rekrytoitiin 545 iältään 10–19-vuotiasta. Aineisto kerättiin haastattelemalla osallistujat käyttäen strukturoituja kyselyitä ja tekemällä heille antropometrisiä mittauksia ja verenpainemittauksia. Kyselyt kattoivat taustatiedot, elintapamuuttujat, fyysisen aktiivisuuden, yleisterveyden ja ruokavalion. Tämä väitös tarttuu neljään spesifiseen nuorten terveyteen liittyvään aihealueeseen: antropometriseen profiiliin, jolla tutkitaan kasvua; verenpaineprofiiliin ja mielenterveyteen; kuukautisten alkamisikään ja ruokavalioon; sekä mielenterveyteen ja sukuelininfektioiden oireisiin.

Ensimmäisen osatyön tarkoituksena oli kuvata nuorten antropometrisiä piirteitä ja ravitsemuksen tilaa ja tutkia siihen liittyviä muuttujia. Pituus suhteessa ikään ja painoindeksi (engl. body mass index) suhteessa ikään toimivat kitukasvuisuuden (engl. stunting) ja laihuuden mittareina arvioitaessa niiden yleisyyttä osallistujien keskuudessa. Samalla kitukasvuisuuden ja laihuuden yleisyyttä verrattiin WHO:n ja Intian vertailuväestöihin. Kitukasvuisuus oli laihuutta yleisempää tutkimukseen osallistuneilla ja pojat kärsivät siitä tyttöjä enemmän. Iän vaikutus kitukasvuisuuteen oli pojilla erilainen kuin tytöillä. Äidin koulutustason ja ruokakunnan koon suhdetta sekä kitukasvuisuuteen että laihuuteen tutkittiin. Äidin koulutustaso korreloi erittäin merkittävästi sekä kitukasvuisuuden että laihuuden kanssa tytöillä ja pojilla. Ruokakunnan koko ja tulot korreloivat merkittävästi tyttöjen ravitsemustilanteen kanssa. Äitien kouluttaminen nuorten ravitsemuksellisiin tarpeisiin liittyen voisi parantaa nuorten antropometristä profiilia ja tulevaa terveyttä.

Verenpaineprofiileja ja korkean verenpaineen yleisyyttä 10–18-vuotiailla tytöillä ja pojilla arvioitiin toisessa osatyössä. Kehitimme mielenterveysasteikon ja verenpaineen yhteyttä tämän asteikon lukemiin tutkittiin huomioiden tunnetut riskitekijät kuten ikä, pituus, painoindeksi ja suvussa esiintynyt korkea verenpaine. Systolisen verenpaineen kanssa merkittävästi korreloivat muuttujat olivat ikä, keskitason lukema mielenterveysasteikolla, kitukasvuisuus ja laihuus. Lisäksi diastolisen verenpaineen kannalta merkittäviä olivat sukupuoli, korkea lukema mielenterveysasteikolla ja isän koulutustaso. Siirryttäessä alhaisista mielenterveysasteikon lukemista keskitasolle, verenpainelukemat alenivat ja sama tulos havaittiin asteikon korkeilla lukemilla. Tulokset osoittivat, että nuorten riski huumausaineiden väärinkäyttöön, terveysongelmiin ja kohonneeseen verenpaineeseen oli korkeampi, mikäli heillä havaittiin merkkejä ahdistuksesta. Siksi huomiota tulisi kiinnittää nuorten mielenterveysohjauksen tärkeyteen.

Kolmannessa osatyössä arvioitiin kuukautisten alkamisiän sekä rasvoja ja eläinproteiinia sisältävien ruokien kuluttamisen ja antropometrisen statuksen yhteyttä tytöillä, joilla kuukautiset olivat alkaneet. Kuukautisten alkamisikä (keskiarvo 13.7 vuotta) tutkimuksen slummeissa oli suhteellisen korkea verrattuna Intian keskiarvoihin. Kuukautisten alkamisikä ei korreloinut maitotuotteiden, lihan, kalan tai kananmunien kuluttamisen kanssa. Ruokakunnan henkeä kohti kuluttamalla kasvirasvan määrällä oli käänteinen yhteys tytön kuukautisten alkamisikään ja tulokset viittasivat positiiviseen korrelaatioon kirkastetun voin (ghee) käytön

ja kuukautisten alkamisiän välillä. Nämä yhteydet eivät hävinneet, kun huomioitiin antropometrinen status ja sosioekonomiset piirteet. Rasvojen ja proteiinia sisältävien ruokien kulutus huono-osaisissa talouksissa Intiassa on alhaista ja heijastuu verrattain myöhäiseen kuukautisten alkamisikään.

Toisessa osatyössä kehitettyyn mielenterveysasteikkoon palattiin neljännessä osatyössä, jossa tarkasteltiin asteikon lukemien yhteyttä tyttöjen seksuaaliterveyteen. Erityisesti tarkasteltiin yhteyttä itse ilmoitettujen sukuelinten tulehdusoireiden ja mielenterveyden välillä. Lähes joka toinen tyttö, jolla kuukautiset olivat alkaneet, ilmoitti sukuelinten tulehduksiin viittaavia oireita tutkimusta edeltäneen vuoden ajalta. Heikompaan mielenterveyteen merkittävästi liittyvät muuttujat olivat kitukasvuisuus ja sukuelinten tulehduksiin viittaavat oireet. Slummioloissa tytöillä, joilla kuukautiset olivat alkaneet, mielenterveys ja jotkin somaattisen terveyden piirteet näyttävät olevan vahvasti yhteydessä toisiinsa.

List of original publications

This dissertation rests on the four original articles listed below and referred to in the text by Study I-IV. Articles can be found at the end of this thesis. In addition, some unpublished data is presented.

I.   Sushama A. Khopkar, Suvi M. Virtanen, Sangita Kulathinal (2014). Anthropometric characteristics of underprivileged adolescents: A study from urban slums of India. **Journal of Anthropology**, Article ID 197048, 9 pages; DOI: http:// dx.doi.org /10.1155/ 2014/197048.

II. Sushama A. Khopkar, Suvi M. Virtanen and Sangita Kulathinal (2015). Mental health, anthropometry and blood pressure among adolescents living in slums of Nashik, India. **Tanzania Journal of Health Research** 17(4), 9 pages;

Doi: http://dx.doi.org/10.4314/thrb.v17i4.6.

III. Sushama Khopkar, Sangita Kulathinal, Suvi Virtanen and Minna Säävälä (2015). Age at menarche and diet among adolescents in slums of Nashik, India. **Int J Adolesc Med Health**, 6 pages; DOI 10.1515/ijamh-2014-0056.

IV. Sushama Khopkar, Sangita Kulathinal, Suvi M. Virtanen & Minna Säävälä (2016). Mental wellbeing and self-reported symptoms of reproductive tract infections among postmenarcheal adolescent girls: Findings from a cross-sectional study in an Indian slum (submitted for publication in Finnish year book of population).

V.   Sushama A. Khopkar, Suvi M. Virtanen, and Sangita Kulathinal (2017).Corrigendum to Anthropometric Characteristics of Underprivileged Adolescents: A Study from Urban Slums of India ; **Journal of Anthropology**, vol. 2017, pp. 1–2.

Abbreviations

BDI   Beck's depression inventory

BMI   Body mass index

CVD   Cardio vascular disease

DBP   Diastolic blood pressure

GHQ   General health questionnaire

HIV   Human immunodeficiency virus

IIPS   International Institute for Population Sciences, in Mumbai, India

RTI   Reproductive tract infection

SBP   Systolic blood pressure

SD   Standard Deviation

UNICEF   United Nations International Children's Education Fund

WHO   World Health Organisation.

1. Introduction

Adolescents, young people of 10-19 years of age, are central to realising development that is sustainable and equitable, and they are the future of the society. Adolescents who are healthy and happy are better equipped to contribute to the society as young citizens. They will also be strong building blocks for their society when they enter into adulthood and transit to parenthood. The adolescent population is considered as a country's wealth, since many developed countries are facing severe problems brought on by an ageing population and scarcity in labour force. There were 1.6 billion persons aged 12-24 in the world in 2012 (Patton 2007).

Adolescence is the period of transition between childhood and adulthood, and it is one of the most rapid phases of human development. This phase of life brings in biological maturity, beginning with physical changes of puberty, followed by psychological maturity, learning to manage emotions and relationships. Hence, this is a period of life with specific health and developmental needs, and a time to develop knowledge and skills. Although the developmental process and the changes appear to be universal, the timing and the speed of change vary among individuals. These changes are influenced by both individual and environmental characteristics, such as sex, nutrition, habits, hygiene, behaviour, sanitation, and overall living conditions. The changes in adolescence have health consequences over the life-course, and hence, investing in adolescent education, health and the work force can shape the well-being of tomorrow's adults and the coming generations. Despite the recognised importance and need to address the health issues of adolescents, the research in the field of adolescent health is scarcely adequate. Many young people bear the burden of poor health owing to economic hardship and unfavourable living conditions such as those existing in urban slums.

India has a large population of adolescents constituting almost 243 million (Census of India 2011). About 15% of the total urban population of India lives in slums (Census of India 2011, Upinder 2013). Maharashtra has the highest slum population as a proportion of the urban population (27.3%) in India (Upinder 2013). Generally, the slum population is economically poor and also hierarchically positioned low in a caste society. Assessment of health issues of the adolescents in slums, needs special consideration, since this subpopulation constitutes a large proportion of the urban population and suffers from adverse living conditions such as unsafe water, poor housing, overcrowding and limited health facilities, especially when

compared to school-going urban adolescents not living in slums.

This thesis on the health profile of adolescents from urban slums is neither a complete epidemiological report on the disease burden among adolescents, nor a public health policy or programme guide. Instead, it addresses a range of issues of interest to picture young people's health situation in order to make it, once again, explicit that specific attention in health policy and programmes are required for adolescents. Such groups of adolescents are in need of youth-friendly health services, which will help them achieve and sustain healthy behaviour. The elements of this picture, each to be examined in a separate chapter, include anthropometric profile, mental wellbeing, blood pressure profile and reproductive health.

2. Literature review

2.1 General health of adolescents in low-income countries

The literature on adolescent health and related issues is vast, especially from developed countries. Hence, the review here is restricted to Asia and India, in particular, in most parts. The main topics for the literature search were anthropometry, blood pressure, mental well-being and issues related to the reproductive health of adolescents. A recent report, on adolescent health published by the WHO gives a comprehensive account of this research area and the research needs (WHO 2012). According to the WHO, in 2012 approximately 1.3 million adolescents died who could have been saved, if they had been treated in time. Further, 330 adolescents per day died due to road traffic injuries. Other main causes of adolescent deaths included HIV, suicide, lower respiratory infections and interpersonal violence. Of all mental health disorders in adults, 50% appear to have started by the age of 14 years, but in most cases, they remain undetected and untreated (WHO 2012).

India is recognised worldwide for the large size of its adolescent population. Major health problems observed in adolescents in the country are undernutrition, nutrient deficiencies, obesity and, anorexia nervosa, emotional problems, behavioral problems, identity problems, sexually transmitted infections, substance abuse and injuries (IIPS 2006: Results from the National Family Health Survey-3). In India, every year on an average, 26% of girls marry below the age of 15 years and 54% of girls below the age of 18 years. Of the adolescents, 4.5% are drug abusers. Of all HIV positive new infections, 50% are in the age group of 10-25 years. At least 20% of young people (10 to 24 years) in India are likely to experience some form of mental illness, such as depression, mood disturbances, substance abuse, suicidal behaviours, eating disorders and others (WHO 2012, Singh et al. 2014).

Millions of children live in urban slums in India, without access to basic services. They are vulnerable to dangers from living in crowded settlements. Their situations and needs are often represented by aggregate estimates that show urban children to be better off than their rural counterparts, obscuring the disparities that exist among the children within the cities. This has resulted in behavioural problems in children living in urban slums (Kalaiyarasan et al. 2014). The data available on physical growth, nutritional and health status demonstrate that the health scenario of a large proportion of adolescents in India is plagued by undernutrition, anaemia and

infectious diseases resulting from poor environmental sanitation and ignorance about cleanliness.

2.2 Nutrition and growth

Nutrition is an input to and foundation for health and development. Interaction between infections and malnutrition is well documented. Better nutrition means a stronger immune system, less illness and better health. Malnutrition is a major contributor to the total global disease burden, and poverty is a central cause of it (WHO 2005). Further, the socioeconomic status of a family affects the nutritional status (Harishankar et al. 2004), especially in girls (UNICEF 2009). Children of poor socioeconomic status have moderate, severe, acute or chronic malnourishment (Elankumaran 2003, IIPS 2007), and over half of the children from this group are undernourished in India (Ramachandran 2003, IIPS 2007). Some adolescents are particularly vulnerable to poor health and adverse developmental outcomes as a result of individual and environmental factors, including marginalisation, exploitation and living without parental support.

Childhood undernutrition remains a major health problem in India, especially in slums (Ghosh et al. 2004, Kapur et al. 2005, Bisai et al. 2009). A high prevalence of underweight, stunting and wasting was observed among the slum children (Bisai et al. 2009). Anthropometric measures help in assessing nutritional status and health risks among adolescents (WHO Tech. Rep. 854 1995, Thakor et al. 2000). The three most common anthropometric measures are height, weight and body mass index (BMI).

Recommended measures for assessing nutritional status in school-aged children and adolescents are height-for-age and BMI-for-age (de Onis et al. 2007). Low height-for-age is classified as stunting and low BMI-for-age as thinness and high BMI-for-age as overweight and obesity (de Onis et al. 2007). Stunting is a primary manifestation of malnutrition in early childhood and is an indicator of chronic undernutrition, while thinness indicates current malnutrition. Stunting increases the risk of morbidity, impairs cognitive development, and reduces work productivity in later life (Basu et al. 2014). The consequences of undernutrition extend not only to later life, but also to future generations (WHO Fact sheet 2005). Both childhood obesity and thinness are linked to under achievement in school and lower self-esteem (Kramer 1987). Assessment of stunting and thinness is crucial for adolescents, and a reference population is central to it.

Studies from India have used height-for-age and BMI-for-age z-scores, which are derived using WHO as well as Indian reference populations (Khadilkar et al. 2011, Rawat et al. 2014). Household characteristics such as the mother's education, poverty, and household size are closely linked to aggregate anthropometric failure in India (Arnold et al. 2005, Gaiha et al. 2014). It is known that the mother's education is generally reflected in a child's wellbeing and health. Educated mothers could be more aware of health issues, with more means to get information than uneducated mothers (Arnold et al. 2005). Dietary fat protein are important macronutrients for the growth of children (Mary et al. 2005). In many studies on anthropometric profile, dependence on dietary fat protein was examined.

2.3 Mental wellbeing

Mental wellbeing is a dynamic state in which the individual is able to develop potential, work productively and creatively, build strong and positive relationships with others and contribute to their community. It is enhanced when an individual is able to fulfil his/her personal and social goals and achieve a sense of purpose in a society (Jenkins 2008).

A set of questions used in this study, to study the mental wellbeing of adolescents, was derived using the General health questionnaire.-12 and Beck Depression Inventory (BDI) II due to the wide age range (10-19 years) of the study participants. Hence, we review the literature on GHQ-12 and BDI II .

The GHQ is a measure of current mental health and since its development by Goldberg in the 1970s it has been extensively used in different settings and different cultures (Goldberg et al. 1970, Goldberg et al. 1988, Jacob et al. 1997, Schmitz et al. 1999, Donath et al. 2001). The questionnaire was originally developed as a 60-item instrument, but at present a range of shortened versions of the questionnaire including the GHQ-30, the GHQ-28, the GHQ-20, and the GHQ-12 are available. The scale asks whether the respondent has experienced a particular symptom or behaviour recently. Each item is rated on a four-point scale (less than usual, no more than usual, rather more than usual, or much more than usual); and for example, when using the GHQ-12 it gives a total score of 36 or 12 based on the selected scoring methods. The most common scoring methods are bi-modal (0-0-1-1) and Likert scoring styles (0-1-2-3). Since the GHQ-12 is a brief, simple and easy to complete, its application in research settings as a screening tool is well documented.

The WHO study of psychological disorders in general health care in 15 different centres indicated that substantial factor variation between centres exist for the GHQ-12. Similar studies among young adolescents reported that the GHQ-12 is a particularly useful measure with adolescents where there are likely to be a number of different threats to their psychological health, such as poor self-esteem, that may not necessarily constitute a formal psychiatric condition (Tait et al. 2003). In India, the GHQ-12 has been validated against the Indian Psychiatric Survey Schedule and has been found to demonstrate excellent sensitivity and specificity, meaning that it is able to accurately identify the presence of psychological disturbance with few false negatives and false positives (Shamsunder et al. 1986). A study of life events, life strains and coping behaviours were compared in psychologically 'distressed' and 'non-distressed' college students. Of the total, 21% fell in the distressed group. Students who obtained a high score on the GHQ experienced a significantly greater number of negative life events and strains and more subjective distress compared to 'non-distressed (Zeena et al. 1990).

The Beck Depression Inventory (BDI) was created in 1961 by Aaron T. Beck, with the purpose of determining the severity and intensity level of the symptoms of depression (Farinde 2013). The Beck Depression Inventory is a widely utilised 21-item self-report scale in both clinical and research studies (Beck et al. 1996). The scale was originally developed in 1961 as an interviewer-assisted format. The Beck Depression Inventory-II is a depression rating scale that can be used in individuals that are ages 13 years and older, and it rates symptoms of depression in terms of severity on a scale from 0 to 3 based on the 21 specific items.

Gender is among the most commonly observed variables associated with mental wellbeing (Torsheim et al. 2006, Patel et al. 2007, Landstedt et al. 2009). Several studies have shown that the quality of relationships within family (mainly siblings and parents) is a major determining factor of psychological wellbeing in adolescents. The other factors contributing to fluctuations in psychological wellbeing in adolescents are stress (Siddique et al. 1984), physical health (Mechanic et al. 1987) and both popularity and intimacy in peer relationships.

Epidemiological studies of adolescent mental health in the slums are few (Fatori et al. 2013). Factors associated with mental health disorders or symptoms in slum conditions are low educational status, unemployment, and large family size (Silvanus et al. 2012) ; male gender, lower socioeconomic status, large family, being first born, having low birth weight, and a BMI

less than 18.5 (Rahi et al. 2005). Family violence and restrictions to independence were associated with mental health problems (Ram et al. 2014). Physical punishment and maternal anxiety/depression are among other important factors associated with mental health in slum conditions (Fatori et al. 2013).

2.4 Blood pressure

High blood pressure or hypertension is an important public health burden in all populations of the world. Recent 'Global Burden of Hypertension' data showed that more than a quarter of the world's adult population (nearly one billion) had hypertension in the year 2000, and this is projected to increase by about 60% (to 1.56 billion) in 2025 (Kearney et al. 2005). Hypertension is one of the leading causes of cardiovascular disease (CVD) and premature mortality and the lifetime risk of developing hypertension exceeds 50% for most populations (Murray et al. 2013). The World Health Report 2002 estimates that 7 million premature deaths were attributable to hypertension.

Hypertension is showing an increasing trend in developing countries like India. In India, the prevalence of hypertension has increased by 30 times in urban populations over 25 years, and by 10 times in rural populations over 36 years (Padmavati 2002).

 In children, blood pressure tracking patterns in the United States have confirmed that persistent blood pressure elevation may be related to hypertension in adulthood (Bao et al. 1994), and that there appears to be ethnic variations in blood pressure trajectories (Manatunga et al. 1993). The emerging evidence also suggests that primary hypertension is detectable and occurs commonly in the young (Pediatrics 2004). In addition, the presence of elevated blood pressure in childhood has been linked with left ventricular hypertrophy (Daniels et al. 1998).

Hypertension has its origin in childhood. It is very essential to detect it during this period so that hypertension complications can be prevented at an early stage (Sukumar et al. 1978, Agrawal et al. 1982, Agrawal et al. 1992). Although blood pressure normally increases with growth and development; children with higher levels of blood pressure tend to either maintain that position as they mature or progress to higher levels of blood pressure in adulthood in comparison to their peer group (Lupekar et al. 1999). In addition, the presence of elevated blood pressure in childhood has been linked with left ventricular hypertrophy (Daniels et al. 1998). Data from diverse populations show that the tracking of blood pressure from childhood

into adulthood is very strong (Voors et al. 1977, Durrani 2011). A cohort of 756 subjects (with baseline information as a cross-sectional study in 2002) was followed up in 2006 to track BP distribution in adolescents (Soudarssanane et al. 2008).

The risk factors influencing blood pressure can be categorised into non-modifiable and modifiable factors. The non-modifiable factors include ethnicity, genetic influences, age, gender, seasonal variation, and the modifiable factors include food habits, physical activity, smoking, tobacco use and alcohol intake. Some other factors that influence blood pressure are : height, weight, overweight, somatic growth and sexual maturation, sodium, type of dietary fat and other dietary intakes, sympathetic nervous system reactivity and stress.

The data on blood pressure profile in Indian school children are inadequate with few studies showing different patterns of normal blood pressure (Agrawal 1983, Sachdev 1984, Gupta et al. 1990). Taking into account the above observations and findings and the early detection of hypertension in children and adolescents seems to be the best strategy for the prevention of hypertension in adulthood.

2.5 Reproductive health

Adolescence is one of the most rapid phases of human development. Biological and psychosocial maturity takes place during this period, culminating in sexual maturity. The onset of menstruation, menarche, is a major indicator of growth and maturation for girls. The timing and speed with which the changes take place are influenced by both individual or internal and environmental or external factors. Certain health problems seen in adolescence may reflect both the biological changes of puberty and the societies and cultures in which they are growing up.

In most of India, students currently are not provided structured, comprehensive sexual health or sexuality education in secondary schools (Sengupta 2009). In 2009, in a courageous attempt to adjust educational policy in India, the Ministry of Human Resources Development proposed the Adolescence Education Program, a comprehensive sex education program that would be implemented into school curricula across the country. A parliamentary committee rejected the proposal, citing that the 'social and cultural ethos are such that sex education has absolutely no place in India' (Sengupta 2009).

Age of menarche in urban India was shown to be 12.6 years, and in rural India it was in the range of 15-16 years (Das et al. 1966, Rana et al. 1986, Singh 1992, Agrawal et al. 1992, Sen 1994, Indian Pediatrics 2006).

The variation in mean age at menarche is associated with heredity, family size, dietary habits, nutritional, birth order, general health consideration, some chronic diseases and different environmental factors like effects of climate, altitude, rural and urban residence and the socio-economic level of family (Tanner 1962).

In addition to the most important genetic determinants of age at menarche, the single environmental factor that stands out possibly explaining as much as 25% of the individual deviation in the age of puberty- is nutritional status in childhood (Karlberg 2002). The most widely studied dietary factor in relation to age at menarche is energy intake. In a review article, age at menarche in developing societies is concluded to reflect a trend in energy balance rather than in general nutritional status. The protein source of the diet in early life could also influence the timing of puberty, because high animal against vegetable protein ratio at ages 3-5 years is associated with earlier puberty even after controlling for body size. The sum effect of phyto-estrogens in the diet may be anti-estrogenic. A phyto-estrogens rich diet has been suspected to delay puberty (Khadilkar 2006).

There are several misconceptions and traditional beliefs regarding menstruation and practices during menstruation are mostly unsafe and unhygienic (Gupta et al. 1998). The physiological process of menstruation is still regarded as an unclean state, such perceptions segregate girls from the activities of normal life, such as bathing, swimming and exercise (Rierdan et al. 1995), which may make girls vulnerable to depression and stress as well as reproductive problems. About 40% - 45% adolescent girls reported menstrual problems. The reason for this might mainly be psychosocial stress and emotional changes (Chakravarty 1989). Menarche emerged as a strong predictor of depression and anxiety among adolescent girls. Even after the addition of measures of perceived social stress to a multivariate model, the association of depression and anxiety with menarche persisted (Patton et al. 1996).

The understanding of reproductive health in general and young adult reproductive health is considered to be poor in India, and most needs to solve these problems are not adequately addressed (Jejeebhoy 1998). The resistance to sex education in schools, combined with a

formative phase of adolescence and young adulthood, can leave young people unprepared for the realities of being an adult, specifically with regard to sexual behaviour. Reproductive tract infections (RTIs) are one of the important sexual and reproductive health problems among adolescents, irrespective of their sexual activity. Some RTIs are sexually transmitted, but environmental conditions, poor general health status and poor personal hygiene can also contribute to RTIs. (Whittakar 2002). The common reproductive health problems among young girls in India are menstrual problems, reproductive tract infections and gynaecological problems and they are reported as principal health concerns by adolescent slum-dwelling girls in India. (Joseph et al. 1997, Mmari 2014).

The prevalence of self-reported RTI symptoms among Indian women of age group 15-24 years has been 11–18% in nationally representative studies. The prevalence of laboratory-diagnosed RTI symptoms has ranged from 28% to 38% for Indian women in the age group of 15-24 years. According to studies that have explored women's patterns of seeking treatment for RTI symptoms, between one-third and two-thirds of symptomatic women did not seek treatment (Sabarwal et al. 2012). A positive association between age of women and RTIs was also observed, and women having no child have recorded the highest prevalence rate, around 40% both in urban and rural areas (Kanitkar et al. 2004).

The reproductive mental health situation of unmarried women and adolescents in low-income settings, such as urban informal settlements in India, remains particularly poorly understood (Astbury 2009, WHO 2009). With this motivation, we addressed rather open research questions of association between age at menarche and diet and mental wellbeing and self-reported symptoms of RTIs among post-menarcheal girls.

2.6 Justification of research

Adolescents constitute a large part of the population of India, and nearly 10% - 30% of young people suffer from adverse health impacting behaviours and conditions. According to a UN report, an estimated 1.7 million young people aged 10 to 19 years die each year in India due to accidents, violence, and problems related to pregnancy or illnesses that are either preventable or treatable. Many adolescents develop chronic illnesses that affect their quality of life. Anaemia is very prominently observed among the population in the age group of 10-19 years. Malnutrition in children and adolescents is at a high level, and it can cause lifelong health

problems, while failure to care for pregnant adolescents can damage their own health and that of their offspring.

When there is a shortage of food, it is not well understood that adolescents require extra nutrition for their growth and development. Inadequate diet and poor nutrition can delay development; in girls, it can delay puberty and can lead to the development of a small pelvis. Poorly nourished adolescent mothers are more likely to give birth to babies with a low birth-weight and the health problems pass from one generation to the next. Earlier studies have reported unprotected and unsafe sexual behaviour among adolescents, resulting in unwanted pregnancies, unsafe abortions and the steep rise in the prevalence of the HIV infection. A large number of adolescents living in slums do not attend school, work in vulnerable situations, and are likely to get exposed to tobacco and alcohol (Ashoka 2014). The challenging environment and living conditions of urban slums may have adverse effect on their mental wellbeing.

The majority of the studies involving adolescents from India have been undertaken in schools, where adolescents from socially and economically higher classes attend. The published studies have mostly focused on one or a few aspects, e.g. anthropometric measurements or hypertension or menarche or mental wellbeing or reproductive health or growth status. The literature lacks studies addressing various aspects of the health of adolescents simultaneously.

As described above, there is enough evidence indicating the unmet need for assessing health status and factors affecting it, of adolescents from the underprivileged sector of the society. A more complete picture of the anthropometric, blood pressure, mental wellbeing and reproductive health profile of adolescents from urban slums would be useful to address the major problems and plan interventions for the improvement of their general health.

