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Cohort profile: the Ho Chi Minh City Youth Cohort

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Cohort profile: the Ho Chi Minh City Youth Cohort

Trang Doan Nguyen Hoang Hanh [a,b*], Hong Tang Kim [a], Michael John Dibley[b]

[a] Department of Public Health, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam

[b] Sydney School of Public Health, Sydney Medical School , The University of Sydney, NSW 2006, Australia

**** Corresponding author:***

Nguyen Hoang Hanh Doan Trang

Pham Ngoc Thach University of Medicine,

86/2 Thanh Thai Street, District 10, Ho Chi Minh City, Vietnam

Tel: +84 8 8631383; +84 933191899

Fax: +84 8 8650025

E-mail: nguyenhoang_doantrang@yahoo.com; dngu6292@uni.sydney.edu.au

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Abstract: (271)

Objectives: The Ho Chi Minh Youth cohort study aimed to assess the change in nutritional status, indicators of adiposity, diet, physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of HCMC.

Design: Systematic random sampling was used to select 18 schools in urban districts. Children were followed-up over five years with an assessment in each year. Consent, from both adolescents and their parents, was required. Anthropometric measurements were taken using established guidelines. Six main groups of exposure factors including dietary intake and behaviours, physical activity and sedentary behaviours, family social and physical environment, school environment, socioeconomic status, and parental characteristics were measured. Categorical data were compared by Pearson chi-square or Fisher's exact test, whereas continuous data were tested with Student's t-test or Wilcoxon Mann-Whitney test.

Results: Retention rate was high (77%). Within 5 years period, the prevalence of combined overweight and obesity using IOTF cut-off values increased from 14.2% to 24.5%, representing an average annual relative increase of approximately 15%. Time spent on physical activity decreased significantly in the 5 year period from 87 minutes / day to 50 minutes / day. Time spent on sedentary behaviours increased in the 5 year period from 512 minutes / day to 537 minutes / day

Conclusions:

The complete data analysis of this cohort study will allow a full exploration of the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and also identify the factors most strongly associated with excess weight gain and the appearance of overweight and obesity in different age groups of adolescents from this large city in Vietnam.

Article summary:

Article focus:

- The change in nutritional status, indicators of adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of Ho Chi Minh city

Key messages

- Prevalence of combined overweight/obesity increased from 14.2% to 24.5% in 5 year period
- Time spent on physical activity decreased significantly in the 5 year period from 87 minutes / day to 50 minutes / day
- Time spent on sedentary behaviours increased in the 5 year period from 512 minutes / day to 537 minutes / day

Strengths and limitations:

- This is the first cohort in Vietnam on adolescent obesity in Vietnam, which has assessed a full set of potential risk factors from dietary intake, physical activity and sedentary behaviours to environmental factors, allowing a wide ranging assessment of the factors related to excess weight gain and overweight and obesity among urban Vietnamese adolescents.
- The present longitudinal study revealed changes in anthropometric measurements, physical activity, sedentary behaviour, diet associated with age in both genders.

Introduction

In recent years, the increasing prevalence of obesity has become one of the major health concerns in children and adolescents in developed countries, and in developing countries where an economic transition is underway.[1] Vietnam and especially Ho Chi Minh City (HCMC) - the largest city in Vietnam - is in an early 'nutrition transition' where both under-nutrition and the emerging problem of overweight and obesity can be found.[2] Evidence of this transition can be found in the results of two cross-sectional nutrition surveys, which reported an increase in the prevalence of overweight and obesity of adolescents in HCMC from 5.8% in 2002 to 13.7% in 2004, and over the same period a decline in the prevalence of underweight from 11.3% in 2002 to 6.6% in 2004.[3]

It is known that adolescent obesity is associated with a range of potential medical and psychosocial complications, as well as being a risk factor for increased morbidity and premature mortality in adulthood.[4] The intermediate consequences include the development of cardiovascular risk factors and persistence of obesity into adulthood. Reviews of the evidence suggest that the risk of cardiovascular disease and all-cause mortality are elevated among adults who were overweight during childhood.[5] However, evidence on risk factors for childhood obesity is limited at present, especially for transitional societies, and most previous studies on risk factors for obesity have been unable to adequately account for confounding variables, particularly socioeconomic status.[6] Although both genetic and environmental factors are thought to cause obesity, awareness is increasing for the importance of environmental factors [7] including school, neighbourhood and home microenvironments, which play an influential role in determining unhealthy lifestyle choices.[8]

Ho Chi Minh City (HCMC) with a population of 7 million is one of the largest cities in Vietnam [9] and is located in the south east region of the country (*Figure 1*). Over the last

two decades the city has experienced rapid social, economic and demographic changes. Parallel to these social and economic changes, overweight and obesity have emerged as amongst the most significant public health issues in the city. The examination of risk factors in a setting where such rapid changes are taking place provides a unique opportunity to obtain a picture of how overweight and obesity emerges in children in a population undergoing social and economic transition. The urban area of HCMC, with its high population density of 3,155 persons / km^2 and its rapid socioeconomic development, is an ideal setting to identify risk factors for excess weight gain in adolescents because of the ease of tracking and following-up students.