3. Aims and objectives of the study

Regular assessment of growth is important for monitoring health during childhood and adolescence. Screening for adolescents to identify those who are not consistent with normal growth in a population is an essential step prior to clinical investigation (Bong et al. 2012).

The purpose of this thesis was to gain insight into some of the key areas of health of adolescents from slums in India and to understand factors affecting their health. The specific objectives of the study relate to nutrition and growth, mental wellbeing, blood pressure and lifestyle, and reproductive health. Main research questions and aims are as follows.

The specific objectives of the study relate to nutrition and growth, mental wellbeing, blood pressure and lifestyle, and reproductive health. Main research questions and aims are as follows :

1. How is the growth, as measured by the anthropometric measurements of height and weight, of the study subjects and how does it compare to the general Indian and WHO standards ? How do the socio-demographic factors such as parental education, income, and diet associate with these measures ?

2. What is the prevalence of hypertension in the study population and what roles do stress and mental health play on blood pressure ? The secondary aim was to assess the role of anthropometric measurements and lifestyle factors on mental health.

3. At what age do the girls living in slums attain menarche and is this age associated with the nutritional status and different types of oils and fat in the diet ?

4. What is the prevalence of reproductive tract infections, observed using the self-reported symptoms suggestive of reproductive tract infections, and how does it associate with the mental health ?

4. Subjects and methods

4.1 Subjects and overview of the study cohorts and design

The study area was the slums of Nashik city. Nashik is located in Western India, in the state of Maharashtra. Nashik is a fast-growing industrial city. It is the third largest city in Maharashtra after Mumbai and Pune and the 14th most populous city in India. According to the Census of India, in 2011, Nashik city had a population of nearly 1.5 million, males constituting 54% of the population and females 46%. Nashik had an average literacy rate of 74%, higher than the national average of 64%, male literacy was 80%, and female literacy was 66%. About 14% of population is under 6 years of age, and 53% between 15–59 years of age. Hinduism, Islam, Buddhism and Jainism are the major religions in Nashik with 64%, 23%, 10% and 2%, respectively of the population following them. About 13% of the city population resides in the slums (Census of India 2011) with a sex ratio (females per 1000 males) of 924 and literacy rate 71%. The Nashik non-slum population has a sex ratio of 848 and literacy rate of 91%. Though the literacy rate is high in the non-slum population, the sex ratio is very low as compared to the slum population. This is alarming in view of social development.

The sampling used in this study is explained in Figure 1. Nashik has 59 notified slums, 32 within the city limits and 27 on the outskirts of the city. Two slums (one within the city limits and one on the outskirts) were randomly selected. The two slums selected were Sundarnagar and Phulenagar.

Sundarnagar slum is on the outskirts of Nashik city. There are seven small streets in this slum. Cement roads are built up in between the households. It is situated on a small stream known as Valmiki river. There are 298 households in the slum. Nearly 2000 people live in this slum. One full street has a Muslim population. The remaining six streets have a Hindu population. All houses are of one room with an attached kitchen and washroom, but no toilet.

Phulenagar slum is one of the oldest slums within the city limits with a population of 15000. The streets of Phulenagar are densely populated and not clean. There are 20 streets, and the accompanying area is also included in it. The slum was named after Mahatma Phule, an eminent social reformer in Maharashtra, India.

Due to the lack of enumerated data on households from the selected slums, data were collected to create a sampling frame using a structured questionnaire.

Figure 1 : Selection of households from the two slums of Nashik city, Maharashtra, India

Slums of Nashik city: 32 inside and 27 outside the city

1 slum from inside and 1 from outside the city selected randomly

Sundarnagar (Outside city) (298 households)	Phulenagar (In city) (241 households)

Eligible households were those with at least 1 child of 10-19 years of age

150 households	200 households

Parental consent to participate in the study

120 households	156 households

All adolescents from these 276 households

Figure 2 : The number of adolescents selected from the households of the two slums, Nashik city, India

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                    ┌──────────────────────────────────────────────┐
                    │  Selected households from the two slums = 276 │
                    └──────────────────────────────────────────────┘
                                         │
                                         ▼
                    ┌──────────────────────────────────────────────┐
                    │  Distribution of the households by the number of │
                    │  adolescents selected                        │
                    └──────────────────────────────────────────────┘
                         │                          │
                         ▼                          ▼
  ┌───────────────────────────────────┐  ┌───────────────────────────────────┐
  │ Number of adolescents:  1  2  3  4 │  │ Number of adolescents:  1  2  3  4 │
  │ Households:            44 46 23  7 │  │ Households:            52 58 40  6 │
  └───────────────────────────────────┘  └───────────────────────────────────┘
                         │                          │
                         ▼                          ▼
  ┌───────────────────────────────────┐  ┌───────────────────────────────────┐
  │ Altogether 233 adolescents        │  │ Altogether 312 adolescents        │
  │ Boys=117, Girls = 116             │  │ Boys=152, Girls = 160             │
  └───────────────────────────────────┘  └───────────────────────────────────┘
                         │                          │
                         ▼                          ▼
              ┌──────────────────────────────────────────┐
              │          Total   545 adolescents         │
              │          Boys= 269, Girls=276            │
              │          From 276 households             │
              └──────────────────────────────────────────┘
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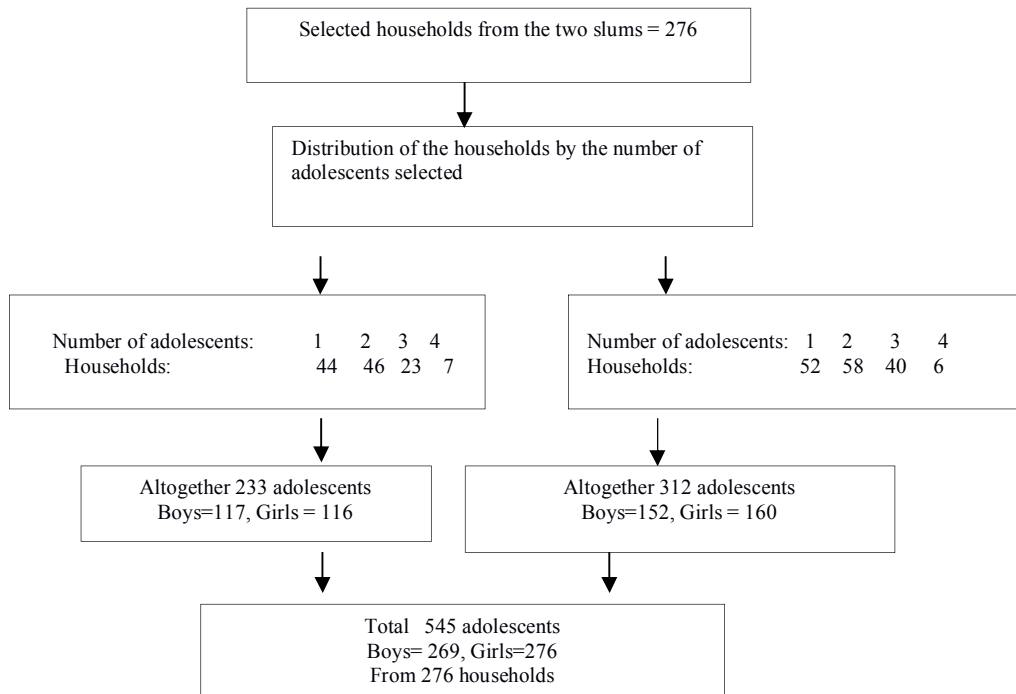
Sampling frame questionnaire: After the selection of the slums, enumeration of the population of the two slums was undertaken using a pretested structured sampling frame questionnaire.

A survey was carried out using a sampling frame questionnaire during March 2010 and April 2010, to gather demographic data *viz.,* the number of members staying in each household, number of boys and girls between the age of 10-19 years and whether the family possessed a yellow-coloured ration-card. The yellow coloured ration-card is an indicator of the household being below the poverty line declared by the government of India, and hence, specifying a low income of the household owner.

Out of the total study population, two thirds of the population was below the poverty line of the Indian Planning Commission for the State of Maharashtra 2009-10 (below per capita monthly income of Indian Rupee 961 or US$ 15). Using these sampling frame data, the households with at least one adolescent in the age range of 10 to19 years were identified. Meetings with the parents of the adolescents were conducted in these slums to explain the purpose of the survey, and to obtain the written consent letters for participation in the survey. The enumeration continued until the target sample size of 500 adolescents was achieved. Every day after 4 p.m., the investigator (Mrs. Khopkar) visited the slums and checked the collected information.

Figure 1 includes the necessary detailed information of the sample. There were 298 households in Sundarnagar slum, which is on the outskirts of the city. Sampling frame questionnaires were completed by all the 298 households. There were 150 households with at least one adolescent. Out of the 150 households, written consent letters from 120 parents for the participation of adolescent/s in the survey were received. From these 120 households of the Sundarnagar slum, 233 adolescents participated in the survey. Out of the total of 233 adolescents, 117 boys and 116 girls are included in the study.

Phulenagar slum, which was within the city limits, had 1384 households. From 241 households surveyed by the sampling frame questionnaire, 200 households had at least one adolescent. Out of the 200 households, the parents' written consent letters for participation of adolescent/s in the survey were received from 156 households. From these 156 households of Phulenagar slum, the parents of 312 adolescents gave written consent letters for their participation in the survey, of which 152 are boys and 160 are girls.

Finally, the sample size for the study was 545 adolescents from 276 households.

The adolescents, whose parents gave written consent for participating in the study and who were willing to participate, included in the study. Participation in this survey was voluntary. Adolescents were guaranteed that this survey was anonymous and confidential, and answers of individuals would not be identifiable from the results.

4.2 Ethical approval

The field study was approved by the Institutional Review Board of Tampere School of Health Sciences in 2010. Ethical guidelines in the Helsinki Declaration of 1975, as revised in 2000 were followed for the conduction of this study.

Approval from the adolescents and their parents was needed for anthropometric measurements, blood pressure measurements and answering the questionnaires, which was taken in the form of written consent in the inclusion criterion of the survey.

4.3 Methods

The specific areas related to the health of adolescents: anthropometric profile for studying growth, blood pressure profile and mental wellbeing, menarche and diet, and mental wellbeing and symptoms of reproductive tract infections were selected for the studies. Table 1 and Figure 2 give a detailed picture of the various methods and sample sizes of various studies.

Table 1: Aims, methods and sample size of the studies I to IV

Studies	I	II	III	IV
Aim	Anthropometric Profile, association with socio-demographic variables and diet	Association between blood pressure, and mental wellbeing and anthropometry	Association between age at menarche and diet pattern	Mental wellbeing stunting, BMI and self-reported symptoms of reproductive tract infections
Study population	Boys and girls aged 10-18* years	Boys and girls aged 10-17** years	Postmenarcheal girls aged 10-19 years	Postmenarcheal girls aged 10-18 ***years from Phulenagar slum
Method	Anthropometric measurements Interview administered, structured, Questionnaires	Anthropometric measurements BP measurements Interview administered, structured, Questionnaires	Questionnaires Interview administered, structured,	Anthropometric measurements Interview administered, structured, Questionnaires
Sample size	518 Boys=257, Girls=261	497 Boys=250, Girls=247	160 All girls	91 All girls

* In study I, the growth curves from India are available up to the age of 18 years.

** In study II, blood pressure percentiles were available for the age 10-17 years

***In study IV, post-menarche girls from the inner-city slum were included to control the effect of the living environment and the potentially different exposure to reproductive health experience and information.

To cover various aspects of the study including sensitive issues such as addiction, having a boy/girlfriend, sexual health, following methods were used for data collection.

· Interviews of the study subjects and their parent (in most cases mothers) using structured questionnaires translated into the local language, Marathi, performed by trained surveyors,

- All the participants were able to read and write.
- The questionnaires were filled out by the surveyors, after asking each question of the questionnaires to the adolescents.
- Two teams consisting of three trained surveyors were working on this project until all questionnaires were filled out.
- Daily at 4 p.m. investigator visited the slums to check the entered data in the questionnaire. If the information was not filled out properly, it was rectified on the same day.

- Anthropometric measurements by trained technicians,

- Blood pressure measurements by experienced and trained technicians.

4.3.1 Interview-administered questionnaires

Household questionnaire : The household information of the selected households was collected using structured questionnaires by a house-to-house survey using a pre-tested questionnaire. Preferably, the mother of the selected adolescent was interviewed to collect the information for this questionnaire. The reason for interviewing the mother for this survey was that she was usually the one who was responsible for the household matters. If the mother was not available at the time of the survey, then any other senior member of the household who could provide the required information was interviewed.

The household questionnaire included questions on family and households of the adolescents. Data were collected on the following factors:

(i) number of members in the family in which adolescent stays, (ii) native state, religion, mother tongue, caste of the family, (iii) sex, age, education, literacy, marital status, work type, and income of each household member, (iv) household characteristics like type of house, number of rooms in the house, status of hygiene in the house, health of the household members, (vi) whether the adolescent's mother and father had high blood pressure, (v) information about per capita weekly consumption of oil, dal/pulses, and meat/egg/ fish were asked from the adult respondent (in most cases the mother). The question asked was how often various items were consumed weekly in the household and the quantity of each item bought per week.

Adolescent questionnaire: Once the data on households were collected, adolescents were interviewed using a pre-tested questionnaire during November 2010 and April 2011. The interviewer filled in the prescribed questionnaire by interviewing the adolescent in the presence of his/her own mother or any other senior household member, if preferred, by the respondent. The interviewer encouraged the respondent to answer the questions on topics such as addiction, sexual health without the presence of others.

The adolescent questionnaire included structured questions on:

(i) Sex, age, ability to read and write, present educational level, whether currently employed, educational level of the parents, marital status, (ii) Substance abuse and addiction, (iii) Personal health and hygiene such as pain and discomfort, sleep and energy, worry, depression, (iv) Mental wellbeing such as mood, feelings and friendship, pessimism, past failure, worthlessness, self-dislike, loss of interest, indecisiveness, self-image, changes in sleeping pattern, tiredness or fatigue, (v) Physical activities, (vi) Sexual health and behaviour, and (vii) Future perspectives.

The girl respondents were asked about age at menarche and presence of symptoms related to RTI.

4.3.2 Anthropometric measurements, blood pressure and mental wellbeing score

Camps were conducted on consecutive days, to perform anthropometric and blood pressure measurements. The participants were invited to the camps at scheduled times with their parent or guardian for the recording of anthropometric and blood pressure measurements. There were five qualified technicians (employed as nurses in clinics. on each day for taking measurements in the camp, two for anthropometric measurements and three for taking the blood pressure measurements.

Anthropometric measurements : Height (in cm) was measured using a simple non-elastic measurement tape to the nearest integer. Weight (in kg) was recorded using a new bathroom scale (Libra brand with 770 model no.) to the nearest integer. Two readings each were taken for height and weight and the average was used for analyses here.

After taking anthropometric measurements of each adolescent in person, the qualified technicians were able to recognize an adolescent with a suspected addiction, and the technicians talked to the adolescent about his/her addiction assuring confidentiality. Questions included in the adolescent questionnaire on addiction were asked again. This was the way to conduct an in-depth interview for addiction, and data collected through the questionnaires for addiction were validated.

Blood pressure measurements took place in a quiet room and special care was taken to ensure that the subject was calm and a parent or a guardian was present during the blood pressure measurements. Subjects were advised to avoid stimulating beverages like tea or coffee and to be in the supine position for 10 minutes before the measurements of blood pressure. At a gap of 5 minutes, two measurements were taken with the subject in a supine position with both arms stretched comfortably and naturally using a new aneroid sphygmomanometer with a certified accuracy of ± 2mm Hg. The cuff size used was appropriate to the child's right arm according to recommendations by the National High Blood Pressure Education Working Group on High Blood Pressure in Children and Adolescents (2004). The average of two systolic blood pressure (SBP) and two diastolic blood pressure (DBP) measurements were used for the analysis.

Blood pressure measurements were taken by trained first aid personnel who had been actively in their job for at least 3 years.

An in-depth interview about the history of high blood pressure in one or both of the parents was conducted when the adolescent under study was accompanied by either the mother or the father. The questions included in the household questionnaire related to blood pressure were asked. The data on high blood pressure in either parent collected through the household questionnaire were validated.

Mental wellbeing was calculated by the help of twelve questions related to mental wellbeing and included the topics of being worried, feeling helpless, level of pessimism, perceiving personal failure, feeling of worthlessness, disappointment, loss of interest in other people, ability to make decisions, satisfaction with one's appearance, sleeping pattern, feeling fatigue and appetite. Thus, the questions concentrated on symptoms related to potential depression and anxiety, self-esteem, stress, and coping. Each item response was evaluated by a 4-point scoring

system ranging from a better than normal option, the same as usual and a worse than usual to a much worse than usual option. The responses were coded into two categories : 1 (better than normal option) and 0 (other options), and then all twelve answers added up to derive a total score. The total score ranged from 0 to 12; the higher the score, the better the adolescent's mental wellbeing. There is no threshold available for such binary scoring, we classified each subject, using the tertile, into one of the three categories : (i) low : score less than or equal to 7, (ii) mid score between 8 and 10 and (iii) high : score 11 or 12. Similar binary scoring has been used in other studies (Ram et al. 2014).

4.3.3 Derived variables used in the statistical analyses

Derived variables: Apart from the data collected using structured questionnaires and measurements, several variables were derived for specific analysis, and they are described below :

· **Height-for-age :** a measure of long-term nutritional status. The height of a child under study is compared with the expected height of a healthy child of the same age. The score was derived using the WHO as well as the Indian reference population (Khadilkar 2009, de Onis 2007).

· **Stunting :** a subject was classified as stunted if the height-for-age z score was below -2 SD, and not stunted otherwise.

· **BMI :** an anthropometric index of weight and height that is defined as the ratio of the body weight (in kg) to the squared height (in m). BMI is the commonly accepted index for classifying adiposity in adults and it is recommended for use in children and adolescents.

· **Thinness :** A subject was classified as thin if BMI-for-age score was below -2 SD and overweight if BMI-for-age score was above 1 SD, and normal otherwise.

· **Measures of physical health :** Stunting was defined using the Indian reference population (Khopkar et al. 2014). Prehypertension was defined using the blood pressure percentiles for given sex, age (between 10 and 17 years) and height as described in (Pediatrics 2004). For 18-year-old subjects, the standard definition of hypertension for adults was used.

· **Prehypertensive**: Blood pressure percentiles for the given sex, age (between 10 and 17 years) and height were computed using the National High Blood Pressure Education Program,

· Working Group on High Blood Pressure in Children and Adolescents 2004. If a subject had both systolic as well as diastolic blood pressure percentiles for sex, age and height below 90 then he/she was classified as normotensive. If either of the blood pressure percentiles were above 95 then he/she was classified as hypertensive, and in other cases prehypertensive. A subject with an SBP of 120 mm Hg or above, or with a DBP 80 mm Hg or above was classified as prehypertensive, even if the percentiles were below 90. For 18-year- old subjects, the standard definition of hypertension for adults was used. A subject was classified as prehypertensive with if the SBP was at least 120 mm Hg but below 140 mm Hg or the DBP was at least 80 mm Hg but below 90 mm Hg, and hypertensive if the SBP was 140 mm Hg or above, or the DBP was 90 mm Hg or above. All the others were classified as normotensive. In this thesis, prehypertensive and hypertensive are combined and are referred to as prehypertensive.

· **Family history of hypertension :** The survey questionnaire included two questions on the family history of high blood pressure. If either of the parents was known to have high blood pressure, then the family history of high blood pressure was coded as yes and otherwise coded as no.

· **Per capita income :** The level of economic wellbeing is one of the basic factors of the household that is reflected in child undernutrition. The socio-economic status is among the most evident variables reflected in health, also in mental wellbeing (Bosch 2005). The poverty that children experience is associated with inadequate food and low maternal education. (Bradley et al. 2002, Paxson et al. 2005, Deaton et al. 2009). The socio-economic gradient was determined by maternal- and paternal education and per capita household income; educated parents with better income can provide good facilities to their children. The Indian state-specific poverty line was used as a cutting point (Govt. of India, press note 2012).

The per capita income was obtained by dividing the total household income by the number of household members.

· **Parental educational level :** The questionnaire included questions: "What is your mother's educational level ?" and "What is your father's educational level ?" These were used to obtain the parents' educational levels. The mother's education level and father's education level in this study were grouped into two categories for analysis : i) primary or no education, and ii) secondary or higher education.

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India's education system is referred to as ten + two + three system. The first ten years of education are, theoretically, obligatory, and are referred to as 1st to 10th standard.

Primary and secondary education in India is segregated as Primary (1st standard to 4th standard), Upper Primary (5th standard to 7th standard), Lower Secondary (8th standard to 10th standard) and Higher Secondary (11th and 12th standard).

· **Per capita weekly consumption of a specific food items in household (in gms) :** Dietary patterns of the members of the household are derived from the household questionnaire where an adult respondent (preferably mother of the adolescent) was asked about how many times weekly the item was consumed in the household and the quantity of the item procured weekly. Then these weekly quantities were divided by the number of household members to calculate the household per capita weekly consumption of dairy and meat, fish and egg food items. Vegetable oil and ghee consumption were estimated using the same method, in grams. In short, this was derived by dividing the weekly purchase of that item by the number of family members.

· **Per capita weekly consumption of meat/egg/fish (in gms) :** This was derived by combining consumption of meat (in gms), eggs (1 egg ≈ 50 gms), and fish (in gms).

· **Per capita weekly consumption of dairy products (milk, yoghurt) (in gms) :** Animal protein food items, the quantity of yoghurt (curd) and milk was combined into dairy consumption (cheese is not part of the traditional diet in this region) in litres.

· **Per capita weekly consumption of dal/pulses (in gms) :** Dal/Pulses are a source of vegetable protein. Quantity of consumption of pulses per week in grams was considered for the study.

· **Per capita weekly consumption of vegetable oil (in gms) :** The cooking oil usually used in the area is peanut oil. Quantity of consumption of oil per week in litre was considered for the study.

· **Per capita weekly consumption of ghee (in gms) :** Ghee is clarified butter made of cow's or buffalo's milk. The quantity of consumption of ghee per week in grams was considered for the study.

· **Household size:** Number of persons living together in one house.

- **Addiction:** An individual was classified as current user of tobacco, if there was at least one positive answer to the question "Do you currently use any substances ? (smoke, chew tobacco, gutka)". Gutka is a powdery, granular substance, within moments of chewing, it mixes with saliva and may impart upon its user a "buzz" somewhat more intense than that of tobacco chewing. Similarly, the current use of alcohol was defined.

- **Symptoms of RTIs :** The girls were asked in the survey whether they had started menstruating. If the respondent was post-menarcheal, she was asked about experiencing symptoms related to reproductive tract infection during the last 12 months such as white discharge, itching in genital area, leakage of urine, increased frequency of urinating, burning sensation while urinating. If a respondent reported having experienced any symptoms of the reproductive tract infection, she was considered as having suffered or suffering from symptoms suggestive of RTIs.

- **Age at menarche :** Age at menarche as retrospectively informed by the girl herself and recorded in full years. The question asked in the adolescent questionnaire was "how old were you when menstrual period started ?"

- **Level of maturation :** The physiological, mental and social effects of menarche are partly abrupt and partly start to influence a girl's health status gradually (Apter et al. 1980). Here we divided girls into two categories according to the level of maturation: 0 = menarche within the previous 12 months or earlier and 1 = menarche more than 12 months from the survey.

- **Studying :** A question "Are you currently studying ?" was used to derive the current status of attending school or studying.

- **Able to speak to parents :** Parental support is shown to be an important determinant of mental wellbeing also in slum conditions (Fatori et al. 2013). The relationship was examined by the question 'Can you talk to your parents about things that concern you?' The answers were categorised as those who answered 'always' or 'often', and those who gave other answers.

4.4 Statistical analyses

The data were summarised using descriptive statistics such as mean, standard deviation, range, and percentiles. The data included more than one adolescent from the same households in studies I, II and III. The data on adolescents from the same household might be correlated and, hence, regression models used for the analysis included a household-specific random effect.

(McCulloch et al. 2008). Age-adjusted means were obtained using linear regression of each variable of interest (denoted by *y*) over independent variable (denoted by *x*) using the linear mixed effects model :

$$y_{ih} = b_0 + b_1 x_i + \epsilon_{ih} + u_h, i = 1,...,n_h, h = 1,...,H,$$

where b_0 and b_1 are the fixed-effects, x is the age, ϵ is the random error due to the model and u is the household-specific random effect. Both ϵ and u are assumed to be independent and normally distributed.

For the analysis of binary dependent variables such as stunting and thinness, mixed effects logistic regression models were used. The mixed effects logistic regression model specified in terms of the log odds is given as follows :

$$\log\left(\frac{p(y_{ih} = 1 / x_{ih}, b, h)}{p(y_{ih} = 0 / x_{ih}, b, h)}\right) = b_0 + b_1 x_{1i} + b_2 x_{2i} + ... + b_p x_{pi} + u_h, i = 1,..,n_h, h = 1,..,H,$$

where y is a response variable (stunting or thinness), x = (x_1, x_2, ..., x_p) is a vector of p independent variables, b = (b_0, b_1, ..., b_p) is a vector of fixed effects and u is the household-specific random effect.

Study I : Anthropometric data was restricted to the age group 10-18 years since the growth curves from India are available up to the age of 18 years. For the same reason, the blood pressure profile was also obtained for this age group.

Pearson's correlation coefficient was obtained to study the association between two variables of interest.

For the analysis of stunting and thinness, mixed effects logistic regression models applied.

Study II : One of our main hypotheses of interest was to test whether mental wellbeing was associated with SBP and DBP. These associations were studied using generalised linear mixed effects model. Two linear mixed effects models were fitted for each SBP and DBP. The first model included age, sex and mental wellbeing score. In the second model, other factors such as family history of blood pressure, which were expected to associate with blood pressure, were added. To account for the effect of age on height and BMI, stunting and thinness were used in the second model in place of height and BMI.

Study III : Age at menarche was the variable of interest in this study. The association between age at menarche and household-wise use of sources of animal protein and oil and fat was examined by using mixed effects linear regression models.

Study IV : Only post-menarcheal girls from the inner-city slum were included in this study. Limiting the sub-study to only the inner-city slum helped to control the effect of the living environment and the potentially different exposure to reproductive health experience and information. The dependent variable was symptoms of RTI, and independent variables were stunting, studying, able to speak to parents, level of maturation, parental education, hypertension, poverty status, and high or low mental wellbeing score. These variables were summarised by estimating the proportions of a high mental wellbeing score and corresponding confidence intervals for each category of the independent variables. A logistic regression analysis was carried out using the independent variables that showed differences in the proportions of a high score between their categories. The predictive probabilities for a post-menarcheal girl with a high score and given specific values of the independent variables were calculated.

All analyses were performed using the statistical computing environment *R* and the regression were implemented using the glmer function from the package lme4 of *R* (R core team, Bates, M. Maechler, B. Bolker, and S. Walker 2013).

5. Results

5.1 Household characteristics

The information gathered from the house to house survey helped to know the lifestyle, actual economic and environmental condition of people living in slums. Discussions and meetings with people of slums were conducted to explain the purpose of the survey. Before conducting this survey, some eminent social workers and doctors were invited to deliver lectures in the slums to explain the usefulness of this work, which created a supportive atmosphere at the time of the data collection. The investigator visited the slums daily for interacting with adolescents and their mothers. If they had some difficulty in answering questions in the questionnaires, the investigator discussed with them and checked the data filled in by the surveyors. It generated faith and comfort amongst adolescents, and their mothers for answering the research questions and confidence in surveyors for filling out the questionnaires.