The present cohort study aimed to assess the change in nutritional status, indicators of adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of the province. The results of this study will provide new insights into how the childhood obesity epidemic in a transitional society differs from that in developed countries. It will also provide evidence to plan and evaluate the most appropriate interventions to prevent excess weight gain in adolescents in HCMC in the future.

Methods and analysis:

Study design:

Sample selection The cohort study began from a multi-stage cluster cross sectional survey in 2004. This survey covered 140 secondary high schools including public and private schools, of which 47 schools were from wealthy urban areas and 93 schools were of less wealthy urban districts. The total number of students in wealthy urban schools was 62,853 whilst that of less wealthy urban schools was 119,717. From these 140 schools, 31 clusters (schools) were selected with 17 clusters (schools) selected from the list of schools in wealthy urban districts, and 14 clusters (schools) from less wealthy urban districts, using probability

proportionate to size (PPS) sampling within each strata. In each selected school, lists of classes from grades 6 and 7 combined, and grades 8 and 9 combined were prepared. Simple random sampling was used to select one class from each group of grades. All students in the selected classes were invited to participate in the study.

For the cohort study, systematic random sampling was used to select 18 schools from these 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts. The sub sample of children required for the cohort study was selected from one class from grades 6 and 7 combined in each school, resulting in 784 students of the cohort study.

Sample size

The study started with a cross-sectional study consisting of 1,243 students from schools in wealthy districts and 1,417 students from schools in less wealthy districts. This sample included 607 students from grade 6, 725 from grade 7, 814 from grade 8, and 514 from grade 9. The sampling design for this survey has been described previously.[10] With an average of 45 students per class, the design effect was 2.01.

The sample size estimates for the cohort study were based on expected differences in the average change of BMI between exposure groups (Insufficiently active vs. active students viewing >20 hrs TV per week vs. <20 TV viewing per week, students in the lowest quintile of nutrient intake vs. other quintiles of intake, students who ride bicycles to school vs. were taken to school by motorcycle), using a standard deviation of 1.5 and assuming a 5% significance level, 80% power. Sample size estimates were calculated using the PS program,[11] with 20% drop-outs, resulting in the sample size of 720 children. This represented approximately 60% of urban junior high school students in the cross-sectional survey, who were invited to participate in the cohort study.

Informed consent

Informed written consent was firstly obtained from the principals of the schools participating in the study. Information about the study was distributed to the selected class by the school principals and class teachers using flyers and notices. All the students in selected classes were invited to participate in the cohort study. Discussions were held with the school principals to establish a timetable of visits to ensure project staff could meet all the children and parents. Information sheets and consent forms for the adolescents and their parents were distributed by the project staff at their first visit to the class. Project staff was also available to answer questions regarding the study on this visit. Consent from both the adolescents and their parents was required for participation in the study and collected one week apart.

Frequency of follow-up

Children were followed-up over five years with an assessment in each year. During the first three years when the study participants were in junior high schools, data was collected by class surveys. In Vietnam, junior and senior high schools are separate institutions and students from one junior high school may move to many different senior high schools. So, when the study participants moved to senior high school, follow-up was sustained with individual contact by phone calls, home visits and group surveys for those students still together in a single high school.

Data collection

At each assessment round, we measured the main outcome variables (anthropometric measurements) as well as the exposure factors. In the third round, we collected biochemical data for assessing cardiovascular and metabolic disease risks.

Measurement of outcome variables: All the anthropometric measurements were taken using established guidelines.[12] Standing height was measured using a portable direct-reading stadiometer and body weight was measured using a digital scale. Waist and hip circumferences were measured with a non-elastic tape at the level of the umbilicus and with

maximal extension of the buttocks. Standardization exercises with the anthropometrists were used every 6 months to monitor the quality of anthropometric measurements. Blood samples (done in the third round) and blood pressure were measured at the end of data collection. Height, weight and blood pressure were measured twice and the average value was used.

Biochemical measurements:

A sample of five millilitres of venous blood was collected from the participants' forearm by experienced, trained technicians. Fasting blood glucose and the lipid profile (triglyceride, total cholesterol, high, low and very low density cholesterol) were assayed by a photometer (Hitachi 917 Japan) using a standard method at the Diagnostic Center in HCMC.

Standard internationally recommended procedures were used for the handling and processing of blood specimens,[13] and the specimens were transported to the laboratory within 2 hours of collection at the schools. Serum samples were stored in special plastic tubes with sealed lids. Unused portions of the blood samples collected were stored at - 20^0 degrees in freezers in the laboratories of the Diagnostic Center, HCMC in case reanalysis was needed once the data was examined. These specimens were destroyed once all the data has been cleaned.