The total number of members in the households in which the adolescents under study live was 3060, of which 433 (14%) were children, 545 (18%) adolescents (between 10 to 19 years) and 2082 (68%) adults. Nearly 85% of the families had lived in the same household in the same slum for more than 10 years. A negligible proportion of the members of the households had faced food security and scarcity problems in the past 4 weeks.

The slum population was homogeneous with regards to its native place Maharashtra, and mother tongue Marathi. The major religion was Hindu (87%), followed by Muslim (10%), Buddhism (2%), and other religions (1%).

The castes observed in the slums were Scheduled Caste (SC, 40%), Scheduled Tribes (ST; 32%), Open Caste (10%), Other Backward Class (OBC, 9%) and other caste (9%). Of the total houses under study, 74% were owned, while 26% of houses were rented by the parents of the adolescents.
 The houses had one or two rooms with a carpet area of about 10 m^2 (one room, 44%) or about 20 m^2 (two rooms, 56%). The houses had overcrowded populations with a household crowding index ranging from   2.5 to 5. The average number of Wage-earning members in these households was 1.5. On average, each household had one or two Wage- earning members.

51% of the houses were Kaccha houses (made out of mud), 45% were Pucca houses (cement houses) while the rest, 4 % , were Semi-Pucca (floor made of cement and walls of mud and bricks) houses. 97% of the houses utilised the shared toilet facility provided by the Nashik Municipal Corporation. The rest, 3%, did not have any toilet facilities. 59% of the households had one tap for drinking water, while the rest used the public tap facility provided by the municipality as a source of water for drinking. Kerosene lanterns were used as a source of light in 5% of the households, while the remaining 95% had been given a temporary or permanent source of electricity.

Table 2 : Socio-economic characteristics of the parents of the adolescents under study in the two slums

Variables under study	Outskirts slum	City slum	p-value[**]
	Sundarnagar	Phulenagar	
No. of adolescents	233	312	---
Household size (%)			0.671
- 4 or less	36	39	
-5	26	29	
-More than 5	38	32	
Below poverty line*			
(%±SE)	76±2	55±2	< 0.001
Per Capita income in INR			
(Mean ± SE)	780±178	1023±126	< 0.001
Mother's education			< 0.001
-Primary or no education (n (%))	155(68)	107(34)	
-Secondary or higher (n (%))	72(32)	205(66)	
-Missing no. of observations	6	0	
Father's education,			< 0.001
-Primary or no education (n (%))	114(52)	51(17)	
-Secondary or higher (n (%))	107(48)	242(83)	
-Missing no. of observations	12	19	
Family history of hypertension (%±SE)[***]			
Yes	4±1	14±1	< 0.001

* Below poverty line if the monthly per-capita income in the household is below INR 961 per person per month for urban Maharashtra, India (Government of India, press note).

** Using chi-square test.

*** If either of the parents was known to have high blood pressure then family history was coded as yes

Table 2 gives an idea of the overall picture of the socio-economic conditions of the parents of the adolescents under study in the two slums. The majority of the households were with a household size five or more. The median household size for outskirt slum was six, while that of the city slum was seven. The mean per capita income per month was also different in the slums. The mean per capita income per month was observed as INR 960 and INR 843 for the families of the boys and girls, respectively, which puts 60% boys and 68% girls below the

poverty line. Occupations of the parents of the adolescents' were reported. In outskirt slum, 60% mothers were at home, 13% worked as household helpers, 13% worked as labourers and 14% were in the service sector. In the city slum, 68% mothers were at home, 10% worked as household helpers, 10% worked as labourers and 12% were in the service sector.

In the outskirt slum, 45% of the fathers were labourers, 22% had small businesses, and 9% were in the service sector, while 24% were unemployed. In the city slum, 41% of the fathers were labourers, 22% had small businesses, and 11% were in the service sector, while 26% were unemployed.

5.2 Characteristics of the adolescents

· There were 269 boys and 276 girls in the sample size of 545 adolescents. The average age of the adolescents included in the study, from the outskirt slum was higher than the city slum (p value < 0.001).The average number of currently studying adolescents in the outskirt slum was lower than the city slum (p value < 0.001). In the outskirt slum, 10% of the adolescents had no education, while in the city slum it was only 2%.

· In outskirt slum, 29% of the adolescents were engaged in earning money, while in the city slum, 25% were engaged in earning money. A larger proportion of the households were below the poverty line in the outskirt slum as compared to the city slum (Table 2)

In both the slums, nearly all the adolescents collected information (recent events in politics, science and happenings around) from newspapers and television. It was noted that in the outskirt slum, 95% collect information about political activities and new scientific developments from their peer group, while in the city slum, it was 48% of the adolescents. In the city slum, there was one school, one library and a common meeting place. Combined results for the two slums indicated that of the boys, 25% were smokers and 24% and 35% chewed tobacco or gutka, respectively. There were no girl smokers in this sample. Among girls, 7% either chewed tobacco or used gutka. No boy had tried to stop smoking tobacco in the past 12 months.

In the adolescent questionnaire, questions on the presence of addiction in father, mother, siblings and friends were asked from the adolescents (Table 3).

Table 3 : Proportion of presence of addiction (%± SE) in the family members and friends reported by the 545 adolescents under study

n=545	Smoke tobacco	Chew tobacco	Chew *Gutka	Drink alcohol	Use Narcotics
Father	21.3±1(398)	69.9±3.5(135)	60.5±2(184)	35.9±2(331)	1.1±0.4(506)
Mother	0.7±.03(514)	19.2±1.8(422)	9.3±1(475)	0.35±0.2(517)	0.2±0.1(517)
Siblings**	1.8±1(509)	7.8±3.7(482)	10.6±1(474)	0.35±0.2(517)	0(519)
Friends #	2.0±1(506)	4.1±2.7(495)	4.7±0.9(496)	1.1±0.4(513)	0(519)

*Gutka is a powdery, granular substance, within moments of chewing, it mixes with saliva and may impart upon its user a "buzz" somewhat more intense than that of tobacco chewing.
** Presence of addiction in one or more siblings is considered here.

Presence of addiction in one or more friends is considered here.

Large number of missing values in the data

Table 3 shows addiction in adolescents' family members and friends. Fathers had a high prevalence of addiction in all the categories compared to the other family members. Tobacco and Gutka chewing is more prevalent in both the father and the mother. Chewing tobacco was the most common among mothers.Tobacco and gutka seemed to be major addiction problems in the slums.

Table 4: Health status reported by adolescents (N = 545)

	Outskirt slum (N = 233)	City slum (N = 312)	p-value
Described general health as (last 12 months before survey) (n (%))			0.260
- Very good	117(51)	173(56)	
- Good	104(45)	131(42)	
- Moderate	10(4)	7(2)	
- Missing values	2	1	
Suffering from a chronic illness diagnosed since the last five years (n (%))			0.963
- Yes	8(3)	12(4)	
- No	222(97)	297(96)	
- Missing values	3	3	
Serious injuries in the last 12 months before survey (n (%))			<0.001
- Yes	16(9)	6(2)	
- No	164(91)	299(98)	
- Missing values	53	7	
Malnourishment (diagnosed by a doctor) in the last 12 months before survey (n (%))			
- Yes	6(2)	13(4)	0.569
- No	222(98)	294(96)	
- Missing value	5	4	
Visited a doctor in the last 6 Months (n (%))			<0.001
- Did not visit	72(32)	107(35)	
- Visited once	83(37)	165(53)	
- Visited twice	62(27)	31(10)	
- Visited three times or more	10(4)	6(2)	
- Missing values	6	3	

Table 4 presents the general health status reported by the adolescents in the two slums.

- Of the boys 2.7% (7 out of 259) and of the girls 4.6% (12 out of 258) had malnutrition.

- Of the boys 7.9% (18 out of 226) had had serious injuries, while 1.2 % (3 out of 237 girls) of

- The girls had had serious injuries. For the remaining variables shown in the above table, no

- Sex difference was observed.

From the literature, it was found that it was better to study the presence of reproductive tract infection for the girls who had their menstrual cycle for at least 1 year, which ensures regular menstrual periods. In the outskirt slum, 72%, while in the city slum 91% of the girls had onset of menarche at least 1 year prior to the survey.

5.3 Growth of the adolescents (Study I)

The analysis of anthropometric data was restricted to the age group of 10–18 years (boys = 257, girls =261, total = 518) since the growth curves from India are available up to the age of 18 years.

- The mean height and weight increased with an increase in age in both sexes.
- The trends of height for girls and boys were similar until the age of 12 years, and the mean weight of girls showed a similar pattern until the age 14 years.
- From the age of 13 years on, boys were taller than girls.
- The present study population had lower median values (about 10 cm for height and 3 kg/m^2 for BMI) for all ages compared to the WHO reference population.
- Stunting showed an increasing trend with age among boys and a decreasing trend among girls.
- The proportion of stunted boys was lower compared to girls at ages 10 and 11 years, after which the trend was reversed.

The regression analyses for stunting (Table 4, Study I) and thinness (Table 5, Corrigendum to Study I), were carried out by adding the independent variables of household size, mother's education, income, and dietary data on consumption of oil, egg/meat/fish and dal/pulses, one by one to the model in addition to age. The results of Table 4 and 5 are also presented as bar plots in Figure 3.

Income was significantly associated with stunting among girls, with a ten-standard deviation unit increase in income, reducing the odds of stunting by 20% among girls. There was no significant association of dietary data observed in this study. For girls, age, mother's education, and income remained significant and, in addition, household size was significantly associated with stunting. When moving from a household size of four or less to more than five, the odds of stunting among girls were reduced by 70%.

Figure 3: Association between stunting and age in years, household size, mother's education and income in INR for boys and girls, and also between thinness and these factors using mixed effects logistic regression model. Regression coefficients and 90% confidence intervals are shown.
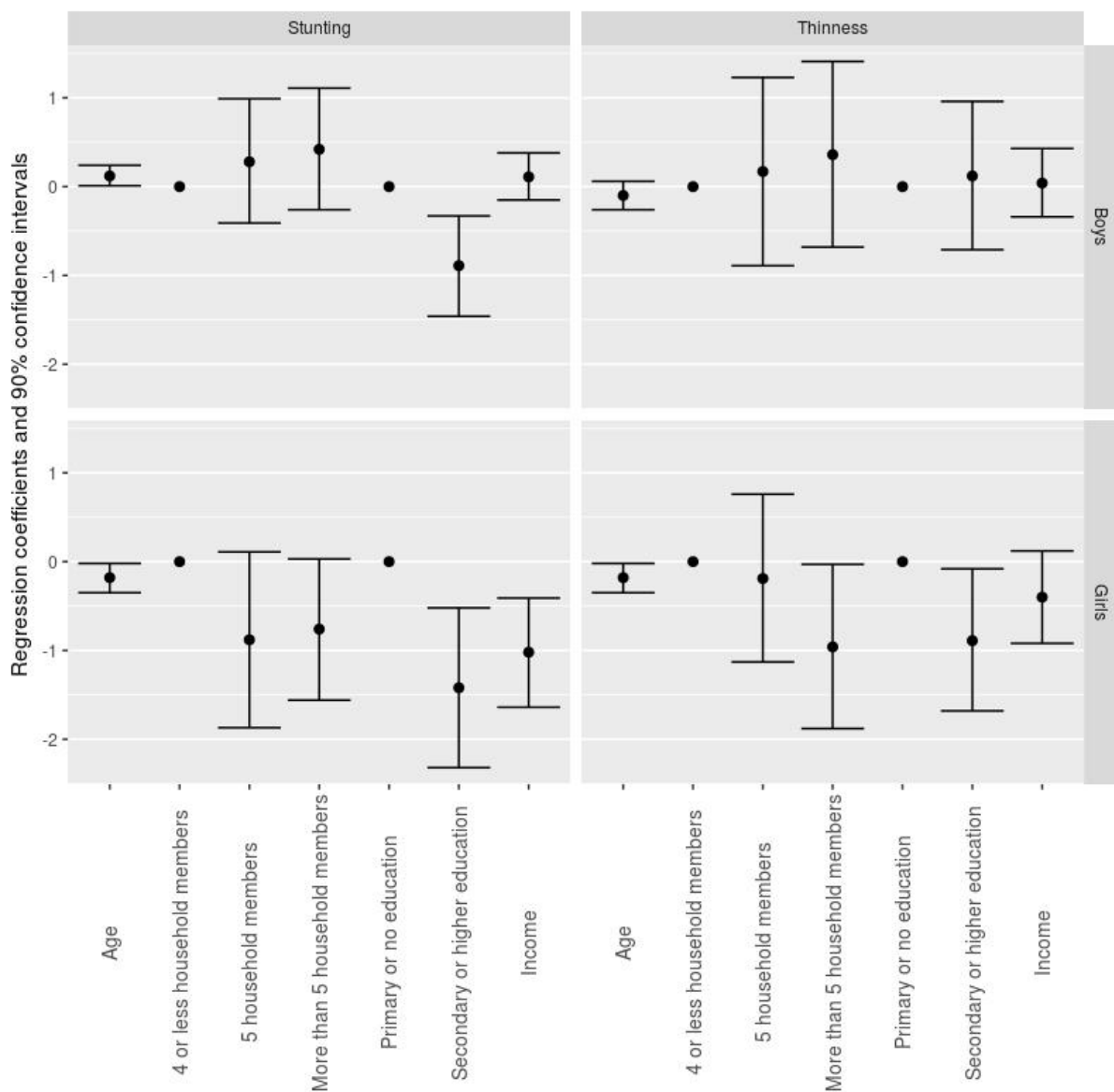
Odds of thinness versus normal BMI were analysed under the regression models with age as an independent variable and then each of the other variables was added to the model. None of the independent variables showed significant association with thinness among boys (Table 5 above and Figure 3). For girls, age, mother's education, and household size were significantly associated with thinness. When mother's education increased from primary or no education to secondary or higher education, the odds of thinness versus normal BMI were reduced by 58%. One unit (1 year) increase in a girl's age reduced the odds by 17%, while moving from a household size of 4 or less to more than 5 reduced the odds by 62%. Once again, dietary data did not show any significant effect. In the multivariate analysis including all the independent variables, age and mother's education remained significant for girls with similar effects as described above.

5.4 Mental wellbeing and blood pressure profile (Study II)

The analysis was restricted to the age group of 10–18 years (boys = 257, girls = 261, total = 518). Nutritional status of adolescents was one of the factors under study.

- The factors like the scenario of different types of pain in last 30 days, moods, presence of
- positive attitude and tendency of friendship which were taken in to consideration to evaluate
- mental wellbeing score of adolescents under study (Table 1, Study II).

The categorical variables were summarised by providing proportions, and blood pressure was summarised by sample mean and standard deviation, for the three categories of mental wellbeing score (Table 1, Study II). Girls had a higher mental wellbeing score compared to boys. The nutritional status of 91% of the adolescents was normal, and there were no differences observed in the mental wellbeing scores with regard to the nutritional status. However, the percentage of stunting was the highest (22%) among those with a low-score as compared to the other mental wellbeing score categories (10% and 12% in the mid- and high-score categories, respectively). The prevalence of current use of tobacco (20%) and alcohol (17%) were the lowest among those with a high-score. The same applies to the health-related problems, higher the score lower the prevalence of problems. Adolescents with higher mental scores tended to have a higher percentage of both parents with secondary or higher education (61% mothers and 82% fathers) compared to lower score (46% mothers and 59% fathers).

Association of blood pressure and mental wellbeing was considered in the study. Mean systolic and diastolic blood pressure values decreased as the mental wellbeing score increased and the prevalence of prehypertension was lowest among those with a high mental wellbeing score. The overall prevalence of prehypertension (which included prehypertensive and hypertensive) among the study subjects was 20%, of which 7% of all were prehypertensive or hypertensive.

For boys in the age group of 10 - 18 years, an average difference between one-year age group in SBP was 2.0 mm Hg and in DBP was 1.2 mm Hg. The same for girls were 1.8 mm Hg and 0.9 mm Hg.

When the mental wellbeing score was used as an independent variable in a regression model, it was adjusted for age and sex, with systolic blood pressure as a dependent variable. These results are also presented as bar plots in Figure 4, no significant association was observed. But when diastolic blood pressure was used there was significant decrease in the DBP with an increase in the mental wellbeing score range, and sex was also significant with girls having a higher DBP than boys.

SBP and DBP increased when moving from the normal to the overweight category, while it decreased when moving to the thin category. Stunted adolescents tended to have a lower SBP and DBP compared to other adolescents.

When moving from a low mental wellbeing score to a mid score, the SBP and DBP decreased, and the same was observed for a high score. The DBP was higher when moving from primary or no education of the father to secondary or higher education. The father's education showed a positive association with DBP of adolescents in this data.

Figure 4 : Association between systolic blood pressure (SBP) and mental wellbeing score, thinness and parents' education, family history of hypertension, age in years and sex, and also between diastolic blood pressure and these factors using mixed effects linear regression model. Regression coefficients and 90% confidence intervals are shown.
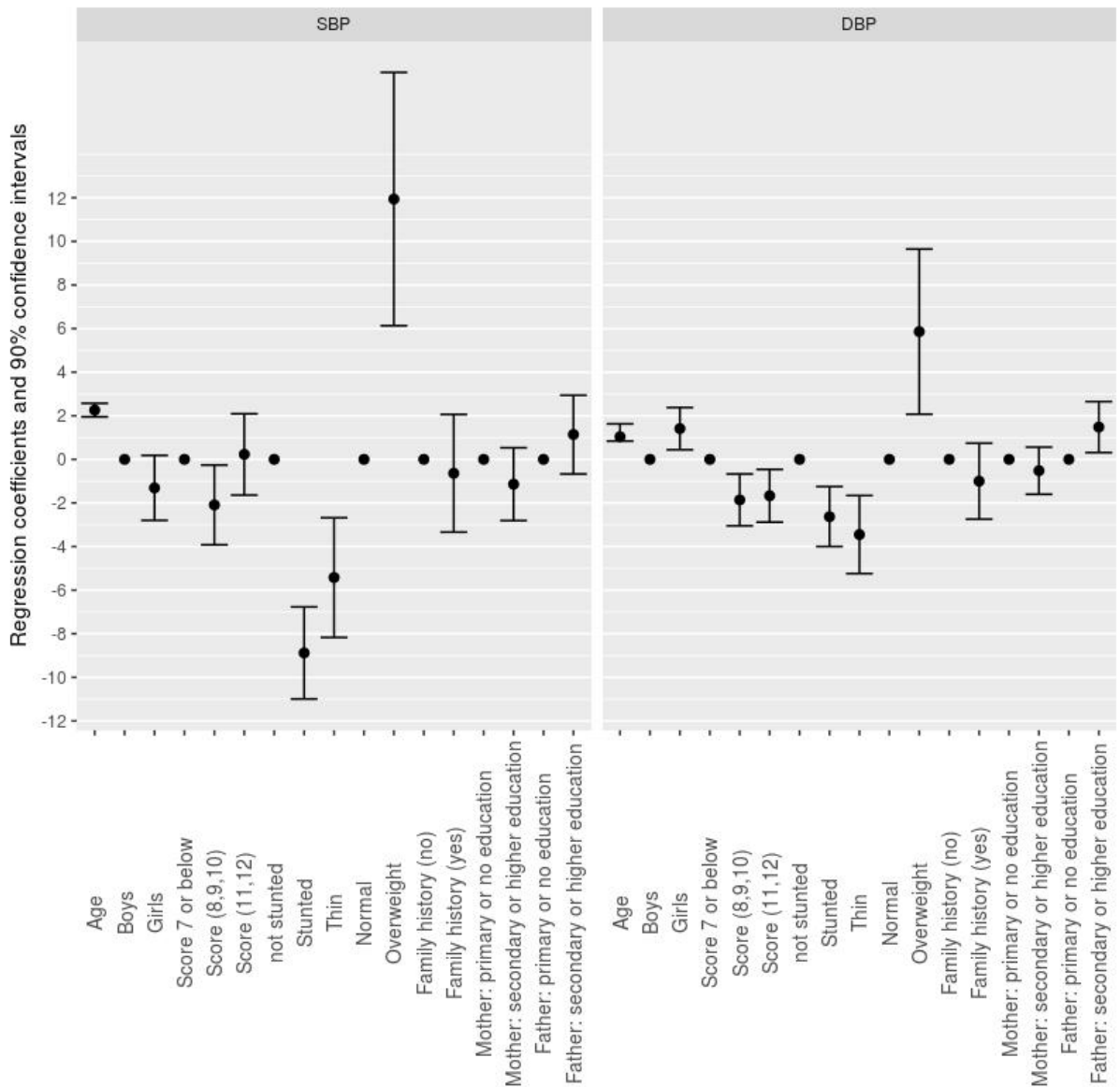
5.5 Age at menarche (Study III)

Out of the 272 girls, 160 had attained menarche at the time of the survey (Table 1, Article III). The mean age at menarche was 13.7 years (SD 0.962) and the median 14 years. Eight percent had reached menarche before they turned 13, and 4% after their 16th birthday.

The economic level among the households of the adolescent girls was low. Two thirds of the surveyed post-menarcheal girls' households were below the poverty line of the Indian Planning Commission for urban Maharashtra 2009 - 10 (Government of India, press note 2012, Dhambare 2012). Of all the mothers of the adolescent girls, nearly every other one and 29% of the fathers had no or below primary education (descriptive statistics not shown). The most common caste categories of the respondents were Scheduled Tribes and Scheduled Castes, the two lowest categories in the social hierarchy; 73% of all respondents originated from these two categories.

Only three variables examined separately produced statistically significant regression coefficients: per capita vegetable oil consumption (– 1.485), ghee consumption (5.025), and height (0.032).

In order to analyse dietary variables more closely, a linear regression analysis was carried out in three different models (Table 2, Study III).

Vegetable oil (2.160) and meat, fish and eggs (– 0.572) consumption had negative regression coefficients, but of these, only oil was significantly associated with the age at menarche. The regression coefficient of ghee was strongly positive (6.665) and also appeared highly significant (Table 2, Study III). Because dietary patterns related to the consumption of food that are important sources of protein and fat could potentially relate to the total energy intake and anthropometric status of the girl, height and BMI were added in the second model.

Height was slightly positively associated with the age at menarche (coefficient 0.034), and the BMI did not show an association with the age at menarche in the model (coefficient 0.011). The coefficients of vegetable oil and ghee remained relatively unchanged even when anthropometric characters were taken into account.

The third model examined whether adding some basic socioeconomic variables could change the association between the consumption of oil and ghee and the age at menarche. Caste

categories were analysed, using Scheduled Caste as the reference population. The coefficients of oil and ghee consumption and height did not change considerably and remained significant. Caste categories did not produce statistically significant coefficients, although the coefficient of Scheduled Tribes shows some indication of a positive relationship with the age at menarche compared with girls of Scheduled Castes. The per capita household income was also tried out in the model as a potential confounder of the association between oil and ghee consumption and the age at menarche, but the regression coefficient became very close to zero, as it also did in univariate regression.

In a linear regression model controlling for the selected dietary variables, anthropometric status and social background, the consumption of vegetable oil and ghee remain statistically significantly associated with the age at menarche. This relationship was inverse so that girls from households consuming more vegetable oil tended to have their first menses earlier. Those consuming more ghee appeared in turn to have a tendency to have their menses later. The association between these two types of fats and age at menarche did not disappear when bringing into the model anthropometric status or the socioeconomic situation of the household. However, the relationship between ghee consumption and age at menarche should be interpreted cautiously due to skewness of the distribution. Of all the households of the girls, 53% did not consume any ghee at all.

5.6 Mental wellbeing and self-reported symptoms of reproductive tract infections (Study IV)

In the present study, the analysis was restricted to girls who had attained their menarche at the time of the survey. Only post-menarcheal girls from the city slum were included. Limiting the sub-study to only the city slum helped to control the effect of the living environment and the potentially different exposure to reproductive health experience and information. The number of girls included in the multivariate analysis was 91.

The main source of information about menstruation for 88% girls was their mother. 9.4% obtained information from their close relative or neighbours or friends, and 0.6% girls did not receive any information at all. The remaining 2% girls were informed by their teachers. All the girls had a menstruation period with premenstrual syndrome (pain in abdomen, body pain, and headache). The most common menstrual problem was dysmenorrhea (51%). Most of the girls (87%) used old plain cloth as absorbent during menstruation, and 13% used commercially

available sanitary napkins. During the last one year low cost pads have been made available in India by government organisations to reduce reproductive diseases.

Nearly every other post-menarcheal girl expressed having suffered from at least one symptom suggestive of a reproductive tract infection. The proportion of girls with menarche of more than 12 months from the survey was 53%. The level of maturation gave an indication of potentially being related to a worsening mental wellbeing score. The prevalence of stunting was 8%, and it was seen in the data that these girls had a lower mental wellbeing score. As age increases, it was seen that the mental wellbeing score was worsening. For stunted girls, the mental wellbeing score was low.

One in four girls was prehypertensive; hypertension nevertheless was not associated with the mental wellbeing score. The response about being able to speak to the parents, which was used as an indicator of parental support, did not reflect on the mental wellbeing score. Of the socioeconomic variables (mother's education, father's education and whether below poverty line), only 58% of the girls living below the poverty line gave an indication of being related to lower mental wellbeing. 25 girls out of the total 49 girls living below the poverty line gave an indication of being related to a lower mental wellbeing score.

The proportions of having a high mental wellbeing score showed clear a difference between the categories of the following variables: symptoms of reproductive tract infection, level of maturation, stunting, and below the poverty line. These selected variables were included in the logistic regression model.

Using logistic regression, the two most evident variables lowering the odds for having high mental wellbeing were 'being stunted' (OR 0.14, CI 0.01-0.86) and 'reporting symptoms suggestive of reproductive tract infections' (OR 0.35, CI 0.15 – 0.79). The level of maturation and living in a household below the poverty line also seemed to lower odds for good mental wellbeing; however, the confidence intervals were quite wide (Table 2, Study IV).

Reported symptoms of reproductive tract infections reduced the predictive probability of having good mental wellbeing, both among stunted and not stunted girls (Table 3, Study IV). The predictive probability of a high mental wellbeing score was the highest for a girl who was not stunted and had no symptoms suggestive of reproductive tract infection, and was the lowest for a girl who was stunted and had symptoms of reproductive tract infection.

6. Discussion

6.1 Summary of findings

Looking at the family data of the adolescents, most of the adolescents live in overly crowded households and areas. Crowding has been linked to a number of biological mechanisms that can increase both the risk and the intensity of infection and mental or psychological health. About two thirds of the study population was below the poverty line of the state of Maharashtra (below per capita income of INR 961 or US$ 15). One out of three household members was a wage-earning member. Nearly 85% of the families had stayed in the same household of the same slum for more than 10 years. This shows that there is not enough economic progress of the people living in these households to move into a better locality or household. In this study sample, about half of the adolescents stayed in Kaccha houses that are made from mud, which is also a source for infectious diseases.

The nutritional status and possible associated factors of adolescents from an economically deprived slum population constitutes a sizeable proportion of the overall Indian urban population. With increasing urbanisation, this population is likely to grow.

The prevalence of stunting and thinness were lower using the Indian reference population compared to that of the WHO. The prevalence of stunting was higher among boys than girls after the age of 11 years and also the prevalence of thinness was higher among boys at all ages.

Stunting was more prevalent than thinness in the study subjects, and boys suffered more from it than girls. The mother's education was strongly associated with both stunting and thinness in both sexes. Household size and income were significantly associated with the nutritional status of girls.

With regard to BMI-for-age, a high proportion (90%) of the study population had a normal nutritional status. The overall prevalence of being overweight (1% boys and 2% girls) and thinness (8%) were low compared to other studies on urban children in India (Khadilkar et al. 2009, Thakor et al. 2000). In this paper, no association was observed between dietary factors under study and stunting and thinness. Unfortunately, the total diet of the participating adolescents could not be evaluated in the current study. It could be assumed that the study population was rather homogeneous with regard to the lifestyle.

To the best of our knowledge, this is the first study where the association between mental wellbeing and blood pressure of underprivileged adolescents in India has been examined. This study suggests that the known factors of age, height and BMI, but not family history, influence blood pressure among adolescents. This may be partly explained by the low proportion of family history of high blood pressure in the current study population. An analysis of normal and non-stunted adolescents revealed that adolescents with mid- and high- mental wellbeing scores had significantly lower DBP compared to those with low-scores. The mother's education was associated with decreased DBP.

The adolescents studied here formed a socio-economically and culturally relatively homogenous and starkly underprivileged population in terms of caste, parental education, income and food consumption. The majority of people received very little animal protein, and the consumption of vegetable protein was low. The staple diet in the slums consists of unleavened wheat bread and cooked rice, eaten with vegetable curry or homemade pickle or chutney and occasionally dal (thick stew prepared of split pulses). Some households also prepare unleavened bread of pearl millet (bajri).

- Age at menarche in the present study was higher than even in some other Indian studies of
- underprivileged populations (Bagga 2000, IIPS 2010). BMI was not associated

with age at menarche, while height was associated with it.

Oil consumption and age at menarche were associated in the present study, but the type of the oil made a difference to the direction of the effect. Vegetable oil was negatively related to age at menarche, while ghee, butter oil, was positively related to it. The evidenced relationship between oil and age at menarche was contrary to many studies in high-income countries that have generally failed to establish a relationship (Rogers et al. 2010).

It is hard to say whether earlier or late menarche is desired in this population since the association between gain in height and menarche remain rather unclear. It is believed that if menarche is late then there may be some extra years for growth. However, if dietary changes, such as increase in the intake of oils, are recommended then they should be implemented in early childhood so that the (genetically potential) growth in height is achieved by the time menarche is reached. In these cases, menarche may be earlier.

In the present study in post-menarcheal adolescent girls living in slum conditions, we found

evidence of an association between poor mental wellbeing and having symptoms of reproductive tract infections.

The high prevalence of RTIs could be due to the self-reported symptoms of RTIs and the questions might not have been well understood by the girls. Moreover, common problems such as itching in genital area, leakage of urine, increased frequency of urinating, burning sensation while urinating are due to hygiene and the girls living in the slums have limited access to water and sanitation.

6.2 Strengths and limitations of the study

The important strength of the present house-to-house interview based survey was that the local and well-respected social workers, with training in collection of data for different surveys, conducted this survey. Initially, surveyors were given training for collection of the data for this survey. Camps were conducted in the slums under the supervision of expert doctors; technically trained nurses measured anthropometric factors and took blood pressure measurements. Both adolescents who were attending school as well as not attending school were reached. The overall response rate and item-response rates were high. To the best of our knowledge, this is the first survey of its kind focusing on adolescents living in urban slums gathering information on measurements of growth, blood pressure, mental wellbeing, reproductive health, and lifestyle factors, simultaneously.

The present study was a small cross-sectional study and had several limitations that are worth mentioning. It covered adolescents residing in only two slums from a city and city outskirts, and hence, it may not be a representative sample of the adolescent slum population of India. More slums from within the city limit and outskirts would be required to estimate the population-level characteristics of adolescents residing in these areas. However, small studies such as the present one are useful to bring out the important aspect of research questions, and bigger studies can be built on the findings.

Due to the limited resources, the adolescents from non-slum areas of the city could not be covered, and hence, comparisons of adolescents living in and outside of slums could not be carried out, though that would have been of great interest. For example, comparisons of adolescents living in slums and non-slums with respect to mental wellbeing and other socio-

demographic factors would be of interest. Only two measurements of blood pressure were taken in the present study as against the recommendation of three measurements.

The dietary data were restricted to the invalidated food frequency questionnaire, from which only food consumption data was available, not that of nutrient intake. In spite of these limitations, the study points towards an emerging public health issues of stunting, mental wellbeing and hypertension among adolescents, and it brings out the determinants which might be helpful in planning interventions and guidance to parents and community, in general.

This study derives from self-reported symptoms of reproductive tract infections and not from bacteriological specimen. Self-report is found to be an inaccurate basis for determining the prevalence of gynaecological morbidity among adult women in India. (Bhatia et al. 1995, Koening et al. 1998, Patel et al. 2006). It is necessary to take this into consideration when interpreting the study results.

The association between symptoms suggestive of reproductive tract infections and poorer mental wellbeing in this study sample cannot be directly interpreted as a sign of a causal relationship - reproductive health problems causing poor mental health - although such a causal, relationship can exist. Those having poor mental wellbeing can possibly report reproductive health symptoms as an idiom of mental distress, or end up in behavioural patterns that lead to poorer reproductive health conditions.

The other major problem observed through this study, was the use of chewing tobacco and gutka among boys, girls and their parents in the slums. The prominent presence of all types of addictions were observed in fathers. Most mothers were working outside the house and hence, were not available to attend to the needs of their children. In Indian culture, such responsibilities are still with the mothers. Children are vulnerable to substance abuse, malnutrition and possible drop-out from schools.

6.3 Comparison with the results of other studies

Compared to other studies from urban adolescents from India, this population had a higher prevalence of stunting but not thinness (Haboubi 2009, Rajaretnam et al. 2012, Patil et al. 2013, Kumarvel et al. 2014). However, this trend was reversed when compared to school children (10–17 years) from the rural area of Wardha, Maharashtra, and the rural area of northern

Karnataka (Taksande et al. 2008, Rajaretnam 2012). The phenomenon may also indicate that the diet of these households was deficient in protein-rich foods. The growth reference curves for India were derived using apparently healthy affluent Indian children (Khadilkar et al. 2009), and the present slum population seemed to have a lower anthropometric profile in comparison.

The prevalence of stunting was higher than the prevalence of thinness among boys and girls. This could be because girls were nutritionally better off than boys (Venkaiah 2002). This highlights a less researched question about boys suffering growth-related issues and possibly nutritional deficiency as the focus of such research has been mostly on girls and women.

The association between stunting and thinness with higher income and more family members among girls is in line with the rural Wardha study (Deshmukh 2006) and Gaiha's study (Gaiha et al. 2014).

The mother's education was found to be an important factor affecting stunting as well as thinness among boys and girls in accordance with other studies (Das et al. 2005, Deshmukh et al.2006, Abudayya et al. 2007).

There is evidence that blood pressure measured in adolescence will predict future blood pressure, and adolescents with blood pressure levels in the higher portion of the blood pressure distribution curve tend to maintain that position over time (Lewington et al. 2002).

The average SBP and DBP were lower than those reported in earlier studies (Chiolero et al. 2007, Delpeuch 1997, He, Q. et al. 2000). However, apart from diastolic blood pressure, the results for girls were comparable to the school children from Kerala (He Q.et al. 2000). A positive correlation between blood pressure and anthropometric measurements (height, weight, BMI) is observed in the current study. These correlations are higher compared to rural school children (combining boys and girls) of Wardha (Khadilkar et al. 2009) and lower compared to the urban study from Kolkata (Greden 2001).

There is a wide variation in the prevalence of hypertension in children in India ranging from a high of 11% to as low as 0.46% (Mohan et al. 2004, Singh et al. 2006, Kumar et al. 2012). The prevalence of pre-hypertension was high compared to other studies from India. However, it was comparable to that observed in developed countries, e.g. USA (18.9%) and Switzerland (24.7%) (McNeice et al. 2007, Chiolero et al. 2007). This also requires immediate action from

the community health workers and primary health centres. The adolescents who were identified as pre-hypertensive could be checked by a health worker regularly for a proper follow-up. A factor affecting blood pressure and worth discussing here is the mental wellbeing. A recent study on adolescents from the US brings into focus the maintenance of a healthy body mass index and control of hypertension in improving the mental health of younger populations in the US (Tevie et al. 2015). Both high blood pressure and depression are very common disorders (Murray et al. 2013). Adolescents living in slums may face challenges and feel deprived of basic needs. A regular evaluation of their mental status and counselling would give them a platform to talk openly about their problems and help to be in a better frame of mind. This will help to keep their mental wellbeing score in the higher range. An analysis of normal BMI-for-age score and non-stunted adolescents revealed that mid- and high-mental wellbeing scores had significantly lower DBPs compared to those with a low-score.

The reproductive development among girls from slums showed delay in the age of menarche compared to other Indian studies (Bagga et al. 2000, IIPS 2010). The poor economic situation and diet deficient in protein and fat may be responsible for this. The age at menarche was significantly associated with height, but not with BMI for study participants. Some studies have pointed out that the percentage of body fat may be a more relevant factor than BMI or other anthropometric measures in explaining age at menarche in India (Rao et al.1998). Further, the association of consumption of oil and ghee with the age at menarche gave a further indication of the potentially divergent roles of different fats in relation to the age at menarche and more widely to women's reproductive health. The reason behind the type of fat consumed makes a difference for reproductive development and women's health, in conditions of low energy intake and common undernutrition is still being studied. The potentially changing dietary patterns accompanied by economic development may lead to unexpected consequences for the health of those who have suffered from food scarcity for generations. Because oil is a highly valued food item, improvement in the income level among the economically poor leads to replacement of cereals by oils and other food items (Jacobsen et al. 2007). No relationship between the consumption of animal protein and the age at menarche was in line with Wiley's (Wiley 2011) study in the US, and a number of older studies in high income countries (Moisan et al. 1990, Maclure et al. 1991) as well as studies in China (Zhu et al. 2006), Turkey (Atay et al. 2011) and Iran (Ramezani et al. 2013).

Continuing with the problems related to the menstruation and reproduction, nearly every other post-menarcheal girl in the sample expressed having had at least one symptom suggestive of RTIs during the last 12 months. The prevalence of self-reported RTI symptoms among Indian women has been found to be 11-18% in nationally representative studies and 40-57% in small-scale studies. Data on the prevalence of symptoms suggestive of RTIs among unmarried adolescent Indian girls remains limited, as most studies have concentrated on married women (Sabarwal et al. 2012). Among urban slum-dwelling married women 39% had reported having had symptoms during the preceding 12 months (Hegde 2013). In a sub-nationally representative study, 13% of unmarried adolescents had had symptoms during the preceding three months (Sabarwal et al. 2012). Even when taking into account differences in reporting periods and populations, the prevalence of reported symptoms suggestive of reproductive tract infections (48%) in this study was relatively high by Indian standards. The comparison to other studies is also limited by the fact that studies have examined somewhat different lists of symptoms.

The two variables importantly associated with poorer mental health were stunting and reported symptoms suggestive of reproductive tract infections. The interrelation between mental health and reproductive health among South Asian adolescents has rarely been empirically studied, apart from those who are sexually or physically abused (Patel et al. 2001). Socio-cultural norms in India expect unmarried girls and women to be sexually inexperienced and ignorant. If they face any sexual or reproductive health problems, it is difficult for them to reveal the situation to family members, friends or health-care service providers, which rarely meet the requirements of confidentiality (Mmari et al. 2014). South Asian adolescent girls' mental wellbeing is potentially jeopardised by the unhappy combination of vulnerable reproductive health (Bhatia et al. 1995), lack of personal autonomy (Ram et al. 2014) and social taboos of seeking treatment (Koening et al. 1998).

After controlling for other potential factors, this study did not find evidence of a relationship between consumption of other food items than fats and age at menarche.

The result related to the absence of association between the consumption of animal protein and age at menarche is in line with the study in US (Wiley 1999).

7. Summary and Conclusions

This study has brought out the important areas of health of adolescents living in challenging slum conditions. The study topics clearly explained why anthropometric measurements, blood pressure measurements and evaluation of reproductive health factors were necessary to observe frequently for mental wellbeing in adolescents. This message is very important in the long run.

The age-specific stunting among boys was clearly noticeable. Boys with a higher prevalence of stunting compared to girls might have suffered from high levels of chronic undernutrition, a consistent lack of consumption of required nutrients both in quantity and quality, and partly from untreated infections. Proper care is needed for growing boys to meet their nutritional requirements according to age. The mother's education was highly significant in reducing stunting among both sexes and hence, educating the mothers of adolescents about their nutritional needs may help in improving adolescents' anthropometric profile and future health. A longitudinal study looking at anthropometry and dietary intake data would be needed for planning of a proper nutritional intervention for urban slum populations to overcome the problem of stunting.

Household size and income were significantly associated with the nutritional status of girls. Educating mothers about the nutritional needs of adolescents may help to improve adolescents' anthropometric profile and future health. No association was observed between dietary data and growth status. One reason for this could be that the study population was rather homogeneous with regard to the food habits and to some extent, lifestyle. Another obvious explanation is that not very detailed food consumption and nutrient intake data could be collected.

An analysis of normal and non-stunted adolescents revealed that mid- and high- mental wellbeing scores were associated with significantly lower DBP compared to low-scores. Adolescents having educated mothers seem to have lower DBPs.

Chronic and acute undernutrition was prevalent in the present study population. BMI was associated with blood pressure among largely undernourished adolescents, even in a population such as slum-dwelling adolescents that does not suffer from a high prevalence of overweight and obesity.

In this study of post-menarcheal adolescent girls living in slum conditions, we found evidence of an association between poor mental wellbeing and self-reported symptoms of reproductive tract infections. Poverty and stunting are both related to poor socioeconomic status and bring forward the close interaction between material wellbeing, somatic health and mental wellbeing, also in slum environments.

The present thesis highlights that a significant proportion of youth has health-impacting behaviours and conditions that affect their growth and mental wellbeing. The health problems in adolescents are showing an increasing trend, and are interlinked, and they must be taken care of in near future.

- Boys with a higher prevalence of stunting compared to girls might have suffered from high levels of chronic undernutrition, a consistent lack of consumption of required nutrients both in quantity and quality, and partly from untreated infections.

- The importance of mental health management in adolescents is realised here mainly due to the association of mental wellbeing with stunting, blood pressure, and RTIs.

- The high prevalence of pre-hypertension (including hypertension) among the study participants is alarming. The relationship between high BP and depression is thought to be bidirectional by many researchers (Tevie et al. 2015). However, it is natural to expect that mental anxiety is likely to increase BP, at first temporarily, but it may later on develop into permanent hypertension, but it is not very clear how the relationship works the other way around. Throughout adulthood, blood pressure is strongly and directly related to vascular as well as overall mortality (Lewington et al. 2002). Early diagnosis, treatment, and follow-up of the hypertensive cases and preventive methods may decrease future morbidity and mortality.

- Intake of dietary fats and foods that are important sources of protein among underprivileged households in India is low and may be reflected in the relatively late age at menarche. The potential differences in the association between various types of fatty acids, energy intake and age at menarche in conditions of undernutrition requires further prospective study.

- Provision of youth-friendly reproductive health services for adolescents in slums would be important to reduce stress related to reproductive health problems. Attention should be paid to the mental wellbeing of school-going adolescents in developing educational practices.

- The present analysis highlights that a significant proportion of adolescents has health-impacting behaviours and conditions that affect their growth and mental wellbeing. Their health problems need careful evaluation and follow-up. Further, proper guidance to the mothers would help enhance their health status.

- This is the first empirical study to point to the interrelationship between mental wellbeing and symptoms of RTIs among unmarried, underprivileged Indian adolescent girls. The results stress the necessity to consider this association when planning ways to improve and secure young people's health status in developing countries. The proportion of young people among the global population is growing, and reproductive and mental health issues will be among the most important health concerns to tackle by national and international health initiatives.

- Health service development in growing informal urban agglomerations in India should provide integrated mental and reproductive health services to adolescents. The importance of a holistic approach to health should be acknowledged; those adolescents who suffer from stunting and live in households below the poverty line are also the most vulnerable to poor mental wellbeing. Securing employment and proper income for the underprivileged will also lead to lesser anxiety and depression among adolescents. What is needed is adolescent-friendly health care, instruction on child nutrition to reduce stunting and better food security for the poor.

8. Implications for future research

After completion of this study, the immediate implications for the future could be clearly seen and are noted below:

- Government policies towards mid-day meal and other means of providing food to adolescents seems to be working. However, there is a need to educate parents about nutritional needs of adolescents so that there can be appropriate redistribution of the resources spend on food.

- A policy for providing sanitation and clean water to everyone need to be implemented more rigorously.

- High level of addiction in parents and also the adolescent boys needs policy action.

- Policies that would involve fathers in child caring are required to be framed in India.

- A longitudinal study looking at anthropometry and food intake data would be needed for planning a proper nutritional intervention for urban adolescent slum populations to bring in behavioral change in diet and address the problem of stunting in a more coherent manner. The intervention should also include education for parents, especially mothers, in the nutritional needs of adolescents.

- A larger study assessing the role of mental health and blood pressure is called for. If this is implemented properly then it would help in building health promotion and disease prevention measures for mental health and hypertension.

- A study evaluating knowledge, attitude and practice of sexual and reproductive health will help develop a proper intervention to make behavior changes and safe practices towards sexual and reproductive health.

- To achieve wholesome adolescent health, a multidimensional approach is needed covering all the adolescent health problems with special emphasis on mental health, behavior change, communication towards healthy lifestyle and positive social environment to acquire life skills.

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References

Abudayya A, Thoresen M, Abed Y, Holmboe-Ottesen G. 2007. Overweight, stunting, and anemia are public health problems among low socioeconomic groups in school adolescents (12–15years) in the North Gaza Strip. Nutrition Research, 27(12) : 762 - 771.

Adolescents:"http://www.who.int/maternal_child_adolescent/topics/adolescence/en/"http://www.who.int/maternal_child_adolescent/topics/adolescence/en/.Adolescents: health risks and solutions. 2014. Fact sheet no. 345.

Agarwal DK, Agarwal KN. 1992. Physical and sexual growth pattern of affluent Indian children from 5-18 years of age. Indian Pediatrics. 29 : 940 - 949.

Agrawal R, Mandowara SL, Bhandari B, Garg OP. 1982. Prevalence of hypertension in apparently healthy schoolchildren. Indian Pediatrics. 19: 779 - 789.

Agrawal R, Mandowara SL, Bhandari B. 1982. Blood pressure pattern in school children. Indian Pediatr. 19 : 597 - 600.

Agarwal VK. 1983. Blood pressure profile in children of age 3-15yrs. Indian Pediatrics. 20 : 921 - 925.

Arnold F, Parasuraman S, Arokiasamy P, Kothari M. 2005. Nutrition in India. National Family Health Survey (NFHS-3), International Institute for Population Sciences, Mumbai, India. ICF Macro : Calverton, Md, USA.

Ashoka S, Gayatri N. 2014. Conceptual Framework of Adolescent health Trend in India, IOSR Journal of Humanities and Social Science (IOSR-JHSS) Ver. VIII Sep. 19(9) : 13 - 19. e-ISSN: 2279 - 0837, p-ISSN: 2279 - 0845.

Astbury J. 2009. An overview of key issues. In: Fisher J, Astbury J, Cabral de Mello M, Saxena S, editors. Mental health aspects of women's reproductive health : a global review of the literature, Geneva : World Health Organization; 1 - 7.

Atay Z, Turan S, Guran T, Furman A, Bereket A. 2011. Puberty and influencing factors in school girls living in Istanbul : end of the secular trend ? Pediatrics. 128 : e40. DOI:10.1542/peds.2010 - 2267.

Bagga A, Kulkarni S. 2000. Age at menarche and secular trend in Maharashtrian (Indian) girls. Acta Biol Szege. 44 : 53 - 7.

Bao W, Threefoot SA, Srinivasan SR, Berenson GS. 1994. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood : the Bogalusa Heart Study. Am J Hypertens. 8 : 657 - 65.

Basu D, Islam G, Gogoi R, Dey S, Deori J. 2014. Child's growth and nutritional status in Two communities— Mishing tribe and Kaibarta caste of Assam. International Journal of Sociology and Anthropology. 62 : 59 - 69.

Bates D, Maechler M, Bolker B, Walker S. lme. 2014. Linear mixed-effects models using Eigen and S4. R package version 1.1-7, 2014; (URL: "http://CRAN.R/"http://CRAN.R Project.org/package=lme4).

Beck AT, Steer RA, Brown GK. 1996. Beck Depression Inventory Manual, 2nd Edition. San Antonio, TX, Psychological Corporation.

Bhatia CJ, Cleland J. 1995. Self-reported   symptoms of gynaecological morbidity and their treatment in South India. Studies in family Planning. 26(4): 203 - 216.

Bisai S, Bose K. 2009. Undernutrition in the Kora Mudi tribal population, West Bengal, India: a comparison of body mass index and mid-upper-arm circumference.
Food Nutr Bull. 30 : 63 - 67.

Bong Y, Shariff A, Majid A. 2012. Reference charts for height and weight of school children from West Malaysia in comparison with the United States Centers for Disease Control   and Prevention, AF Mercian Iranian J Publ Health. Feb. 41: 2, 27 - 38.

Bradley R,Corwyn R. 2002. Socio-economic status and child development, Annu. Rev. Psychol. 53 : 371 - 99.

Census of India, Single Year Age Data Table C13.2011.
"http://www.censusindia.gov.in/2011census/Age level data/Age level data.html"http://www.censusindia.gov.in/2011census/Age level data/Age level data.html.

Chakravarty BN. 1989. Adolescent gynaecological problems. In K. Bhaskarrao (ed), Postgraduate Obstetrics and Gynaecology. 72 - 89. New Delhi: Orient Longman.

Chiolero A, Paccaud F, Bovet P. 2007. Pre-hypertension and hypertension among adolescents of Switzerland. Journal of Pediatrics. 151: e24-e25.

Daniels SR, McMahon RP, Obarzanek E, Waclawiw MA, Similo SL, Biro FM. 1998. Longitudinal correlates of change in blood pressure in adolescent girls.
Hypertension. 31 : 97 - 103.

Das DK, Biswas R. 2005.Nutritional status of adolescent girls in a rural area of North 24 Parganas district, West Bengal, Indian Journal of Public Health. 49(1) : 18 - 21.

Das PB, Das BM. 1966. Age at Menarche of Kalita girls in Assam.
Man in India. 47(2) : 113 - 117.

Deaton A, Dr`eze J. 2009.Food and nutrition in India: facts and Interpretations. Economic and Political Weekly. 44(7) : 42 - 65.

de Onis. 2006. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study," Acta Paediatrica, International Journal of Paediatrics. 95 : 450, 56 - 65.

de Onis, Onyango AW , Borghi E, Siyam A, Nishida C, Siekmann J. 2007. Development of a WHO growth reference for school-aged children and adolescents Bulletin of the World.

Delpeuch F, Maire B. 1997. Obesity and developing countries of the south. Med Trop (Mars). 57: 380 - 388. Health Organization. 85(9) : 660 - 667.

Deshmukh P, Gupta SM, Bharambe S, et al. 2006. Nutritional status of adolescents in rural Wardha. Indian Journal of Pediatrics. 73(2) : 139 - 141.

Dhambare DG, Wagh SV, Dudhe JY. 2012. Age at menarche and menstrual cycle pattern among school adolescent girls in central India. Glob J Health Sci. 4 : 105 - 111.

Donath S. 2001. The validity of the 12-item General Health Questionnaire in Australia : a Comparison between three scoring methods. Aust N Z J Psychiatry. 35 : 231 - 235.

Durrani AM, Wasim F. 2011. Determinants of blood pressure distribution in school children European Journal of Public Health; 22(3) : 373 - 377.

Editorial: Secular Trends in Puberty. 2006. Indian Pediatrics.

Elankumaran C. 2003. Malnutrition in pre-school children of Jaffna Society- A post-exodus statistical perspective University of Ruhuna, Sri Lanka. November : 28 - 30 .

Farinde A. 2013. The Beck Depression Inventory. The Pharma Innovation- journal IC Journal No: 7725, Vol. 2(1) . Online Available at HYPERLINK "http://www.thepharmajournal.com/"www.thepharmajournal.com.

Fatori D, Bordin IA, Curto BM, De Paula CS. 2013. Influence of psychosocial risk factors on the trajectory of mental health problems from childhood to adolescence: A longitudinal study. BMC Psychiatry. 13 : 1 - 6.

Gaiha R, Jha R, Kulkarni VS. 2014. Child Undernutrition in India; http://ssrn.com/abstract=1734591.

Ghosh S, Shah D. 2004. Nutritional Problems in Urban Slum Children Indian Pediatrics. 41 : 682 - 696.

Goldberg DP, Blackwell B. 1970. Psychiatric illness in general practice. A detailed study using a new method of case identification. Br Med J. 1 : 439 - 443.

Golderberg D, Williams P. 1988. A user's guide to the General Health questionnaire; Windsor,UK: NFER-Nelson.

Government of India, Press Information Bureau. Planning commission, poverty estimates for 2009 - 10. Available at: http://pib.nic.in/newsite/erelease.aspx?relid=81151. Accessed 30 July 2014. Government of India. Press note on poverty estimates, 2009–10, Government of India, Planning Commission, 2012, http://planningcommission.nic.in/news/presspov1903.pdf.

Greden J. 2001.The burden of recurrent depression: causes, consequences, and future prospects. Journal of Clinical Psychiatry. 62 : 5 - 9.

Gupta AK, Ahmad AT. 1990. Normal blood pressure and elevation of sustained blood pressure elevation in childhood. Indian Pediatr. 27 : 33 - 42.

Gupta SD, JainN. 1998. Report on a study of reproductive health and sexual behaviour among adolescents; Indian Institute of Health Management Research, Jaipur.

Haboubi GJ, Shaikh RB. 2009. A comparison of the nutritional status of adolescents from selected schools of South India and UAE: a cross-sectional study. Indian Journal of Community Medicine. 34(2), 108 - 111.

Harishankar, Dwivedi S, Dabral S, Walia D. 2004. Nutritonal status of children under 6 years of age. Indian J. Prev.Soc.Med. Med. 35: 3 & 4.

He Q, Ding ZY, Fong D, Karlberg J. 2000. Blood pressure is associated with body mass index in both normal and obese children. Hypertension. 36 : 165 - 170.

Hegde SKB, Agrawal T, Ramesh N, Sugara M, Joseph PM, Singh S. 2013. Reproductive tract infections among women in a peri-urban under privileged area in Bangalore, India: Knowledge, prevalence, and treatment seeking behaviour. Annals of Tropical Medicine and Public Health. 6 : 215 - 20.

International Institute for Population Sciences (IIPS) and Population Council. Youth in India: situation and needs 2006 – 2007. Mumbai: IIPS, 2010. IIPS and ORC Macro 2000.

International Institute for Population Sciences (IIPS) & Macro International. National Family Health Survey (NFHS-3), 2005 – 06: India: Volume I. International Institute for Population Sciences, Mumbai, 2007. IIPS 2010 Reports.

Indian Pediatrics 2006.

Jacob K , Bhugra D, Mann AH. 1997. The validation of the 12-item, General Health questionnaire in ethnic Indian women living in the United Kingdom. Psychol Med. 27 : 1215 - 1217.

Jacobsen BK, Heuch I, Kv a le G. 2007. Association of low age at menarche with increasedall-cause mortality: a 37-year follow-up of 61,319 Norwegian women. Am J Epidemiol. 166 : 1431– 7.

Jejeebhoy S. 1998.Adolescent sexual and reproductive behaviour: a review of the evidence from India. Social Science & Medicine. 46 : 1275 - 90.

Jejeebhoy SJ. Santhya KG. 1998. Sexual and reproductive health of young people in India: A Review of policies, laws and programmes, Page 3; Population council.

Jenkins R. 2008. Foresight Mental Capital and Wellbeing Project: Final Project Report, London. The Government Office for Science.

Joseph GA, Bhattacharji S, Joseph A, Rao PS.1997. General and reproductive health of adolescent girls in rural South India. Indian Pediatrics. 34 : 242 - 5.

Kaliyarasan MM, Daniel S. 2014.Mental Health among Adolescents, International Journal of Research in Applied, Natural and Social Sciences, Aug. (IMPACT: IJRANSS) ISSN (E): 2321-8851; ISSN (P): 2347 - 4580, 2(8) 27 - 32.

Kanitkar T, Radkar A. 2004. Self-reported Symptoms of Reproductive Health Problems of Women in India Demography India. July - December; 33(2): 231 - 248.

Kapur D, Sharma S, Agarwal KN. 2005. Dietary intake and growth pattern of children 9 - 36 months of age in an urban slum in Delhi. "http://www.indianpediatrics.net/apr"www.indianpediatrics.net/apr . 351 - 356.

Karlberg J. 2002. Secular trends in pubertal development. Horm Res. 57 : 2, 19 - 30.

Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton MK. 2005. Jiang He Global burden of hypertension: analysis of worldwide data. Lancet. 365: 217 - 23.

Khadilkar VV. 2006. Stanhope RG. Secular trends in Puberty Indian Pediatrics. 43 : 475 - 478.

Khadilkar VV, Khadilkar AV, Cole TJ, Sayyad MG. 2009. Cross-sectional growth curves for height, weight and body mass index for affluent Indian children. Indian Pediatrics. 46: 477 - 489.

Khadilkar VV, Khadilkar AV. 2011.Growth charts: a diagnostic tool. Indian Journal of Endocrinology and Metabolism. 15(3) : S166 - S171.

Khopkar SA, Virtanen SM, Kulathinal S. 2014. Anthropometric Characteristics of Underprivileged Adolescents: A Study from Urban Slums of India. Journal of Anthropometry :   http://dx.doi.org/10.1155/2014/197048.

Khopkar SA, Virtanen SM, Kulathinal S.2015.Mental health, anthropometry and blood pressure among adolescents living in slums of Nashik, India. Tanzania Journal of Health Research. 17(4). Doi: http://dx.doi.org/10.4314/thrb.v17i4.6

Khopkar SA, Virtanen SM, Kulathinal S, Säävälä M.2015. Age at menarche and diet among adolescents in slums of Nashik, India.Int J Adolesc Med Health. DOI 10.1515/ijamh-2014-0056.

Khopkar SA, Virtanen SM, Kulathinal S, Säävälä M Mental wellbeing and self-reported Symptoms of reproductive tract infections among postmenarcheal adolescent girls : Findings from a cross-sectional study in an Indian slum. (submitted for publication)

Koenig M, Jejeebhoy S, Singh S, Sridhar S. 1998. Investigating women's gynaecological morbidity in India: not just another KAP survey. Reprod Health Matter. 6 : 84 - 96.

Kramer MS. 1987. Determinants of low birth weight: methodological assessment and meta-analysis. Bulletin of the World Health Organization; 65(5) : 663 - 737.

Kumar J, Deshmukh PR, Garg BS. 2012. Prevalence and correlates of sustained hypertension in adolescents of rural Wardha, Central India. Indian Journal of Pediatrics. 79 : 1206 - 1212.

Kumaravel V, Shriraam V, Anitharani M, Mahadevan S, Balamurugan AN, Sathiyasekaran BW. 2014. Are the current Indian growth charts really representative? Analysis of anthropometric assessment of schoolchildren in a South Indian District. Indian Journal of Endocrinology and Metabolism. 18(1) : 56 - 62.

Landstedt E, Kenneth A, Gillander K. 2009. Understanding adolescent mental health: the influence of social processes, doing gender and gendered power relations. Sociology of Health & Illness. 31 : 7. ISSN 0141–9889, 962–978. Doi: 10.1111/j.1467-9566.01170.x.

Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. 2002. Prospective Studies Collaboration. Age specific relevance of usual blood pressure to vascular mortality: a meta- analysis of individual data for one million adults in 61 prospective studies. Lancet. 360 : 1903 - 1913.

Luepker RV, Jacobs DR, Prineas RJ, Sinaiko AR. 1999. Secular trends of blood pressure and body size in a multi-ethnic adolescent population: 1986 to 1996. Journal of Pediatrics. 134 : 668 - 674.

Maclure M, Travis LB, Willett WC, MacMahon B. 1991. A prospective cohort study of nutrient intake and age at menarche. Am J Clin Nutr. 54 : 649 - 56.

Manatunga AK, Jones JJ, Pratt JH. 1993. Longitudinal assessment of blood pressures in black and white children. Hypertension. 22 : 84 - 89.

Mary Story, Jamie Stang.2005. Nutrition needs of adolescents. Stang J, Story M (eds).Guidelines for Adolescent Nutrition Services 21. "http://www.epi.umn.edu/let/pubs/adol_book.shtm"http://www.epi.umn.edu/let/pubs/adol_book.shtm.

McCulloch CE, Searle SR, Neuhaus JM. 2008. Generalized, Linear, and Mixed Models. Wiley Series in Probability and Statistics. John Wiley & Sons, Hoboken, NJ, USA, 2nd Edition.

McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. 2007. Prevalence of hypertension and pre-hypertension among adolescents. Journal of Pediatrics. 150 : 640 - 644.

Mechanic D, Hansell S. 1987. Adolescent competence, psychological well-being, and Self assessed physical health. Journal of Health and Social Behaviour. *28* : 364 - 374.

Mmari K, Lantos H, Brahmbhatt H, Delany-Moretlwe S, Lou C, Acharya R. 2014. How adolescents perceive their communities: A qualitative study that explores the relationship between health and the physical environment.
BMC Public Health; 14. DOI 10.1186/1471-2458-14-349.

Mohan B, Kumar N, Aslam N, Rangbulla A, Kumbkarni S, Sood NK, Wander GS. 2004. Prevalence of sustained hypertension and obesity in urban and rural school going children in Ludhiana. Indian Heart Journal. 56 : 310 - 314.

Moisan J, Meyer F, Gingras S. 1990. Diet and age at menarche. Cancer Causes Control. 1 : 149 - 54.

Murray C, Lopez A. 2013. Global health measuring the global burden of disease. New England Journal of Medicine. 369 : 448 - 557.

National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. 2004. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescent. Pediatrics; 114(4) : 555 - 576.

Padmavati S. 2002. A meta-analysis-National Heart Institute, New Delhi. Ind Heart J. 54 : 99 -102.

Patel V, Andrew G. 2001. Gender, sexual abuse and risk behaviours in adolescents: A cross-sectional survey in schools in Goa. Natl Med J India. 14 : 263 - 7.

Patel V, Kirkwood BR, Pednekar S, Pereira B, Barros P, Fernandes J. 2006. Gender disadvantage and reproductive health risk factors for common mental disorders in women: A community survey in India. Arch Gen Psychiatry. 63 : 404 - 13.

Patel V, Flisher AJ, Hetrick S, McGorry P. 2007. Mental health of young people: A global public-health challenge. Lancet. 369 : 1302 - 13.

Patil SS, Patil SR, Durgawale PM, Kakade SV, Abhishek K. 2013. Study of physical growth standards of adolescents (10–15 years) from Karad, Maharashtra, International Journal of Collaborative Research on Internal Medicine & Public Health. 5 : 1, 10 - 18.

Patton GC, Viner R. 2007. Pubertal transitions in health, The Lancet, vol. 369, 9567. World Population Monitoring. Adolescents and Youth. A Concise Report. United Nations New York, 2012.

Patton GC, Hippat ME, Carlin J, Shao Q, Roier M, Caust J, Lt. Bowes. 1996. Menarche and onset of depression and anxiety in Victoria, Australia. Journal of Epidemiology and Community Health. 50(6) : 661 - 66.

Paxon C,Case A, Fertig A.2005.The lasting impact of childhood health and circumstance, Journal of health economics. 24 : 365 - 389.

Pediatrics. 2004. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescent. 114 : 555.

Press Note on Poverty Estimates. 2009. Government of India, Planning Commission, 2012, http://planningcommission.nic.in/news/press pov1903.pdf.

R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, HYPERLINK "http://www.r-project.org/"http://www.R- project.org/, accessed 15 Aug 2013.

Rahi M, Kumavat AP, Garg S, Singh MM. 2005.Socio-demographic co-relates of psychiatric disorders. Indian Journal of Pediatrics. 72 : 395 - 8.

Rajaretnam T, Hallad JS. 2012. Nutritional status of adolescents in northern Karnataka, India. Journal of Family Welfare. 58 : 1, 55 - 67.

Ram U, Strohschein L, Gaur K. 2014. Gender socialization: Differences between male and female youth in India and associations with mental health. International Journal of Population Research. ID 357145. Doi 10.1155/2014/357145.

Ramachandran P. 2003. Director, Nutrition Foundation of India, New Delhi. The double burden of malnutrition in India. Government of India.

Ramezani T, Moslehi N, Asghari G, Gholami R, Mirmiran P. 2013. Intake of dairy products, calcium, magnesium, and phosphorus in childhood and age at menarche in the Tehran, Lipid and Glucose Study. PLoS One; 8:e57696.

Rana T, Raman L, Rau P, Rao K. 1986. Association of growth status and age at menarche in urban upper middle income group girls of Hyderabad. Indian J. Med Res. 84 : 522 - 530.

Rao S, Joshi S, Kanade A. 1998.Height velocity, body fat and menarcheal age of Indian girls. Indian Pediatr. 35 : 619 - 28.

Rawat R, Santosh K, Manju L, Regi J. 2014. Prevalence and Determinants of Undernutrition among School-aged Children in an Urban Slum in India Academic Medical Journal of India; October – December, Volume II, Issue 3.

Report on adolescent health WHO2015.

Results from the National Family Health Survey-3.

Rogers IS, Northstone K, Dunger DB, Cooper AR, Ness AR, et al. 2010. Diet throughout childhood and age at menarche in a contemporary cohort of British girls. Public Health Nutr. 13 : 2052 - 63.

Rierdan C, RiseJ. 1995. Living arrangement and health behaviours in adolescence and young adulthood. Health Education Research, Theory and Practice. 8(4) : 494 - 503.

Sabarwal S, Santhya KG. 2012. Treatment-seeking for symptoms of reproductive tract infections among young women in India. Int Perspect Sex Reprod Health. 38: 90 - 8. Doi: 10.1363/3809012.
Sachdev Y. 1984. Normal blood pressure and hypertension. Indian Pediatr . 21: 41 - 49.

Saha I., Paul B, Dasgupta A. 2008. Prevalence of hypertension and variation of blood pressure with age among adolescents in Chelta, India. Tanzania Journal of Health Research. 10 : 108 - 111.

Sen T. 1994. A historical study of ages at menarche, marriage, menopause and family size in high- caste Bengalis of Calcutta. Man in India. 74 : 241 - 250.

Schmitz N, Kruse J, Tress W. 1999. Psychometric properties of the General Health Questionnaire (GHQ)-12) in a German primary care. Acta Psychiatr Scand. 100 : 462 - 468.

Sengupta A. 2009. Parliamentary panel says no to sex education in schools. The Times of India; April 16. Retrieved from http://www.timesofindia.com.

Shamsunder C, Sriram TC, Muraliraj SG, Shanmugham V. 1986.Validity of a short 5 items version of the general health questionnaire, Indian J Psychiatry. 217 - 219.

Siddique C, D'Arcy C. 1984. Adolescents, stress and psychological well-being. Journal of Youth and Adolescence; *13*, 459 - 473.

Silvanus V, Subramanian P.2012. Epidemiological study of mental morbidity in an urban Slum community in India for the development of a community mental health programme. Nepal Medical College Journal : 14 : 13 - 7.

Singh UP, Shukla BRK. 1992. Trend of menarche in five endogamous groups of Tharu tribal females of Uttar Pradesh. Man in India. 72 : 343 - 352.

Singh AK, Maheshwari A, Sharma N, Anand K. 2006.Lifestyle associated risk factors in adolescents. Indian Journal of Pediatrics. 73 : 901 - 906.

Singh S, Gopalkrishna G. 2014. Health behaviours & problems among young people in India: Cause for concern & call for action. Indian J Med Res. 140 : 185 - 208.

Sounderssane MB, Mathanraj S, Sumanth MM, Sahai A, Karthigeyan M. 2008. Tracking of blood pressure among adolescents and young adults in an urban slum of Puducherry, Indian journal of community medicine. 33 : 2.

Sukumar I, Alurkar V. 1978.Systemic high arterial blood pressure in children.
Ind Heart J. 30 : 69.

Tait RJ, French DJ, Hulse GK. 2003. Validity and psychometric properties of the General
Health Questionnaire-12 in young Australian adolescents.
Aust N Z J Psychiatry. 37 : 374 - 381.

Tanner JM. 1962. Growth at Adolescence, 2nd edn. Oxford, Blackwell.

Taksande A, Chaturvedi P, Vilhekar K, Jain M. 2008. Distribution of blood pressure in
school going children in rural area of Wardha district, Maharashtra India.
Annals of Pediatric. 1 : 101 - 6.

Tevie J, Shaya FT. 2015. Association between mental health and co-morbid obesity and
hypertension among children and adolescents in the US. European Child Adolescent
Psychiatry. 24 : 497 - 502.

Thakor H, Kumar GP, Desai VK, Srivastava RK. 2000. Physical growth standards of Urban
Adolescents (10–15 years) from south Gujarat.
Indian Journal of Community Medicine. 25(2) : 86 - 92.

The Fourth report on the diagnosis, evaluation and treatment of high blood pressure in
children and adolescents: National High Blood Pressure Education Program Working
Group on High Blood Pressure in Children and Adolescents.
Pediatrics 2004, 114 : 555 - 76.

Torsheim T, Currie C, Boyce W, Samdal O. 2006;Country material distribution and
adolescents' perceived health: multilevel study of adolescents in 27countries. Journal of
Epidemiology and Community Health. 60 : 156 – 161.

 UNICEF, 2009 Fact sheet.

Upinder S. 2013.Slum population in India: extent and policy response. International Journal
of   Research in Business and Social Science. 2(1) : 2147 - 4478.

Venkaiah K, Damayanti MU, Nayak, Vijayaraghavan K. 2002. Diet and nutritional status of
rural adolescents in India. European Journal of Clinical Nutrition. 56(11) : 1119 - 1125.

Voors AW, Webber LS, Frerichs RR. 1977. Body height and body mass as determinants of
basal blood pressure in children–The Bogalusa Heart Study.
Am J Epidemiol. 106 : 101 - 8.

Whittaker M. 2002.Negotiating care: reproductive tract infections in Vietnam.
Women Health. 35 : 43 – 57.

World Health   Organization. Physical status: the use and interpretation   of anthropometry,
Tech. Rep. 854, World Health Organization, Geneva, Switzerland, 1995.

WHO Fact sheet EURO/06/05, The Health of Children and Adolescents in Europe, World Health Organization, Copenhagen, Bucharest, 2005.

WHO. 2009. Mental health aspects of women's reproductive health: a global review of the literature. Geneva: World Health Organization.

World Health Organisation (WHO) Depression, Fact sheet N°369, October 2012. URL: http://www.who.int/mediacentre/factsheets/fs369/en/World Population Monitoring, Adolescents and Youth 2012.

Wiley AS. Milk intake and total dairy consumption: associations with early menarche in NHANES 1999 – 2004. PLoS One 2011, 6, e14685.

World Population Monitoring, Adolescents and Youth. A Concise Report. United Nations, 2012.

Youth in India: Situation and Needs 2006 – 2007, page 37.

Young people: no. 345, 8. World Health Organization 2011.

Zeena M, Rao K, Rao S, Subbakrishna, Prabhu. 1990. Stress coping in psychologically distressed and non-distressed college students. Indian Journal of Psychological Medicine. 1363 – 70.

Zhu K, Zhang Q, Foo LH, Trube A, Ma Gl. 2006.Growth, bone mass, and vitamin D status of Chinese adolescent girls 3y after withdrawal of milk supplementation. Am J Clin Nutr. 83 : 714 - 21.

Research Article

Anthropometric Characteristics of Underprivileged Adolescents: A Study from Urban Slums of India

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Purpose. The anthropometric status and growth of adolescents living in challenging conditions such as slums are insufficiently studied. The purpose here was to describe anthropometric characteristics and nutritional status of adolescents from urban slums of India and to study the factors affecting it. *Methods*. Anthropometric, socioeconomic and dietary habit data were collected using structured questionnaires of six hundred adolescents aged 10–19 years by house-to-house survey conducted in two randomly selected slums of Nashik, Western India. The growth of adolescents was compared using WHO and Indian reference populations. Mixed effects logistic regression models were used to examine associations between anthropometric measures and income, mother's education, household size, and dietary intake. *Results*. Prevalences of stunting and thinness were lower using the Indian reference population compared to that of WHO. Stunting was more prevalent than thinness in the study subjects, and boys suffered more than girls. The effect of age on stunting was different among boys than girls. A mother's education was highly significantly associated with both stunting and thinness in both sexes. Household size and income were significantly associated with the nutritional status of girls. *Conclusions*. Educating mothers about the nutritional needs of adolescents may help to improve adolescents' anthropometric profile and future health.

1. Introduction

Adolescence is a transitional phase between childhood and adulthood characterized by marked acceleration in growth [1, 2]. It is a second chance for growth or catch-up growth for those children who have experienced nutritional deficiencies in early childhood [3, 4]. A large number of adolescents from South and South-east Asian countries suffer from chronic malnutrition and anaemia which affect their development [1]. The high rate of malnutrition in girls contributes to the intergenerational cycle of malnutrition, and in most developing countries nutrition initiatives have focused on children and women, essentially neglecting adolescents, especially boys [1].

Anthropometry helps in assessing nutritional status and health risks among adolescents [5, 6]. Recommended measures for assessing nutritional status in school-aged children and adolescents are BMI-for-age and height-for-age [7]. Low BMI-for-age is classified as thinness and high BMI-for-age as overweight and obesity, and low height-for-age as stunting [7]. Stunting is a primary manifestation of malnutrition in early childhood and is an indicator of chronic undernutrition, while thinness indicates current malnutrition. Stunting increases the risk of morbidity, impairs cognitive development, and reduces work productivity in later life [8]. The consequences of undernutrition extend not only to later life, but also to future generations [9]. Both childhood obesity

and thinness are linked to underachievement in school and lower self-esteem [10]. Assessment of stunting and thinness is crucial for adolescents and a reference population is central to it. One of the objectives of the present paper is to compare estimates of malnutrition observed in this study population based on the growth reference curves developed for India [11] and the WHO Multicentre Growth Reference Study [12]. Several factors affect the nutritional status of adolescents. Among these, socioeconomic and demographic factors are associated with worldwide patterns of stunting and thinness [13].

India has a large population of adolescents (10–19 years of age, 21%) and also of slum dwellers in urban areas (15% of total urban population of India, [14, 15]). Although a number of studies from India have been published on adolescents' anthropometry among school children from urban and rural areas reporting prevalence of undernutrition ranging from 17% to 65% [16], there are only a few studies conducted on the growth of adolescents from urban slums covering adolescents not attending school (e.g., [17]). Addressing the growth issues of this underprivileged group could be an important step towards breaking the vicious cycle of intergenerational malnutrition, chronic diseases, and poverty. Such assessments need special consideration since they constitute a large proportion of the urban population and suffer from adverse living conditions such as unsafe water, poor housing, overcrowding, and limited health facilities, especially when compared to school-going urban adolescents not living in slums. The purpose here is to describe anthropometric characteristics and nutritional status of adolescents from urban slums of India and study the factors affecting it. In the current study, nutritional status as determined by height-for-age and BMI-for-age of a sample of adolescents from urban slums of Maharashtra with low per capita income is examined. Their status is also compared with the WHO and Indian reference populations by age and sex. Note that Maharashtra has the highest slum population as a proportion of urban population (27.3%) in India [15]. Further, factors such as mother's education, family income, and diet, known to affect the nutritional status (stunting and thinness) of school children, are examined for these adolescents. Girls have been the focus of nutritional research and growth-related issues stemming from a lack of proper nutrition. The novelty of the present work lies in examining whether the situation among boys differs from that of girls.

2. Methods

The study was undertaken over a six-month period from November 2010 to April 2011 in two urban slums in Nashik city in the state of Maharashtra, Western India. Out of the 32 notified slums by the Nashik Municipal Corporation (NMC) within the city limits, one slum was selected randomly. The slums were enumerated and a number between 1 and 32 was selected randomly. The slum with the selected number was chosen for the study. Similarly, out of 27 slums notified by the NMC on the outskirts of the city, one was selected by randomly choosing a number between 1 and 27.

After the selection of slums, a survey was carried out to gather background information on households, number of family members, and number of boys and girls between the age of 10–19 years from 539 (241 + 298) households. Written consent was also sought, at the same time. One of the selected slums had 1384 households (reported by the NMC) and the first 241 households interviewed, which gave the required number of adolescents for the study, were included. All 298 households from the other slum were included. All the households with at least one adolescent (200 out of 241 and 150 out of 298 households) and which gave consent to participate in the study were selected. This gave 156 (out of 200) and 120 (out of 150) households and 545 adolescents for the present study.

Data on household characteristics, socioeconomic indicators, and eating habits were collected using structured questionnaires by house-to-house survey. The adolescents whose parents gave consent were interviewed to collect data on their demographic and life style factors, habits, physical activity, diet, and so forth. The questionnaires were administered by two teams consisting of three trained surveyors each. Another team of five members carried out measurements. One member of the team collected data on weight, one on height, and the other three on blood pressure. The field study was approved by the Institutional Review Board of Tampere School of Health Sciences in 2010. The study was conducted in accordance with the ethical guidelines in the Helsinki Declaration of 1975, as revised in 2000.

In the present paper, the analysis of anthropometric data is restricted to the age group 10–18 years (boys = 257, girls = 261, total = 518) since the growth curves from India are available up to the age of 18 years.

2.1. Anthropometric Measurements. Data on height and weight were collected in the present study. The participants were invited to camps at scheduled times with their parent or guardian for the recording of anthropometric measurements. Height (in cm) was measured using a simple nonelastic measurement tape to the nearest integer. Weight (in kg) was recorded using a new bathroom scale (brand Libra, Model no. 770) to the nearest integer. Two readings each were taken for height and weight and the average was used for analyses here. Body mass index (BMI) was defined as the ratio of weight (in kg) to the square of height (in m).

2.2. Stunting and Thinness. Height-for-age and BMI-for-age Z-scores were derived using WHO as well as Indian reference populations [11, 12]. A subject was classified as stunted if the height-for-age score was below −2, as thin if BMI-for-age score was below −2, and overweight if BMI-for-age score was above 1 [18].

2.3. Independent Variables. In this study, it was examined whether differences in household per capita income, mother's education, household size, and dietary intake of protein/fat within the slum population were associated with variation in anthropometric status. The level of economic wellbeing is one of the basic factors of the household that is reflected in

child undernutrition. The poverty that children experience is associated with inadequate food, poor sanitation, and poor hygiene, which lead to increased infections, and is also associated with low maternal education, increased maternal stress, and depression [19–21]. Household characteristics such as mother's education, poverty, and household size are closely linked to aggregate anthropometric failure in India [22, 23]. Interestingly, a larger number of over-5-year-old children in a household have been found to be associated with *less* child anthropometric failure than if there were fewer children [23]. The role of household size in determining the nutritional status of children remains unclear. It is known that the mother's education is generally reflected in a child's wellbeing. Educated mothers could be more aware of health issues, with more means to get information than uneducated mothers [22]. Children of mothers with higher education tend to have better nutritional status [19, 23]. The mother's education level here was grouped into two categories for analysis: (i) primary or no education and (ii) secondary or higher education. Per capita income was obtained by dividing the total household income by the household size.

Fat and protein are important macronutrients for the growth of children. The main sources of fat and protein in the diet of the present study population were oil, dal/pulses, and meat/egg/fish among other foods. Information about per capita weekly consumption of oil, dal/pulses, and meat/egg/fish was derived from the household questionnaire where the adult respondent (in most cases the mother) was asked how often various items were consumed weekly in the household and the quantity of each item bought per week. Per capita weekly consumption of a specific item was derived by dividing the weekly purchase of that item by the number of family members. Specifically, weekly consumption of meat/egg/fish was derived by combining consumption of meat (in kg), eggs (1 egg $\approx$ 50 g), and fish (in kg).

2.4. Data Analysis. Basic characteristics of households and adolescents were described. Overall mean and standard deviation were obtained for height, weight, and BMI. We first compared the observed percentiles of height, weight, and BMI for the study population to the WHO and Indian reference populations. Percentages of stunting and thinness using the WHO and Indian reference populations were presented in bar charts. Not much is known about the correlation between height, weight, and BMI among adolescents of low-income and middle-income countries. We also computed Pearson correlation coefficients between these three measures separately for boys and girls. Descriptive statistics of independent variables are also presented.

The study subjects were recruited from 276 households and that resulted in more than one adolescent per household (171 households, 65%). The data on adolescents from the same household might be correlated and, hence, regression models used for the analysis included a household-specific random effect. The analysis was carried out using a generalized linear mixed model [24]. Age-adjusted means were obtained using

linear regression of each (denoted by y) height, weight, and BMI over age (denoted by x) using

$$y_{ih} = b_0 + b_1 x_i + \epsilon_{ih} + u_h, \quad i = 1, \ldots, n_h, \ h = 1, \ldots, H, \quad (1)$$

where b_0 and b_1 are the fixed effects, x is the age, ϵ is the random error due to the model, and u is the household-specific random effect. Both ϵ and u are assumed to be independent and normally distributed.

For the analysis of stunting and thinness, mixed effects logistic regression models were used. Regression analyses were carried out with age as an independent variable, and the other variables added to the model one by one. Multivariate analyses with age and consumption data were carried out in model 1, and in model 2, family information was added. The mixed effects logistic regression model specified in terms of the log odds is given as follows:

$$\log \left(\frac{p\left(y_{ih} = 1 \mid x_{ih}, b, h\right)}{p\left(y_{ih} = 0 \mid x_{ih}, b, h\right)} \right)$$
$$= b_0 + b_1 x_{1i} + b_2 x_{2i} + \cdots + b_p x_{pi} + u_h, \quad (2)$$
$$i = 1, \ldots, n_h, \quad h = 1, \ldots, H,$$

where y is a response variable (stunting or thinness), $x = (x_1, x_2, \ldots, x_p)$ is a vector of p independent variables, $b = (b_0, b_1, \ldots, b_p)$ is a vector of fixed effects, and u is the household-specific random effect.

All analyses were performed using the statistical computing environment R and the regression analyses were implemented using the glmer function from the package lme4 of R [25–27].

3. Results

3.1. Descriptive Statistics. The slum population was rather homogeneous with regard to native place (Maharashtra), mother tongue (Marathi), and eating habits. The major religion was Hindu (87%), followed by Muslim (10%), Buddhism (2%), and other (1%). Forty percent of the population belonged to scheduled caste (SC), 32% scheduled tribe (ST), 10% open, 9% other backward class (OBC), and 9% other caste. 51% houses were of type kaccha, 45% were of type pucca, and the rest 3% were semipucca.

The median ages (14 years) of boys and girls were the same (Table 1). 79% of boys and 82% of girls were currently studying and 52% (45%) of boys and 56% (41%) of girls described their general health as very good (good). 42% of the adolescents were in class 5–7 and 38% were in class 8–10, and 30% boys and 24% girls were engaged in earning money. 25% boys were smokers and 24% and 35% either chewed tobacco or used gutka. Among girls these percentages were the same (7%) but smaller compared to that of boys. 64% of mothers were at home while 18% worked as household helpers. The maximum percentage (44%) of fathers was labourers, 22% had small businesses, and 10% were in the service sector. Comparison of mean values showed that boys were taller than girls but there was no difference in the mean weight (Table 1). The 75th and 90th percentiles of height were higher by 7–9 cm among

TABLE 1: Means, standard deviation (SD), and percentiles of height, weight, and BMI for adolescents (combining 10–18 years) by sex.

| | Boys (N = 257) | | | | | | Girls (N = 261) | | | | | |
| | Mean (SD) | Percentiles | | | | | Mean (SD) | Percentiles | | | | |
		10	25	50	75	90		10	25	50	75	90
Age (years)	14 (2.5)	10	12	14	16	17	14 (2.3)	11	12	14	15	17
Height (cm)	150 (14)	131	139	149	162	169	147 (10)	131	140	148	155	158
Weight (kg)	37 (11)	23	29	36	45	50	37 (9)	25	30	38	43	48
BMI (kg/m^2)	16 (2)	13	15	16	18	19	17 (3)	14	15	17	19	21

TABLE 2: Means of height, weight, and BMI for adolescents by age and sex.

| Age (years) | Boys | | | | Girls | | | |
	N	Height (cm)	Weight (kg)	BMI (kg/m^2)	N	Height (cm)	Weight (kg)	BMI (kg/m^2)
10	27	134	25	14	16	136	28	14
11	30	138	29	15	36	139	30	15
12	40	142	32	15	40	142	33	15
13	31	146	35	16	31	144	35	16
14	25	151	38	16	33	147	38	16
15	21	155	41	17	40	150	40	17
16	32	159	44	17	26	153	43	17
17	29	163	47	18	22	156	45	18
18	22	167	50	18	17	158	48	18

boys compared to girls. The 10th, 25th, and 50th percentiles of weight were higher by about 2 kg among girls but the 75th and 90th percentiles were lower among girls compared to boys. The average BMI as well as percentiles were higher among girls than boys by 1-2 kg/m^2 (Table 1).

An age-wise summary of height and weight showed that height and weight increased with the increase in age in both sexes (Table 2). An average yearly increment in the mean height of boys was 3.6 cm, while that of girls was 2.4 cm, and an average yearly increment in the mean weight of boys was 2.7 kg, while that of girls was 2.2 kg. Girls were at least as tall as boys to the age of 12 years and the mean weight of girls showed a similar pattern to the age of 14 years. Boys tended to be taller than girls from the age of 13 years and heavier from the age of 15 years. The mean BMI for boys and girls was the same at all ages but showed increasing trend with age.

For boys, the Pearson's correlation coefficient between height and weight was 0.89, height and BMI was 0.50, and weight and BMI was 0.83, while for girls the same between height and weight was 0.76, height and BMI was 0.35, and weight and BMI was 0.87. For all adolescents combined, the Pearson's correlation coefficient between height and weight and between weight and BMI was 0.83, while it was lower between height and BMI (0.38), as observed in other studies.

3.2. Stunting and Thinness. The study population had lower median values (about 10 cm for height and 3 kg/m^2 for BMI) for all ages compared to both reference populations (Figure 1). The difference in median height narrowed after the age of 15 years but that of BMI remained the same. This was seen among boys as well as girls. It should be noted that the Indian reference population (of affluent urban adolescents)

had similar median values of BMI but slightly lower median heights compared to the WHO reference population. In the sequel, WHO and IND refer to the classifications based on the WHO and Indian reference populations, respectively. The percentages of stunting among boys (range WHO 13%–59% and IND 13%–41%) were similar using both the reference populations to the age of 12 years and after that the proportion was higher when the WHO reference population was used (except for the age 17 years, Figure 2). Among girls (range WHO 14%–44% and IND 4%–31%) the two classifications differed at all ages. Stunting showed an increasing trend with age among boys and a decreasing trend among girls. It was interesting to note that the proportion of stunted boys was lower compared to girls at ages 10 and 11 years, after which the trend was reversed.

The differences in the two classifications for thinness were much larger compared to stunting (Figure 3). The proportion of thinness, both among boys (range WHO 23%–52% and IND 0%–18%) and girls (range WHO 15%–38% and IND 4%–19%), first increased with age and then tapered off. Small proportions of overweight adolescent boys (range WHO 0%–8% and IND 0%–8%) were observed at ages 11, 15, and 16 years under the WHO but at the age of 14 years under both the classifications. Among girls (range WHO 0%–13% and IND 0%–10%) overweight was observed at ages 11, 12, 13, and 16 years under both classifications. For further analysis, stunting and thinness as defined by the Indian reference population were used.

3.3. Summary of Independent Variables (Table 3). The mean per capita income per month was INR 960 and INR 843 for boys and girls, respectively, which puts 60% boys and 68%

(a) Age versus median height for boys

(b) Age versus median height for girls

(c) Age versus median BMI for boys
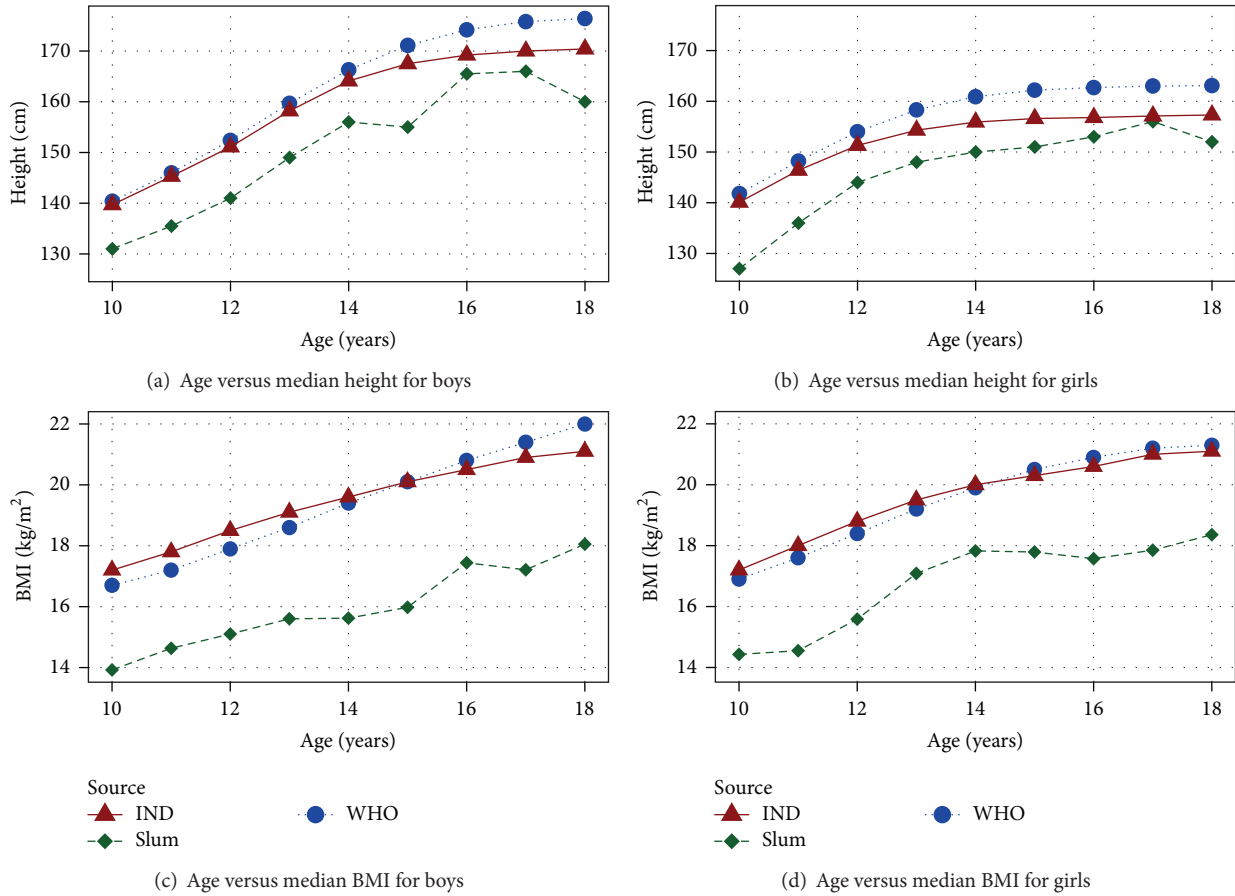

(d) Age versus median BMI for girls

FIGURE 1: Age versus median values of height and BMI of the study subjects (Slum), WHO, and Indian (IND) reference populations by sex.

TABLE 3: Mean, standard deviation (SD), and range (minimum, maximum) for dietary consumption data, income, household size, and percentage of mother's education by sex.

	Income* (INR)	Consumption of			Household size (%)			Mother's education (%)
		Oil* (kg)	Egg/meat/fish* (kg)	Dal/pulses* (kg)				
	Mean (SD)	Mean (SD) range	Mean (SD) range	Mean (SD) range	4 or less	5	More than 5	Primary or no
Boys (N = 257)	221 (140) (28, 1073)	0.23 (0.11) (0.02, 0.75)	0.13 (0.10) (0.00, 0.45)	0.08 (0.04) (0.00, 0.25)	35	30	35	49
Girls (N = 261)	194 (101) (29, 1035)	0.21 (0.10) (0.00, 0.75)	0.12 (0.09) (0.00, 0.45)	0.08 (0.05) (0.00, 0.40)	23	27	50	49

*Per capita weekly.

girls below the poverty line (below INR 961.1 per person per month for urban Maharashtra, [28]). 49% of mothers of the adolescents had primary or no education. The per capita weekly overall consumption of animal protein (meat, fish, and eggs, 120–130 g with SD of 100 g) as well as vegetable protein (dal/pulses, 80 g with SD of 40 g) was very low and similar in households with boys and girls. Intake of a source of energy, which was mainly oil (peanut oil in the study area), varied between negligible and 750 g per person per week. The distribution of household size differed between boys and girls with 50% girls having a household size of

more than 5 members while only 35% boys had more than 5 members. Except for consumption data on meat, egg, or fish (4% missing data), the proportion of missing data was less than 1% (Table 3).

3.4. Regression Analysis. A univariate regression analysis where log odds of stunting versus no stunting were modelled with age as an independent variable showed a significant effect in both boys and girls, but positive in boys and negative in girls (Table 4). An increase in age by one year increased the

TABLE 4: Stunting-regression coefficients (β) and 90% confidence intervals under the mixed effects logistic regression model for stunting by sex. Log odds of stunting versus no stunting were modeled. Each model included age and an additional covariate.

		Boys		Girls	
		β (CI)	$\exp(\beta)$ (CI)	β (CI)	$\exp(\beta)$ (CI)
Age		0.12* (0.01, 0.24)	1.13 (1.01, 1.27)	−0.18* (−0.35, −0.02)	0.83 (0.70, 0.98)
Household size	4 or less	Reference		Reference	
	5	0.28 (−0.41, 0.99)	1.33 (0.66, 2.69)	−0.88 (−1.87, 0.11)	0.41 (0.15, 1.12)
	More than 5	0.42 (−0.26, 1.11)	1.53 (0.77, 3.03)	−0.76 (−1.56, 0.03)	0.47 (0.21, 1.03)
Mother's education	Primary or no	Reference		Reference	
	Secondary or higher	−0.89* (−1.46, −0.33)[1]	0.41 (0.23, 0.72)	−1.42* (−2.32, −0.52)[3]	0.24 (0.10, 0.59)
Income	Standardized	0.11 (−0.15, 0.38)	1.12 (0.86, 1.46)	−1.02** (−1.64, −0.41)	0.36 (0.19, 0.66)
Consumption of	Oil	−0.89 (−3.62, 1.85)	0.41 (0.03, 6.36)	1.41 (−1.88, 4.69)	4.08 (0.15, 108.85)
	Dal/pulses	−0.90 (−7.68, 5.88)	0.41 (0.0005, 357.81)	3.84 (−2.78, 10.46)	46.53 (0.06, 34891.55)
	Egg/meat/fish	−2.93 (−6.23, 0.36)[2]	0.05 (0.002, 1.43)	0.49 (−3.53, 4.52)[4]	1.64 (0.03, 91.84)

[1] Age effect did not remain significant.
[2] Age effect became stronger, regression coefficient and CI were 0.14 (0.03, 0.27), P value = 0.05.
[3] Age effect became stronger, regression coefficient and CI were −0.22 (−0.40, −0.05), P value = 0.04.
[4] Age effect did not remain significant.
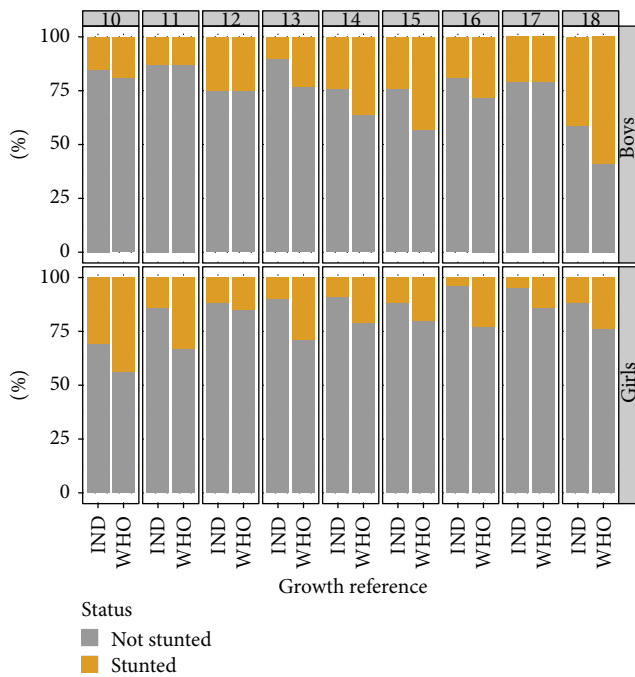* $0.01 \leq P$-value ≤ 0.10, and ** P-value < 0.01.

FIGURE 2: Percentages of stunted and not stunted study subjects by age and sex using WHO and Indian (IND) reference populations.
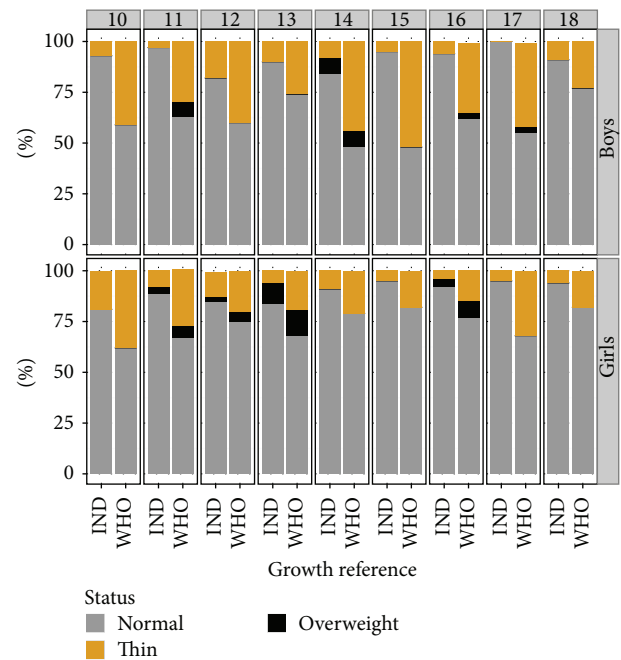
FIGURE 3: Percentages of thin, normal, and overweight study subjects by age and sex using WHO and Indian (IND) reference populations.

odds of stunting among boys by 13%, whereas it reduced the odds by 17% among girls.

Further, bivariate regression analyses were carried out by adding the independent variables, namely, household size, mother's education, income, and dietary data on consumption of oil, egg/meat/fish and dal/pulses, one by one to the model in addition to age. Mother's education was significantly associated with stunting (Table 4). When moving from primary or no education to secondary or higher education of

the mother, the odds of stunting reduced by 59% among boys and 76% among girls. Income was significantly associated with stunting among girls, with a ten standard deviation unit increase in income reducing the odds of stunting by 20% among girls. There was no significant effect of dietary data observed in this study.

The multivariate analysis under model 1 which included age and dietary data did not alter the age effect. The second model which in addition included mother's education,

TABLE 5: Thinness-regression coefficients (β) and 90% confidence intervals under the mixed effects logistic regression model for thinness by sex. Log odds of thinness versus normal BMI were modeled. Each model included age and an additional covariate.

		Boys		Girls	
		β (CI)	exp(β) (CI)	β (CI)	exp(β) (CI)
Age		−0.10 (−0.26, 0.06)	0.91 (0.77, 1.06)	−0.18* (−0.35, −0.02)	0.83 (0.70, 0.98)
Household size	4 or less	Reference		Reference	
	5	0.17 (−0.89, 1.23)	1.18	−0.88 (−1.87, 0.11)	0.41 (0.15, 3.42)
	More than 5	0.36 (−0.68, 1.41)	1.44 (0.51, 4.10)	−0.76 (−1.56, 0.03)	0.47 (0.21, 1.03)
Mother's education	Primary or no	Reference		Reference	
	Secondary or higher	0.12 (−0.71, 0.96)	1.13 (0.49, 2.61)	−1.42** (−2.32, −0.52)	0.24 (0.10, 0.59)
Income	Standardised	0.04 (−0.34, 0.43)	1.04 (0.71, 1.54)	−1.02** (−1.64, −0.41)	0.34 (0.19, 0.66)
Consumption of	Oil	1.13 (−2.62, 4.87)	3.08 (0.07, 130.32)	1.40 (−1.88, 4.69)	4.08 (0.15, 108.85)
	Dal/pulses	−7.44 (−19.26, 4.38)	0.0006 (0.43×10^{-8}, 79.83)	3.84 (−2.78, 10.46)	46.36 (0.06, 34891.55)
	Meat/egg/fish	−2.06 (−6.47, 2.35)	0.13 (0.002, 10.49)	0.49 (−3.53, 4.52)[1]	1.64 (0.03, 91.84)

[1] Age effect was not significant.
*$0.01 \leq P$-value ≤ 0.10, and **P-value < 0.01.

household size and income did not change the results of univariate analysis of each of these variables (adjusted for age). For boys, age did not remain significant in the second model but mother's education remained significant and had a similar effect as described earlier. For girls, age, mother's education, and income remained significant and in addition household size was also significantly associated with stunting. When moving from a household size of 4 or less to more than 5, the odds of stunting among girls were reduced by 70% (*data not shown*).

Similarly, odds of thinness versus normal BMI were analysed under the regression models with age as an independent variable and then each of the other variables was added to the model. None of the independent variables showed significant association with thinness among boys (Table 5). However, for girls, age, mother's education, and income were significantly associated with thinness. When mother's education increased from primary or no education to secondary or higher education, the odds of thinness versus normal BMI were reduced by 76%. One unit increase in a girl's age reduced the odds by 17% while a ten-standard-deviation-unit increase in income reduced the odds by 66%. Once again, dietary data did not show any significant effect. Multivariate analysis including all the independent variables did not change the results of univariate analysis, and age, mother's education, and income remained significant for girls with similar effects as described above (*data not shown*).

4. Discussion

This study examined the nutritional status and possible associated factors, of adolescents from an economically deprived slum population which constitutes a sizeable proportion of the overall Indian urban population. With increasing urbanization, this population is likely to grow. The adolescents of the present study had lower mean height and weight but comparable BMI-for-age compared to those reported in other studies on school children from Indian cities [13, 16, 29, 30]

but higher height and weight but lower BMI compared to school children (10–17 years) from the rural area of Wardha, Maharashtra, and rural area of northern Karnataka [30, 31].

Adolescent growth spurt is a universal phenomenon and occurs in all children during adolescence, though it varies in intensity and duration from one child to another. Growth spurt among girls was observed around the age of 13 years and it was around this age when menarche was attained (median age at menarche of the study girls was 13.7 years, data not shown) after that the BMI tapered off and so did height. For boys it happened about 2 years later that was around 15 years of age. During the growth spurt, boys gained about 20 cm (range 10–30 cm) in height accompanied by a gain in weight of about 20 kg (range 7–30 kg). The peak velocity of height growth averaged about 10 cm per year. In girls the spurt was somewhat narrower in magnitude, and the peak height velocity was averaging about 8 cm per year. Similar observations were also made in other studies [29, 32]. The difference in size between adult men and women is to a large extent the result of the differences in adolescent growth spurt occurrence. In boys the spurt occurs later, allowing an extra period for growth, even at the slow prepubertal velocity and partly because of the greater intensity of the spurt itself; prior to it, boys and girls are practically of the same height [29].

The growth reference curves for India were derived using apparently healthy affluent Indian children [11] and the present slum population seemed to have lower anthropometric profile in comparison. The prevalence of stunting was higher than the prevalence of thinness among boys and girls. The phenomenon of the higher proportion of stunting may indicate that consumption of foods rich in protein responsible for height was far below the required level. We make an observation that the Indian reference population had a higher median BMI-for-age than the WHO reference population which was derived from several countries including India (Figure 1). The prevalence of stunting and thinness was reduced when using the Indian reference population compared to the WHO reference population and similar observations were also made in other studies [33].

The prevalence of stunting was higher among boys than girls after the age of 11 years and also the prevalence of thinness was higher among boys at all ages, though not showing such trend systematically (Figures 2 and 3). This could be because girls were nutritionally better off than boys [34]. The total proportion of stunting was higher among boys (21%) compared to girls (11%) in this study. This highlights a less researched question about boys suffering growth related issues and possibly nutritional deficiency as the focus of such research has been mostly on girls and women.

With regard to BMI-for-age, a high proportion (90%) of the study population had normal nutritional status. The overall prevalence of being overweight (1% boys and 2% girls) and thinness (8%) were low compared to other studies on urban children. In this paper, no association was observed between dietary data and nutritional status. One reason for this could be that the study population was rather homogeneous with regard to the food habits and to some extent, life style.

A study from rural Wardha observed a significantly higher prevalence of stunting among adolescents from the lower family income group [35]. Surprisingly, one study found that a larger number of over-5-year-old children in a household was associated with less child anthropometric failure than if there were fewer children [23].

The association between stunting and thinness with higher income and more family members among girls is in line with the rural Wardha study [35] and Gaiha's study [23]. The mother's education was found to be an important factor affecting stunting as well as thinness among boys and girls in accordance with other studies [35–37].

In summary, boys with a higher prevalence of stunting compared to girls might have suffered from high levels of chronic undernutrition, a consistent lack of consumption of required nutrients both in quantity and quality, and partly from untreated infections. Proper care is needed for growing boys to meet their nutritional requirement according to age. Mother's education was highly significant in reducing stunting among both sexes, and hence, educating the mothers of adolescents about their nutritional needs may help in improving adolescents' anthropometric profile and future health. A longitudinal study looking at anthropometry and dietary intake data would be needed for planning of a proper nutritional intervention for urban slum populations to overcome the problem of stunting.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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References

[1] "Adolescents Nutrition: a review of the situation in selected South East Asian countries," World Health Organization, Regional office of South East Asia, Executive Summary, 2005, http://apps.searo.who.int/PDS_DOCS/B0239.pdf?ua=1.

[2] K. Anand, S. Kant, and S. K. Kapoor, "Nutritional status of adolescent school children in Rural North India," Indian Pediatrics, vol. 36, no. 8, pp. 810–815, 1999.

[3] S. Rao, "Nutritional status of the Indian population," Journal of Biosciences, vol. 26, no. 4, pp. 481–489, 2001.

[4] H. Delisle, V. C. Mauli, and B. De Benoist, "Should adolescents be specifically targeted for nutrition in developing countries? To address which problems and how?" http://www.idpas.org/pdf/1803ShouldAdolescentsBeTargeted.pdf.

[5] World Health Organization, "Physical status: the use and interpretation of anthropometry," Tech. Rep. 854, World Health Organization, Geneva, Switzerland, 1995.

[6] H. G. Thakor, P. Kumar, V. K. Desai, and R. K. Srivastava, "Physical growth standards of Urban Adolescents (10–15 years) from south Gujarat," Indian Journal of Community Medicine, vol. 25, no. 2, pp. 86–92, 2000.

[7] M. de Onis, A. W. Onyango, E. Borghi, A. Siyam, C. Nishida, and J. Siekmann, "Development of a WHO growth reference for school-aged children and adolescents," Bulletin of the World Health Organization, vol. 85, no. 9, pp. 660–667, 2007.

[8] D. Basu, G. Islam, R. Gogoi, S. Dey, and J. Deori, "Child's growth and nutritional status in two communities—Mishing tribe and Kaibarta caste of Assam," International Journal of Sociology and Anthropology, vol. 62, pp. 59–69, 2014.

[9] Fact sheet EURO/06/05, The Health of Children and Adolescents in Europe, World Health Organization, Copenhagen, Bucharest, 2005.

[10] M. S. Kramer, "Determinants of low birth weight: methodological assessment and meta-analysis," Bulletin of the World Health Organization, vol. 65, no. 5, pp. 663–737, 1987.

[11] V. V. Khadilkar, A. V. Khadilkar, T. J. Cole, and M. G. Sayyad, "Cross-sectional growth curves for height, weight and body mass index for affluent Indian children," Indian Pediatrics, vol. 46, no. 6, pp. 477–489, 2009.

[12] M. De Onis, "Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study," Acta Paediatrica, International Journal of Paediatrics, vol. 95, no. 450, pp. 56–65, 2006.

[13] G. J. Haboubi and R. B. Shaikh, "A comparison of the nutritional status of adolescents from selected schools of South India and UAE: a cross-sectional study," Indian Journal of Community Medicine, vol. 34, no. 2, pp. 108–111, 2009.

[14] Census of India, Single Year Age Data Table C13, 2011, http://www.censusindia.gov.in/2011census/Age_level_data/Age_level_data.html.

[15] S. Upinder, "Slum population in India: extent and policy response," International Journal of Research in Business and Social Science, vol. 2, no. 1, pp. 2147–4478, 2013.

[16] V. Kumaravel, V. Shriraam, M. Anitharani, S. Mahadevan, A. N. Balamurugan, and B. W. C. Sathiyasekaran, "Are the current

Indian growth charts really representative? Analysis of anthropometric assessment of school children in a South Indian district," *Indian Journal of Endocrinology and Metabolism*, vol. 18, no. 1, pp. 56–62, 2014.

[17] S. Mandal, V. R. Prabhakar, J. Pal, R. Parthasarathi, and R. Biswas, "An assessment of nutritional status of children aged 0–14 years in a slum area of Kolkata," *International Journal of Medicine and Public Health*, vol. 4, pp. 159–162, 2014.

[18] V. V. Khadilkar and A. V. Khadilkar, "Growth charts: a diagnostic tool," *Indian Journal of Endocrinology and Metabolism*, vol. 15, supplement 3, pp. S166–S171, 2011.

[19] R. H. Bradley and R. F. Corwyn, "Socioeconomic status and child development," *Annual Review of Psychology*, vol. 53, pp. 371–399, 2002.

[20] C. Paxson and N. Schady, *Cognitive Development Among Young Children in Ecuador: The Roles of Health, Wealth and Parenting*, World Bank, 2005, http://wws-roxen.princeton.edu/chwpapers/papers/paxson_schady_childrenecuador.pdf.

[21] A. Deaton and J. Drèze, "Food and nutrition in India: facts and interpretations," *Economic and Political Weekly*, vol. 44, no. 7, pp. 42–65, 2009.

[22] F. Arnold, S. Parasuraman, P. Arokiasamy, and M. Kothari, "Nutrition in India," National Family Health Survey (NFHS-3) 2005-06, International Institute for Population Sciences, Mumbai, India, ICF Macro, Calverton, Md, USA.

[23] R. Gaiha, R. Jha, and V. S. Kulkarni, "Child Under nutrition in India," http://ssrn.com/abstract=1734591.

[24] C. E. McCulloch, S. R. Searle, and J. M. Neuhaus, *Generalized, Linear, and Mixed Models*, Wiley Series in Probability and Statistics, John Wiley & Sons, Hoboken, NJ, USA, 2nd edition, 2008.

[25] R Core Team, *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria, 2013, http://www.r-project.org/.

[26] D. Bates, M. Maechler, B. Bolker, and S. Walker, "lme4: linear mixed-effects models using Eigen and S4," R Package Version 1.1-7, 2014, http://cran.r-project.org/web/packages/lme4/.

[27] D. Bates, M. Maechler, B. M. Bolker, and S. Walker, "lme4: linear mixed-effects models using Eigen and S4," Submitted to *Journal of Statistical Software*.

[28] *Press Note on Poverty Estimates, 2009–10*, Government of India, Planning Commission, 2012, http://planningcommission.nic.in/news/press_pov1903.pdf.

[29] S. S. Patil, S. R. Patil, P. M. Durgawale, S. V. Kakade, and K. Abhishek, "Study of physical growth standards of adolescents (10–15 years) from Karad, Maharashtra," *International Journal of Collaborative Research on Internal Medicine & Public Health*, vol. 5, no. 1, pp. 10–18, 2013.

[30] T. Rajaretnam and J. S. Hallad, "Nutritional status of adolescents in northern Karnataka, India," *Journal of Family Welfare*, vol. 58, no. 1, pp. 55–67, 2012.

[31] A. Taksande, P. Chaturvedi, K. Vilhekar, and M. Jain, "Distribution of blood pressure in school going children in rural area of Wardha district, Maharashatra, India," *Annals of Pediatric Cardiology*, vol. 1, no. 2, pp. 101–106, 2008.

[32] T. Bano, *A comparative study of health nutrition and socio-psycho behaviour of adolescent boys and girls [Ph.D. thesis]*, University of Kashmir, 2012.

[33] S. Maiti, D. De, K. Chatterjee, K. Jana, D. Ghosh, and S. Paul, "Prevalence of stunting and thinness among early adolescent school girls of Paschim Medinipur district, West Bengal," *International Journal of Biological and Medical Research*, vol. 2, no. 3, pp. 781–783, 2011.

[34] K. Venkaiah, K. Damayanti, M. U. Nayak, and K. Vijayaraghavan, "Diet and nutritional status of rural adolescents in India," *European Journal of Clinical Nutrition*, vol. 56, no. 11, pp. 1119–1125, 2002.

[35] P. R. Deshmukh, S. S. Gupta, M. S. Bharambe et al., "Nutritional status of adolescents in rural Wardha," *Indian Journal of Pediatrics*, vol. 73, no. 2, pp. 139–141, 2006.

[36] D. K. Das and R. Biswas, "Nutritional status of adolescent girls in a rural area of North 24 Parganas district, West Bengal," *Indian Journal of Public Health*, vol. 49, no. 1, pp. 18–21, 2005.

[37] A. Abudayya, M. Thoresen, Y. Abed, and G. Holmboe-Ottesen, "Overweight, stunting, and anemia are public health problems among low socioeconomic groups in school adolescents (12–15 years) in the North Gaza Strip," *Nutrition Research*, vol. 27, no. 12, pp. 762–771, 2007.

Mental health, anthropometry and blood pressure among adolescents living in slums of Nashik, India

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Abstract

Background: Both hypertension and depression are common disorders and obesity is on the rise in low and middle-income countries. Because early life changes may prove to be a precursor to the development of diseases in adult, assessing the mental and physical health of younger population is crucial. This study aimed to determine the association between blood pressure, mental health and anthropometric status of adolescents from urban slums in Nashik, India.

Methods: A cross-sectional observational study was conducted among eligible adolescents during November 2010 and April 2011 in two randomly selected slums of Nashik, Maharashtra, India. A total of 545 adolescents were selected from 276 households. Data on socio-demographic indicators, anthropometry, blood pressure, mental wellbeing, and addictions were collected using pretested structured questionnaires by house visits. Mental wellbeing was examined using the General Health Questionnaire with 12 items (GHQ-12). A higher score indicates more-optimal mental wellbeing. Linear mixed effects models were used to analyse the data.

Results: Girls had better mental wellbeing scores than boys. Adolescents with low mental wellbeing score had higher percentage of stunting (22%) compared to high scores. The factors associated significantly with systolic blood pressure (SBP) were age, mid mental wellbeing score, stunting, and thinness. For diastolic blood pressure (DBP), sex, high wellbeing score, and father's education were, in addition, also significant. When moving from the low to mid mental wellbeing score, SBP and DBP decreased and the same was observed for high score. The prevalence of prehypertension was 20%.

Conclusion: The findings showed that the adolescents do run a higher risk of substance abuse, health-related problems and higher SBP and DBP if there is an evidence of distress. It brings into focus the importance of mental health management in adolescents.

Keywords: adolescents, blood pressure, mental wellbeing, nutritional status, slums, India

Introduction

Depression is a common illness worldwide, with an estimated 350 million people of all ages suffering from it (WHO, 2012). The burden of depression and other mental health conditions is on the rise globally and is a leading cause of disability (WHO, 2012). Depression results from a complex interaction of social, psychological and biological factors. It is known to have association with physical health. For instance, hypertension and obesity can lead to depression and vice versa (WHO, 2012; Stein *et al.*, 2014). Among adolescents, depression is associated with poor health and behavioural outcomes, including higher risks of substance abuse, unsafe sexual practices, and violence (Saluja *et al.*, 2004) and lower achievement on tests, lower teacher-rated grades, and poorer peer relationships (Roeser *et al.*, 1998). Unfavourable living conditions of urban slums make them even more vulnerable, and may further increase the risk of substance abuse, adversely affect their general and mental health, and accelerate onset of chronic diseases such as high blood pressure and diabetes. These early life changes may prove to be a precursor to the development of diseases in adult life. Onset of depression before the age of 21 years has been of particular concern because of higher rates of recurrence, and higher overall rates of comorbid disorders, including substance abuse (Greden, 2001).

There have been a few studies exploring the interaction between mental and physical health

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among adolescents. Association between mental health and hypertension has been observed in general population (Stein *et al.,* 2014) and obesity among adolescents in the United States (Kiessling *et al.,* 2008; Tevie & Shaya, 2015). Both obesity and hypertension have shown to increase the odds of poor mental health in a representative United States population of children and adolescents (Tevie & Shaya, 2015). Hypertension can have its origin in childhood and may go undetected unless specifically looked for during this period (Aggarwal *et al.,* 1982). Although blood pressure normally increases with growth and development, children with higher levels of blood pressure tend either to maintain that position as they mature or progress to higher levels of blood pressure in adulthood in comparison to their peer group (Luepker *et al.,* 1999). Data from diverse populations show that the tracking of blood pressure from childhood into adulthood is very strong (Chen & Wang, 2008). There is a general lack of literature on the association between mental health and hypertension among adolescents who are not overweight or obese, and specifically growing up in unfavourable living conditions.

A number of community-based studies have demonstrated that there is a strong positive relationship between anthropometric measurements, especially bodyweight, and blood pressure in adolescents (Muntner *et al.,* 2004; Paradis *et al.,* 2004; Kelishadi *et al.,* 2006; Raj *et al.,* 2007). Obesity is recognised as an important risk factor for cardiovascular disease. The prevalence of obesity is increasing in both developed and developing countries (Delpeuch & Maire, 1997). Body mass index (BMI) is positively correlated with blood pressure even in lean or non-obese populations (Kaufman *et al.,* 1997; He *et al.,* 2000).

As a motivating example, we examined the association between blood pressure, mental health and anthropometric status (stunting and thinness) among adolescents using a sample from a study conducted in two slums of Nashik city in India. Mental wellbeing is a general term used in this article and is characterised by the score derived using the questions concentrated on symptoms related to potential depression and anxiety, self-esteem, stress, and coping.

Material and Methods

Study area
The study was conducted as a cross-sectional survey in two slums in Nashik, located on the banks of Godavari River in the state of Maharashtra, Western India. Nashik is a fast-growing largely industrial city of 1.5 million inhabitants, and situated less than 200 kilometres from Mumbai. Nashik urban agglomeration is the fourth largest in Maharashtra, and according to the census 2011, 12.77% of the city population reside in the slums (Census of India, 2011).

Study subjects and sampling
The present study was conducted during November 2010 and April 2011 in two randomly selected slums of Nashik, Maharashtra, India. The target sample size was 500 adolescents in the age group of 10 to 19 years residing in the selected slums. The sample size was determined based on the main purpose of the study, which was to describe the socio-demographic and health profile of adolescents of urban slums, and the limited budget available for data collection. For this purpose, households with eligible adolescents and which gave written consent to participate in the study were recruited. A total of 545 adolescents were selected from 276 households. Data on socio-demographic indicators, adolescents' anthropometry, blood pressure, mental wellbeing, and addictions were collected using pretested structured questionnaires by house visits.

Blood pressure
Blood pressure (BP) measurements were taken by a trained team in a quiet room in the presence of a parent or a legal guardian and special care was taken to ensure that the subject was calm. Subjects were advised to avoid stimulating beverages like tea or coffee before the BP measurements. They were asked to rest for 10 minutes before the measurements of blood pressure. Two measurements were taken five minutes apart, with the subject in a supine position with both arms stretched comfortably and naturally using a new aneroid sphygmomanometer with a certified accuracy of ± 2mmHg. The cuff

size used was appropriate to the child's right arm according to recommendations by the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004). The average of two systolic blood pressure (SBP) and two diastolic blood pressure (DBP) measurements were used for the analysis.

Blood pressure percentiles for given sex, age (between 10 and 17 years) and height were computed using the steps given in Appendix B and regression parameters given in Table B1 (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004). If a subject had both systolic as well as diastolic blood pressure percentiles for sex, age and height below 90 then he/she was classified as normotensive. If either of the blood pressure percentiles were above 95 then he/she was classified as hypertensive, and in other cases prehypertensive. A subject with SBP of 120 mm Hg or above, or with DBP 80 mm Hg or above was classified as prehypertensive even if the percentiles were below 90. For 18-year-old subjects, the standard definition of hypertension for adults was used. A subject was prehypertensive if SBP was at least 120 mm Hg but below 140 mm Hg, or DBP was at least 80 mm Hg but below 90 mm Hg, and hypertensive if SBP was 140 mm Hg or above, or DBP was 90 mm Hg or above. All the others were classified as normotensive.

Mental wellbeing
Mental wellbeing was examined using the General Health Questionnaire with 12 items (GHQ-12) with slight reformulation to suit the study subjects. GHQ is widely used as a screening instrument to identify psychological distress. The questions concentrated on symptoms related to potential depression and anxiety, self-esteem, stress, and coping. Each item response were in 4-point scoring system ranging from *better than normal* option, a *same as usual* and a *worse than usual* to a *much worse than usual* option. The responses were grouped into two categories: 1 (*better than normal* option) and 0 (other options), and then added up to derive a total score. The total ranged from 0 to 12; the higher the score, the better the adolescent's mental wellbeing. Similar binary scoring has been used in other studies (Ram *et al.,* 2014). Since there is no threshold available for such binary scoring, we classified each subject, using the tertile, into one of the three categories: (i) low: score less than or equal to 7; (ii) mid: score between 8 and 10, and (iii) high: score 11 or 12.

Anthropometric measurements
Data on height and weight were collected in the present study. Height (in cm) was measured using a simple non-elastic measurement tape to the nearest integer. Weight (in kg) was recorded using a new bathroom scale (brand Libra, Model no. 770) to the nearest integer. Two readings each were taken for height and weight and the average was used for analyses here. We refer to (Khopkar *et al.,* 2014) for more details of anthropometric measurements.

Family history of high blood pressure and parent's education
A family history of high blood pressure is known to be a strong risk factor of hypertension. The children of mothers with high education tend to have lower blood pressure (Berg *et al.,* 2013). We tested this hypothesis among the study subjects. The survey questionnaire included two questions on the family history of high blood pressure. If either of the parents was known to have high blood pressure then the family history of high blood pressure was coded as yes, and otherwise coded as no. We included both mother's and father's education in the analysis. The questionnaire included questions: "What is your mother's education level?" and "What is your father's education level?" These were used to obtain parents' education levels. The education levels were grouped into two categories: i) primary or no education, and ii) secondary or higher education, for the analysis purpose here.

Addiction and health-related variables
An individual was classified as using tobacco in any form currently if there was at least one positive answer to the question "Do you currently use any substances? (smoke, chew tobacco, gutka)". Similarly, current use of alcohol was defined. The questionnaire included questions on health-related

problems. Data on experience of neck and back pain, headache, sleep and energy, sadness, problems with interpersonal activities (personal relationship, participation in the community, dealing with tension) were used to examine their association with the mental wellbeing scores. Such associations would be helpful in assessing the scoring system used here for mental wellbeing questionnaire.

Ethical considerations

The field study was approved by the Institutional Review Board of Tampere School of Health Sciences in 2010. The study was conducted in accordance with the ethical guidelines in the Helsinki Declaration of 1975, as revised in 2000.

Data analysis

The analysis was restricted to the age group 10–18 years (boys = 257, girls = 261, total = 518) since the growth curves from India were available up to the age of 18 years. Systolic and diastolic blood pressures were considered as dependent variables. On the other hand, mental wellbeing, thinness and stunting were considered as independent variables. Sex, parental education and family history of blood pressure are known to affect blood pressure and were also considered as independent variables. Other factors such as current use of tobacco and alcohol, health-related problems were assessed with respect to mental wellbeing.

Body mass index (BMI, kg/m^2) was defined as the ratio of weight (in kg) to the square of height (in m). Height-for-age and BMI-for-age z-scores were derived using the Indian reference population (Khadilkar *et al.*, 2009). A subject was classified as stunted if the height-for-age score was below -2; thin if BMI-for-age score was below -2 and overweight if BMI-for-age score was above 1 (Khopkar *et al.*, 2014). Height can be considered to be a measure of childhood nutrition and hence, height was also of interest for this age group. We refer to the classification based on BMI-for-age as nutritional status categorised into normal, thin and overweight. A combined category of prehypertension and hypertension was used for the analysis and was referred to as prehypertension.

Mental wellbeing was central to the analysis presented here and hence, all the variables including blood pressure were summarised according to the mental wellbeing score being in low-, mid- or high-range. The association between blood pressure and mental wellbeing was studied using generalised linear mixed effects model. Data on adolescents from the same household might be correlated and hence, regression models used for the analysis included a household-specific random effect. One of our main hypotheses of interest was to test whether mental wellbeing was associated with SBP and DBP. Two linear mixed effects models were fitted for each SBP and DBP. The first model included age, sex and mental wellbeing score. In the second model, other factors which were expected to associate with blood pressure were added. To account for the effect of age on height and BMI, stunting and thinness were used in the second model in place of height and BMI. All analyses were performed using the statistical computing environment R and regression analyses were implemented using the Glmer function from the package lme4 of R (R Core Team, 2013; Bates *et al.*, 2014).

Results

The categorical variables defined above were summarized by providing proportions and blood pressure was summarised by sample mean and standard deviation, for the three categories of mental wellbeing score (Table 1). It was observed that girls had higher score compared to boys. The nutritional status of 91% of the adolescents was normal, and there were no differences observed in the mental wellbeing scores with regard to the nutritional status. However, the percentage of stunting was the highest (22%) among those with the low-score. The prevalence of current use of tobacco (20%) and alcohol (17%) were the lowest among those with the high-score. The same applies to the health-related problems, higher the score lower the prevalence of problems. Adolescents with higher mental scores tended to have higher percentage of both parents with secondary or higher education (61% mothers and 82% fathers) compared to lower score (46% mothers and 59% fathers). Mean systolic and diastolic blood pressure values decreased as the score increases and the prevalence of prehypertension was the lowest among

those in the range of high mental wellbeing score. The overall prevalence of prehypertension among the study subjects was 20%.

Table 1: Sample characteristics by mental wellbeing score

Variables		Total (N=497)	Mental wellbeing score		
			Low (≤7) (n=200)	Mid (8-10) (n=145)	High (≥11) (n=152)
Age (SD), years		13.8(2.4)	14(2.5)	14(2.4)	13.4(2.3)
Sex (% boys)		50	53	50	47
Height (SD),cm		148.3(12.5)	148(12.8)	148.8(12.6)	148.1(12.1)
Stunting (% stunted)		15	22	10	12
BMI (SD), kg/m^2		16.6(2.8)	16.7(2.6)	16.7(2.7)	16.4(3)
Nutritional status (%)	Normal	91	90	91	90
	Overweight	2	1	2	2
	Thin	8	8	7	8
Addiction	Currently using tobacco	27	30	32	20
	Currently consuming alcohol	20	21	23	17
Health-related problems	Neck and back pain, headache	79	93	79	62
	Sleep and energy related problem	45	53	43	34
	Sadness	15	17	17	12
	Interpersonal activities	29	40	29	13
	Mother's education	51	46	47	61
	Father's education	68	59	67	82
	Family history of BP	10	8	10	12
Blood pressure	SBP (SD), mmHg	105.7 (11.8)	106 (11.6)	105.4 (12.2)	105.7 (11.9)
	DBP (SD), mmHg	65 (7.1)	65.9 (7.5)	64.8 (7.4)	64.2 (6.3)
	Prehypertension (%)	20	20	22	19

When mental wellbeing score was used as an independent variable in a regression model, adjusted for age and sex, with systolic blood pressure as a dependent variable (Model 1, Table 2), no significant association was observed. But when diastolic blood pressure was used (Model 3, Table 2), there was significant decrease in DBP with increase in the score range, and sex was also significant with girls having higher DBP than boys. Model 2 and 4 included other factors which might affect blood pressure. The factors associated significantly with SBP (Model 2, Table 2) were age, mid mental wellbeing score (8, 9, or 10), stunting, and thinness. For DBP (Model 4, Table 2), sex, high mental wellbeing score, and father's education were, in addition, also significant.

Table 2: Regression coefficients and their 90% confidence intervals when systolic and diastolic blood pressure are regressed over mental wellbeing scores and other known risk factors

Variable		Systolic blood pressure		Diastolic blood pressure	
		Model 1	Model 2	Model 3	Model 4
Intercept		74.32*** (69.56, 79.07)	77.08*** (72.2, 81.97)	50.45*** (47.46, 53.44)	50.86*** (47.67, 54.04)
Age (in years)		2.28*** (1.95, 2.6)	2.26*** (1.95, 2.57)	1.05*** (0.84, 1.25)	1.04*** (0.84, 1.625)
Sex (Ref. boys)		-0.45 (-2, 1.1)	-1.31 (-2.8, 0.18)	1.73** (0.76, 2.7)	1.41** (0.44, 2.38)
Mental wellbeing score (Ref. score 7 or below)	Score (8, 9 or 10)	-0.65 (-2.58, 1.28)	-2.09* (-3.92, -0.26)	-1.25* (-2.46, -0.04)	-1.86** (-3.05, -0.67)
	Score (11 or 12)	1.14 (-0.8, 3.08)	0.23 (-1.64, 2.09)	-1.21 (-2.42, 0.01)	-1.67* (-2.88, -0.46)
Stunting (Ref. not stunted)			-8.88*** (-10.99, -6.77)		-2.63*** (-4, -1.25)
BMI-for-age (Ref. normal)	Overweight		11.94*** (6.13, 17.75)		5.86** (2.07, 9.65)
	Thin		-5.42** (-8.17, -2.68)		-3.45*** (-5.24, -1.66)
Family history of BP (Ref. no history)			-0.64 (-3.34, 2.06)		-1.00 (-2.74, 0.74)
Mother's education (Ref. primary or no education)			-1.14 (-2.81, 0.53)		-0.52 (-1.6, 0.56)
Father's education (Ref. primary or no education)			1.14 (-0.67, 2.94)		1.48* (0.31, 2.65)

Significance code: 0 `***` 0.001, `**` 0.01, `*` 0.1; Ref. Reference category used in the model

SBP and DBP increased when moving from normal to overweight category while decreased when moving to thin category. Stunted adolescents tended to have lower SBP and DBP compared to non-stunted. When moving from the low mental wellbeing score (7 or below) to mid score (8, 9, or 10), SBP and DBP decreased and the same was observed for high score. DBP was higher when moving from primary or no education for father to secondary or higher education.

Discussion

India has a large population of adolescents (10-19 years of age, 21%) and also of slum dwellers in urban areas (15% of total urban population of India) (Census of India, 2011; Upinder, 2013). Maharashtra has the highest slum population as a proportion of urban population (27.3%) in India (Upinder, 2013). Generally the slum population is economically poor and also hierarchically positioned low in a caste society. About two thirds of the study population was below the poverty line of the state of Maharashtra (below per capita income of Indian Rupee 961 or US$ 15). To the best of our knowledge, this is also the first study where the association between mental wellbeing and blood pressure of underprivileged adolescents of India has been examined. This study detects that the known factors of age, height and BMI, but not family history, influence blood pressure among adolescents. This may be partly explained by the low proportion of family history of high blood pressure. It also brings into focus that in a situation where the majority of study subjects were classified as normal with respect to BMI-for-age and 85% were not

stunted, reduction in distress among adolescents would help maintaining SBP and DBP at normal levels. An analysis of normal and non-stunted adolescents revealed that mid- and high- mental wellbeing scores had significantly lower DBP compared to low-score (data not shown). And mother's education also decreased DBP.

A recent study on adolescents from US brings into focus the maintenance of a healthy body mass index and control of hypertension in improving the mental health of younger populations in the US (Tevie & Shaya, 2015). Both high blood pressure and depression are very common disorders (Murray & Lopez, 2013). The relationship between high BP and depression is thought to be bidirectional by many researchers (Tevie & Shaya, 2015). However, it is natural to expect that the mental anxiety is likely to increase BP, first temporarily and it may later on develop to permanent hypertension, but it is not very clear how the relationship works the other way around.

Throughout adulthood, blood pressure is strongly and directly related to vascular as well as overall mortality (Lewington *et al.*, 2002). Early diagnosis, treatment, and follow-up of the hypertensive cases and preventive methods may decrease future morbidity and mortality. There is a wide variation in the prevalence of hypertension in children in India ranging from a high of 11% to as low as 0.46% (Mohan *et al.*, 2004; Singh *et al.*, 2006; Kumar *et al.*, 2012). The prevalence of prehypertension (hypertension and prehypertension combined) among the study population is comparable to that observed in developed countries, e.g. USA (18.9%) and Switzerland (24.7%) (McNiece *et al.*, 2007; Chiolero *et al.*, 2007).

A community-based cross-sectional study of adolescents aged 10-19 years from an urban slum of Chetla, Kolkata, India reported the prevalence of hypertension as 2.9% with the highest prevalence (5.6%) observed for the age group 18-19 years (Saha *et al.*, 2008). An epidemiological study of blood pressure among school children (5-14 Years) in Delhi showed that SBP and DBP increased with age in both sexes (Chadha *et al.*, 1999). The cut-off points for high blood pressure were based on the average SBP and/or DBP values of 95th percentile or greater for each age. In the age group 10-14 years, the values for SBP and DBP ranged from 72 mm Hg to 160 mm Hg and from 46 mm Hg to 120 mm Hg, for boys and girls, respectively. There was no significant difference in the prevalence of hypertension (systolic, diastolic or both) on the basis of gender. Anthropometric variables like height, weight and body mass index showed positive correlations with systolic as well as diastolic blood pressure. A family history of hypertension in one or both the parents was present in one-fifth of the children with high blood pressure (Chadha *et al.*, 1999).

The present study had several limitations which are worth mentioning. It was a small study with only two slums, and had two measurements of blood pressure as against the recommendation of three measurements. Comparisons of adolescents living in slums and non-slums with respect to the mental wellbeing and other socio-demographic factors would be of interest and a study with this aim need to be planned. The data on salt intake and physical activities were homogeneous and hence, the association between blood pressure and these variables could not be studied. In spite of these limitations, the study point towards an emerging public health issue of hypertension among adolescents and brings out the determinants that might require attention.

In conclusion, the adolescents do run a higher risk of substance abuse, health-related problems and higher SBP and DBP if there is an evidence of distress. These findings have important implications for mental health management in adolescents.

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References

Aggarwal, R., Mendoware, S.L., Bhandari, B. & Garg, O.P. (1982) Prevalence of hypertension in

apparently healthy school children. *Indian Pediatrics* 19, 779-789.

Bates, D., Maechler, M., Bolker, B., Walker, S. lme (2014) Linear mixed-effects models using Eigen and S4. R package version 1.1-7, 2014, (URL: http://CRAN.R-project.org/package=lme4).

Berg, G.V.D., Eijsden, M.V., Galindo-Garre, F., Vrijkotte, T.G.M. & Gemke, R.J.B.J. (2013) Explaining socioeconomic inequalities in childhood blood pressure and prehypertension: The ABCD study. *Hypertension* 61, 35-41.

Census of India (2011) Single year age data Table C13. (available from http://www.censusindia.gov.in/2011census/Age_level_data/Age_level_data.html).

Chadha, S.L., Tandon, R., Shekhawat, S. & Gopinath, N. (1999) An epidemiological study of blood pressure in school children (5–14 years) in Delhi. *Indian Heart Journal* 51, 178–182.

Chen, X. & Wang, Y. (2008) Tracking of blood pressure from childhood to adulthood: a systematic review and meta-regression analysis. *Circulation* 117, 3171-3180.

Chiolero, A., Paccaud, F. & Bovet, P. (2007) Pre-hypertension and hypertension among adolescents of Switzerland. *Journal of Pediatrics* 151: e24-e25.

Delpeuch, F. & Maire, B. (1997) Obesity and developing countries of the south. *Med Trop* (Mars). 1997; 57, 380-388.

Greden, J. (2001) The burden of recurrent depression: causes, consequences, and future prospects. *Journal of Clinical Psychiatry* 62, 5–9.

He, Q., Ding, Z.Y., Fong, D.Y-T. & Karlberg, J. (2000) Blood pressure is associated with body mass index in both normal and obese children. *Hypertension* 36, 165-170.

Kaufman, J.S., Asuzu, M.C., Mufunda, J., Forrester, T., Wilks, R., Luke, A., Long, A.E. & Cooper, R.S. (1997) Relationship between blood pressure and body mass index in lean populations. *Hypertension* 30, 1511-1516.

Kelishadi, R., Ardalan, G., Gheiratmand, R., Majdzadeh, R., Delavari, A., Heshmat, R., Gouya, M.M., Razaghi, E.M., Motaghian, M., Mokhtari, M.R., Barekati, H., Arabi, M.S. CAPSIAN Study Group (2006) Blood pressure and its influencing factors in a national representative sample of Iranian children and adolescents: the CASPIAN Study. *European Journal of Cardiovascular and Preventive Rehabilitation* 13, 956-963.

Khadilkar, V.V., Khadilkar, A.V., Cole, T.J. & Sayyad, M.G. (2009) Cross-sectional growth curves for height, weight and body mass index for affluent Indian children. *Indian Pediatrics* 46, 477-489.

Khopkar, S.A., Virtanen, S.M. & Kulathinal, S. (2014) Anthropometric characteristics of underprivileged adolescents: a study from urban slums of India. *Journal of Anthropology.* Article ID 197048. doi:10.1155/2014/197048.

Kiessling, S.G., McClanahan, K.K. & Omar, H.A. (2008) Obesity, hypertension, and mental health evaluation in adolescents: A comprehensive approach. *International Journal of Adolescent Medicine and Health* 20, 5-15.

Kumar, J., Deshmukh, P.R. & Garg, B.S. (2012) Prevalence and correlates of sustained hypertension in adolescents of rural Wardha, Central India. *Indian Journal of Pediatrics* 79, 1206–1212.

Lewington, S., Clarke, R., Qizilbash, N., Peto, R. & Collins, R. (2002) Prospective Studies Collaboration. Age specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet* 360, 1903-1913.

Luepker, R.V., Jacobs, D.R., Prineas, R.J. & Sinaiko, A.R. (1999) Secular trends of blood pressure and body size in a multi-ethnic adolescent population: 1986 to 1996. *Journal of Pediatrics* 134, 668-674.

McNiece, K.L., Poffenbarger, T.S., Turner, J.L., Franco, K.D., Sorof, J.M. & Portman, R.J. (2007) Prevalence of hypertension and pre-hypertension among adolescents. *Journal of Pediatrics* 150, 640-644.

Mohan, B., Kumar, N., Aslam, N., Rangbulla, A., Kumbkarni, S., Sood, N.K. & Wander, G.S. (2004) Prevalence of sustained hypertension and obesity in urban and rural school going children in Ludhiana. *Indian Heart Journal* 56, 310–314.

Muntner, P., He, J., Cutler, J.A., Wildman, R.P. & Whelton, P.K. (2004) Trends in blood pressure among children and adolescents. *JAMA* 291, 2107-2113.

Murray, C. & Lopez, A. (2013) Global Health Measuring the Global Burden of Disease. *New England Journal of Medicine* 369, 448-557.

Paradis, G., Lambert, M., O'Loughlin, J., Lavallée, C., Aubin, J., Delvin, E. & Hanley, J.A. (2004) Blood pressure and adiposity in children and adolescents. *Circulation* 110, 1832-1838.

R Core Team, "R: A language and environment for statistical computing. R Foundation for Statistical Computing," Vienna, 2013, Austria. (URL: http://www.R-project.org/).

Raj, M., Sundaram, K.R., Paul, M., Deepa, A.S. & Kumar, R.K. (2007) Obesity in Indian children: time trends and relationship with hypertension. *National Medical Journal of India* 20, 288-293.

Ram, U., Strohschein, L. & Gaur, K. (2014) Gender socialization: Differences between male and female youth in India and associations with mental health. *International Journal of Population Research* Article ID 357145. doi 10.1155/2014/357145.

Roeser, R., Eccles, J. & Strobel, K. (1998) Linking the study of schooling and mental health: selected issues and empirical illustrations at the level of the individual. *Educational Psychologist* 33, 153–176.

Saha, I., Paul, B. & Dasgupta, A. (2008) Prevalence of hypertension and variation of blood pressure with age among adolescents in Chelta, India. *Tanzania Journal of Health Research* 10, 108-111.

Saluja, G., Iachan, R., Scheidt, P.C., Overpeck, M.D., Sun, W. & Giedd, J.N. (2004) Prevalence of and risk factors for depressive symptoms among young adolescents. *Achieves of Pediatrics and Adolescent Medicine* 158, 760–765.

Singh, A.K., Maheshwari, A., Sharma, N. & Anand, K. (2006) Lifestyle associated risk factors in adolescents. *Indian Journal of Pediatrics* 73, 901–906.

Stein, D.J., Aguilar-Gaxiola, S., Alonso, J., Bruffaerts, R., de Jonge, P., Liu, Z., Miguel Caldas-de-Almeida, J., O'Neill, S., Viana, M.C., Al-Hamzawi, A.O., Angermeyer, M.C., Benjet, C., de Graaf, R., Ferry, F., Kovess-Masfety, V., Levinson, D., de Girolamo, G., Florescu, S., Hu, C., Kawakami, N., Maria Haro, J., Piazza, M., Posada-Villa, J., Wojtyniak, B.J., Xavier, M., Lim, C.C., Kessler, R.C., Scott, K.M. (2014) Associations between mental disorders and subsequent onset of hypertension. *General Hospital Psychiatry* 36, 142–149.

Tevie, J. & Shaya, F.T. (2015) Association between mental health and comorbid obesity and hypertension among children and adolescents in the US. *European Child Adolescent Psychiatry* 24, 497–502.

National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004) The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescent. *Pediatrics* 114 (Suppl 4th Report), 555-576.

Upinder, S. (2013) Slum population in India: Extent and policy response. *International Journal of Research in Business and Social Science* 2, 47-56.

World Health Organisation (WHO) Depression, Fact sheet N°369 October 2012. URL: http://www.who.int/mediacentre/factsheets/fs369/en/

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Age at menarche and diet among adolescents in slums of Nashik, India

Abstract

Background and aim: The role of dietary patterns in determining age at menarche is insufficiently understood in low-income countries. The relationship between dietary patterns, particularly the consumption of oil, and age at menarche in a slum-dwelling adolescent population in India is examined.

Methods: Data were derived from a cross-sectional baseline survey and anthropometric measurements among 10- to 19-year-old adolescents (n=545, female respondents 272, of whom 160 were post-menarcheal) and a household survey in two slums in the city of Nashik, Western India. By using mixed effects linear regression models, the association between age at menarche and household-wise use of sources of animal protein and oil and fat is examined.

Results: Age at menarche (mean 13.7 years) in the slums studied was relatively high according to Indian standards. Age at menarche and the consumption of dairy products, meat, fish and eggs were not associated. The household per capita consumption of vegetable oil had an inverse association with a girl's age at menarche, and there was an indication of a positive association between use of ghee (clarified butter) and age at menarche. These associations did not disappear when controlling for anthropometric status and socio-economic characteristics.

Conclusions: Intake of fats and foods that are important sources of protein among underprivileged households in India is low and reflected in the relatively late age at menarche. The potential differences in the association between various types of fatty acids, energy intake and age at menarche in conditions of undernutrition requires further prospective study.

Keywords: low-income countries; nutrition; women's health.

Background

The average age at menarche has been declining in industrialized countries during the last 150 years (1), and a similar trend is occurring in low-income countries along improvements in nutritional status (2). This decline has been indicated to have a relationship with upward shift in body mass index (BMI) and increased obesity, both at individual level and country level (3). Age at menarche is known to be universally related to urban or rural residence and socio-economic group (2, 4).

In addition to the most important genetic determinants of age at menarche, the single environmental factor that stands out – possibly explaining as much as 25% of the individual variation in the timing of puberty – is nutritional status in childhood (3). The most widely studied dietary factor in relation to age at menarche is energy intake. In a review article, age at menarche in developing societies is concluded to reflect a trend in energy balance rather than in general nutritional status (5).

The level of animal protein intake in childhood has been proposed as a potential factor relating to variation in age at menarche in western societies (6–8). Higher consumption of meat either in early, middle or late childhood has been found to be associated with earlier age at menarche in some studies (6, 9, 10), but the results on the association between macronutrients in the period preceding menarche and age at menarche remain inconclusive in others (11–13). In India, a relationship between vegetarianism and later age at menarche was found in one study (14), while another failed to establish any statistically

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significant relationship (15). In a Turkish study (16) and in two Chinese studies (17, 18), no association between intake of animal protein or milk and menarche was detected. In an Iranian study (19), pre-pubertal intake of milk, but not cheese and yogurt, was related to earlier age at menarche. The range of child undernutrition in India is way beyond any of these countries. In India, 48% of under-5-year-olds are at least moderately stunted, which is higher than in sub-Saharan Africa (20). Consequently, the nutritional dynamics of reproductive development may differ.

A relationship between consumption of fat and age at menarche has been suggested. Based on the association of high-fat diets with early estrous cycle in rats (11, 21), it is hypothesized that higher intakes of total and saturated fatty acids could relate with earlier menarche in humans as well. Due to the inconclusive results this far, the relationship between diet and pubertal onset needs more intensive evaluation (1).

This study examines the relationship between diet, particularly the consumption of oil and animal protein, and age at menarche in a socioeconomically underprivileged urban population. Studying this type of context provides further insights into the relationship between animal protein and fat intake and age at menarche and deepens our understanding of the factors related to changing age at menarche and women's health. We test the hypothesis that higher levels of animal protein and oil consumption relate to earlier age at menarche when anthropometric measures and relevant socio-economic variables are controlled.

Data and method

Data collection

The data for the analysis were collected in a cross-sectional survey in two slums in the Western Indian city of Nashik. Nashik is a fast-growing largely industrial city of 1.5 million inhabitants in the western Indian state of Maharashtra and situated <200 km from Mumbai. The field study was approved by the Institutional Review Board of Tampere School of Health Sciences in 2010. The study was conducted in accordance with the ethical guidelines in the Helsinki Declaration of 1975, as revised in 2000.

One slum within the city limits (out of 32 notified slums) was randomly selected and another slum on the outskirts of the city (out of 27 notified slums). First, the household composition of households in the two slums was surveyed to identify households with resident adolescents aged 10–19 years. Second, 200 such households were selected from slum number 1 and 150 such households in slum number 2, totaling to 350 households, of which 156 (slum number 1) and 120 (slum number 2) agreed to participate in the study. The total number of adolescents included in the study was 545.

Survey questions in the local language Marathi ranged from nutrition, substance use, mental wellbeing and reproductive health issues to social relations. Permission to use their data in a study was secured orally both from the guardian and the adolescent. Height was measured using a stadiometer to the nearest centimeter. Weight was recorded using bathroom scale to the nearest kilogram. Two readings for each height and weight were recorded, and the average is taken for the analysis here. Because in some cases more than one adolescent was recruited from the same household, the regression models used for the analysis included a random effect for household. For the analysis of age at menarche, mixed effects linear regression models were used. All analyses were performed by open source statistical program R using function glmer of package lme4 (22–24).

As the *dependent variable*, the recorded age at menarche as retrospectively informed by the girl herself and recorded in full years was used. *Independent variables* included dietary patterns, anthropometric variables (height and the mass index, BMI), and socioeconomic variables (number of household members, parents' education and caste category, and household per capita income). The following dietary variables were examined as independent variables: household weekly per capita consumption of meat, fish and eggs; dairy products (milk, yoghurt); dhal (pulses; a source of vegetable protein); vegetable oil; ghee; and grains (wheat and rice). The cooking oil universally used in the area is peanut oil. Ghee is clarified butter made of cow's or water buffalo's milk. Associations of the independent variables were examined first in univariate linear regression with the age at menarche as a dependent variable. Based on these univariate regression analyses, the influence of some of the dietary and other variables were modeled with control variables in multivariate linear regression analysis.

Household dietary patterns are derived from the household questionnaire where an adult respondent was asked about how many times weekly the item is consumed in the household and the quantity of the item procured weekly. Although the household division of food may not be equal, we assume that variation in the household availability of food items is significantly and consistently reflected in their availability to the young girls as well. We assume that the current dietary patterns in the household are a relevant although not absolute indication of the nutritional situation of the girl during the recent years.

When determining the weekly household procurement of dairy, meat and other animal protein food items, the quantity of yoghurt (curd) and milk was combined into dairy consumption (cheese is not part of the traditional diet in this region) in liters, and the quantity of meat, fish and eggs was combined into consumption in kilograms. Eggs were calculated as 50 g per egg. Then these weekly quantities were divided by the number of household members to calculate the household per capita weekly consumption of dairy and meat, fish and egg food items. Vegetable oil and ghee consumption were estimated using the same method, in kilograms.

Results

Descriptive statistics

Out of the total of 272 female respondents, 160 girls had attained menarche. The mean age at menarche was

13.7 years (SD 0.962) and median 14 years. Eight percent had reached menarche before they turned 13, and 4% after their 16th birthday (Table 1).

The economic level of wellbeing among the house-holds of the adolescent girls was low. Two thirds of the surveyed post-menarcheal girls' households were below the poverty line of the Indian Planning Commission for urban Maharashtra 2009–10 (25, 26). Of all mothers of the adolescent girls, nearly every other and 29% of the fathers had no or below primary education (descriptive statistics not shown). The most common caste categories of the respondents were Scheduled Tribes and Scheduled Castes that are the two lowest categories in social hierarchy; 73% of all respondents originated in these two categories.

The consumption of sources of animal protein (dairy products and/or meat, fish and eggs) and vegetable protein (dhal) in the households of respondents was very limited. Oil procurement was from negligible to 0.5 L per person per week, mean being 200 g. Vegetable oil was replaced by the use of ghee in some households. The mean of ghee consumption per capita was 27 g per week.

Regression analysis

Univariate regression coefficients were calculated on a number of dietary variables, anthropometric variables (BMI and height) and household size, parent's education and caste category when regressed on age at menarche. Only three variables examined separately produced statistically significant coefficients in 90% confidence level: per capita vegetable oil consumption (–1.485), ghee consumption (5.025), and height (0.032; significant also in 95% confidence level; univariate analysis not shown).

In order to analyze dietary patterns more closely, a linear regression analysis was carried out in three different models (Table 2):

Table 1: Percentage of female respondents who had had menarche, according to age at menarche.

Age at menarche, years	Frequency	Percent	Cumulative Percent
11	1	0.6	0.6
12	11	6.9	7.5
13	60	37.5	45.0
14	63	39.4	84.4
15	18	11.2	95.6
16	6	3.8	99.4
17	1	0.6	100.0
Total	160	100.0	

Table 2: Linear regression coefficients (unstandardized) between age at menarche and nutritional, anthropometric and economic variables in three models, and 90% confidence intervals (CI).

	B	CI (90%)	p. z.
Model 1			
(Constant)	13.987	13.568, 14.405	0.000
Consumption of vegetable oil	−2.160	−3.617, −0.702	0.015
Consumption of meat, fish, eggs	−0.572	−2.084, 0.939	0.535
Consumption of dairy products	0.322	−1.532, 2.175	0.776
Consumption of ghee	6.665	2.379, 10.951	0.012
Model 2			
(Constant)	8.562	5.950, 11.175	0.000
Consumption of vegetable oil	−2.146	−3.554, −0.737	0.012
Consumption of meat, fish, eggs	−0.381	−1.847, 1.085	0.670
Consumption of dairy products	0.802	−1.012, 2.616	0.469
Consumption of ghee	6.379	2.195, 10.563	0.012
Height	0.034	0.018, 0.050	0.001
BMI	0.011	−0.033, 0.056	0.678
Model 3			
(Constant)	7.954	5.254, 10.653	0.000
Consumption of vegetable oil	−1.967	−3.421, −0.514	0.026
Consumption of meat, fish, eggs	−0.278	−1.784, 1.228	0.762
Consumption of dairy products	0.766	−1.062, 2.594	0.492
Consumption of ghee	6.169	1.896, 10.442	0.018
Height	0.037	0.020, 0.053	0.000
BMI	0.014	−0.031, 0.059	0.606
Caste category (SC ref.)			
ST	0.298	−0.038, 0.633	0.146
OBC	0.047	−0.420, 0.514	0.868
Other	0.229	−0.156, 0.614	0.329

- First model: Per capita household consumption of vegetable oil; meat, fish and eggs; dairy products; and ghee.
- Second model: Anthropometric variables (height and BMI) were added.
- Third model: Caste categories were added.

First, the association of four dietary variables with age at menarche was examined. Vegetable oil (–2.160) and meat, fish and eggs (–0.572) consumption had negative coefficients, but of these only oil was significant. The coefficient of ghee was strongly positive (6.665) and also appeared highly significant (Table 2). Because dietary patterns related to the consumption of food that are important sources of protein and fat could potentially relate to the total energy intake and anthropometric status of the girl, height and BMI were added in the second model. Height was highly significantly but only slightly positively associated with age at menarche (coefficient 0.034), and BMI did not show an association with age at menarche in the model (coefficient 0.011). The coefficients of vegetable oil and ghee remained relatively unchanged even when anthropometry was taken into account.

The third model examined whether adding some basic socioeconomic variables could change the association between the consumption of oil and ghee and age at menarche. Caste categories were here analyzed, using Scheduled Caste as the reference population. The coefficients of oil and ghee consumption and height did not change considerably and remained significant. Caste categories did not produce statistically significant coefficients, although the coefficient of Scheduled Tribes shows some indication of a positive relationship with age at menarche compared with girls of Scheduled Castes. Also, per capita household income was tried out in the model as a potential confounder of the association between oil and ghee consumption and age at menarche, but the regression coefficient became very close to zero, as also in univariate regression.

In a linear regression model controlling for dietary patterns, anthropometric status and social background, the consumption of vegetable oil and ghee remain statistically significantly associated with age at menarche. This relationship is inverse so that girls from households consuming more vegetable oil tend to have their first menses earlier. Those consuming more ghee appear in turn to have a tendency to have their menses later. The association between these two types of fats and age at menarche did not disappear when bringing into the model anthropometric status or socioeconomic situation of the household. However, the relationship between ghee consumption and age at menarche should be interpreted cautiously due to skewness of the distribution. Of all the households of the girls, 53% did not consume any ghee at all.

Discussion

Indian socio-economic differences in age at menarche still tend to be extensive (2, 15, 26). The poor economic situation of the slum population makes the relatively late mean age at menarche in the sample intelligible. Age at menarche (mean 13.7, SD 0.962) is higher than even in some other Indian studies of underprivileged populations (14, 27).

The adolescent population under study is commonly stunted and wasted, even when Indian reference population instead of WHO standards is used (Khopkar et al., unpublished manuscript). In South Asia, girls whose anthropometric status is better tend to have earlier age at menarche (14, 28, 29). In our analysis, the BMI was not associated with age at menarche in univariate regression and neither in multivariate regression models. Height in

turn remained significant, although the coefficient was small in multivariate models. It has been suggested that the percentage of body fat may be a more relevant factor than BMI or other anthropometric measures in explaining age at menarche in India (4) as elsewhere (11). Prospective anthropometric and dietary data would be needed for a more profound analysis on the relationship between age at menarche and anthropometric condition.

The adolescents studied here form a socio-economically and culturally relatively homogenous and starkly underprivileged population in terms of caste, parental education, income and food consumption. The majority of people receive very little animal protein, and in the surveyed population, also the consumption of vegetable protein is low. The staple diet in the slums consists of unleavened wheat bread and cooked rice, eaten with vegetable curry or homemade pickle or chutney, and occasionally dhal (thick stew prepared of split pulses). Some households also prepare unleavened bread of pearl millet (*bajri*).

Oil consumption and age at menarche were associated in these data, but the quality of the oil makes a difference to the direction of effect. Vegetable oil was inversely related to age at menarche while ghee, butter oil, was positively related with it. The evidenced relationship between oil and age at menarche was contrary to many studies in high-income countries that have generally failed to establish a relationship (6).

In an American prospective cohort study (11), a weak association was found between intake of saturated fatty acids and oleic acid with *later* menarche and the intake of n-3 fatty acids associated with *earlier* menarche. This study gives further indication of the potentially divergent roles of different fats in relation to age at menarche and more widely to women's reproductive health. The vegetable oil used in this region is mostly peanut oil, which contains about 50% oleic acids, a third of linoleic acids and relatively less (17%) of saturated fats compared to many other types of vegetable oils or ghee which has 62% of saturated fatty acids and high content of cholesterol (30).

It remains to be further studied whether and why the type of fat consumed makes a difference for reproductive development and women's health in conditions of low energy intake and common undernutrition. The potentially changing dietary patterns accompanied by economic development may lead to unexpected consequences for the health of those who have suffered from food scarcity for generations. Because oil is a highly valued food item, improvement in income level among the economically poor leads to replacement of cereals by oils and other food items (31).

After controlling for other potential factors, this study did not find evidence of a relationship between consumption of other food items than fats and age at menarche. The absence of association between the consumption of animal protein and age at menarche is in line with Wiley's (7) study in the US and a number of older studies in high-income countries (11–13) as well as studies in Turkey (16), China (17) and Iran (19).

Declining age at menarche has attracted considerable epidemiological attention and concern. In high-income societies women who have relatively lower age at menarche face higher risk of lifetime morbidity and overall mortality (32). In patriarchal low-income countries, early age at menarche may lead to withdrawal of a girl from school and earlier marriage arrangement than in the case of later menarche, in order to avoid her reputation being spoiled by mixing with boys. Examining age at menarche and associated factors provides further understanding into how environmental factors and dietary habits relate to girls' and women's health in changing societies.

References

1. Sloboda DM, Hickey M, Hart R. Reproduction in females: the role of the early life environment. Hum Reprod Update 2011;17:210–27.
2. Parent A-S, Teilmann G, Juul A, Skakkebaek NE, Toppari J, et al. The timing of normal puberty and the age limits of sexual precocity: variations around the world, secular trends, and changes after migration. Endocr Rev 2003;24:668–93.
3. Karlberg J. Secular trends in pubertal development. Horm Res 2002;57(Suppl 2):19–30.
4. Rao S, Joshi S, Kanade A. Height velocity, body fat and menarcheal age of Indian girls. Indian Pediatr 1998;35:619–28.
5. Thomas F, Renaud F, Benefice E, de Meeüs T, Guegan JF. International variability of ages at menarche and menopause: patterns and main determinants. Hum Biol 2001;73:271–90.
6. Rogers IS, Northstone K, Dunger DB, Cooper AR, Ness AR, et al. Diet throughout childhood and age at menarche in a contemporary cohort of British girls. Public Health Nutr 2010;13:2052–63.
7. Wiley AS. Milk intake and total dairy consumption: associations with early menarche in NHANES 1999–2004. PLoS One 2011;6:e14685.

8. Berkey CS, Gardner JD, Frazier AL, Colditz GA. Relation of childhood diet and body size to menarche and adolescent growth in girls. Am J Epidemiol 2000;152:446–52.
9. Kralj-Čerček L. The influence of food, body fluid and social origin on the age at menarche. Hum Biol 1956;28:393–406.
10. Günther ALB, Karaolis-Danckert N, Kroke A, Remer T, Buyken AE. Dietary protein intake throughout childhood is associated with the timing of puberty. J Nutr 2010;140:565–71.
11. Maclure M, Travis LB, Willett WC, MacMahon B. A prospective cohort study of nutrient intake and age at menarche. Am J Clin Nutr 1991;54:649–56.
12. Moisan J, Meyer F, Gingras S. Diet and age at menarche. Cancer Causes Control 1990;1:149–54.
13. Petridou E, Syrigou E, Toupadaki N, Zavitsanos X, Willett W, et al. Determinants of age at menarche as early life predictors of breast cancer risk. Int J Cancer 1996;68:193–8.
14. Bagga A, Kulkarni S. Age at menarche and secular trend in Maharashtrian (Indian) girls. Acta Biol Szege 2000;44:53–7.
15. Rokade S, Mane A. A study of age at menarche, the secular trend and factors associated with it. Internet J Biol Anthropol 2008;3:2. Available at: http://ispub.com/IJBA/3/2/7469#. Accessed 19 June 2014.
16. Atay Z, Turan S, Guran T, Furman A, Bereket A. Puberty and influencing factors in schoolgirls living in Istanbul: end of the secular trend? Pediatrics 2011;128:e40. DOI: 10.1542/peds.2010–2267.
17. Zhu K, Zhang Q, Foo LH, Trube A, Ma G, et al. Growth, bone mass, and vitamin D status of Chinese adolescent girls 3 y after withdrawal of milk supplementation. Am J Clin Nutr 2006;83:714–21.
18. Kwok MK, Leung GM, Lam TH, Schooling CM. Breastfeeding, childhood milk consumption, and onset of puberty. Pediatrics 2012;130;e631.
19. Ramezani Tehrani F, Moslehi N, Asghari G, Gholami R, Mirmiran P, et al. Intake of dairy products, calcium, magnesium, and phosphorus in childhood and age at menarche in the Tehran Lipid and Glucose Study. PLoS One 2013;8:e57696.
20. International Institute for Population Sciences (IIPS) & Macro International. National Family Health Survey (NFHS-3), 2005–06: India: Volume I. International Institute for Population Sciences, Mumbai, 2007.
21. Moral R, Escrich R, Solanas M, Vela E, Costa I, et al. Diets high in corn oil or extra-virgin olive oil provided from weaning advance sexual maturation and differentially modify susceptibility to mammary carcinogenesis in female rats. Nutr Cancer 2011;63:410–20.
22. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: http://www.R-project.org/. Accessed 13 August 2014.
23. Bates D, Maechler M, Bolker B, Walker S. lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-7. Available at: http://CRAN.R-project.org/package=lme4. Accessed 13 August 2014a.
24. Bates D, Maechler M, Bolker BM, Walker S. lme4: Linear mixed-effects models using Eigen and S4. ArXiv e-print; submitted to Journal of Statistical Software. Available at: http://arxiv.org/abs/1406.5823. Accessed 13 August 2014b.
25. Government of India, Press Information Bureau. Planning commission, poverty estimates for 2009–10. Available at: http://

pib.nic.in/newsite/erelease.aspx?relid=81151. Accessed 30 July 2014.

26. Dhambare DG, Wagh SV, Dudhe JY. Age at menarche and menstrual cycle pattern among school adolescent girls in central India. Glob J Health Sci 2012;4:105–11.

27. International Institute for Population Sciences (IIPS) and Population Council. Youth in India: situation and needs 2006–2007. Mumbai: IIPS, 2010.

28. Bosch AM, Willekens FJ, Baqui AH, Van Ginneken JK, Hutter I. Association between age at menarche and early-life nutritional status in rural Bangladesh. J Biosoc Sci 2008;40: 223–37.

29. Rah JH, Abu AS, Ummeh TA, Labrique AB, Rashid M, et al. Age of onset, nutritional determinants, and seasonal variations in menarche in rural Bangladesh. J Health Popul Nutr 2009;27:802–7.

30. United States Department of Agriculture (USDA). Nutrient database, Release 25. Available at: http://ndb.nal.usda.gov/. Accessed 10 June 2014.

31. Deaton A, Drèze J. Food and nutrition in India: facts and interpretations. Econ Polit Wkly 2009;44:42–65.

32. Jacobsen BK, Heuch I, Kvåle G. Association of low age at menarche with increased all-cause mortality: a 37-year follow-up of 61,319 Norwegian women. Am J Epidemiol 2007;166:1431–7.