Measurement of exposure factors: The adolescents were interviewed using the *environmental assessment*, *food frequency, physical activity, and television and computer usage* questionnaires. The parents completed the *family habits and environment questionnaire.* Six main groups of exposure factors were measured:

Dietary intake and diet behaviours was assessed using a validated Youth Food Frequency Questionnaire [14] which allowed the study participants to be ranked by levels of food energy and fat intake and categories of different diet patterns e.g. frequency of fast food, snacks or soft drink consumption.

Physical activity and sedentary behaviours were assessed by a youth Physical Activity Questionnaire (PAQ) [15] and a Adolescent Sedentary Activity Questionnaire (ASAQ) [16]

which were developed and validated among Australian adolescents but modified for use in Vietnam. A validation study comparing the results from the modified PAQ with accelerometer measurements showed that PAQ is a valuable tool to assess physical activity in adolescents of Ho Chi Minh City.[17] They were also objectively measured by use of accelerometers (Actigraph®) for each student over a one-week period to assess long term physical activity patterns.[18]

The *family social environment* was assessed using the family habits and environment questionnaire, which measured exposure to various social and physical home environmental factors (e.g. number and location of TVs at home, and family rules on TV viewing). Questionnaires were completed by the adolescents and their parents to assess exposure to environmental elements at home, school and neighbourhoods. The environmental questionnaire was developed from the results of *group discussions* with approximately 10 to 15 community members in each of four different locations of varying socioeconomic status from across HCMC. These group discussions identified the key environmental elements of homes, schools and neighbourhoods that needed to be included in the questionnaire. Lack of pathways and dangerous traffic were amongst the reasons many parents did not allow their children to walk or cycle alone. *In-depth interviews* were also conducted with selected members to explore in more detail the environmental risks identified and the opportunities for change. Interviews were taped, transcribed, checked for accuracy, and the content and themes were analysed to identify how the environmental risks varied across communities, how easily they might be modified and what methods of change were available in the different communities. The items on the questionnaire were derived from the information gathered from the qualitative data collection.[19]

Physical environment assessments were also taken using a questionnaire. The home environment questionnaire was piloted in a sample of 50 respondents (adolescents and their

parents from different areas in HCMC) and validated by direct observations by the investigators. Information regarding environmental factors at community and household levels as well as socio-demographic factors was obtained via a self-administered questionnaire for parents. The description of this questionnaire has also been published previously.[10]

Distance between the respondent's house and schools and these recreational facilities were measured using Global Positioning System (GPS). GPS readings recorded the location of fast food outlets and recreation areas within 1km surrounding the home of all participants in the cohort study. These data sources will be used to directly estimate the average distances from the respondent's home to these physical aspects of their environments, and also to estimate the average density of these environmental elements.

School environment was assessed using a self-administered questionnaire completed by the school principals, who were asked about school facilities for sport and exercise, availability of such facilities, and the foods and drinks sold in the school canteen.

Additional risk factors including self-recorded parent's weight and height, parental ethnicity, and demographic, socioeconomic status of the child and the family were assessed by structured questionnaires. Also the adolescent's pubertal status was self assessed using a form, which recorded the child's date of birth, gender, weight and height, and questions to self-assessed pubertal status. In a confidential setting, the adolescents self-reported their pubertal status using a questionnaire with photographs illustrating five stages [20] of pubertal development for pubic hair, male genitalia, or female breasts, and for female students the date of their first menstruation was also recorded.

Data analysis

Analyses were conducted using STATA 11 (STATA Corporation, College Station, TX, USA, 2009).

The general characteristics of the population were described. For continuous variables, mean and standard deviation or median and quartile range were calculated according to the distribution of each variable. In the case of categorical variables, absolute and relative frequencies were calculated. 95% confidence interval was also computed. Continuous variables that were not normally distributed were evaluated by the application of transformations and categorisations wherever applicable. Baseline characteristics were compared by gender and the lost to follow-up group were compared with the cohort baseline group using Pearson chi-square or Fisher's exact test for categorical data, whereas continuous data were tested with Student's t-test or Wilcoxon Mann-Whitney test. Kruskal-Wallis test was used to compare medians of time spent on MVPA and sedentary behaviours and chi-square for trend was used to compare prevalence of BMI status by years. The "survey commands" were used to account for the multi-stage cluster sampling design. Future analyses of this cohort data that assess relationships between exposure factors and the change of BMI, physical activity, sedentary behaviours, will require mixed multiple regression models to adjust for the multi-stage cluster sampling and repeated measurements in individual study participants.

Ethics and dissemination:

The research proposal was approved by the Research Ethics Committee, Pham Ngoc Thach University of Medicine, Ho Chi Minh City. It was also approved by the Human Research Ethics Committee, University of Newcastle (ethics reference: H-879-0904). Informed written consent was obtained from the principals of the schools participating in the study. Consent from both the adolescents and their parents were required prior to their participation in the study.

Results

At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to take part in the cohort study, of which 740 participated in the first follow-up data collection including anthropometric measurements, dietary, physical activity, sedentary behaviours and environment assessment. Therefore, the attrition rate for one year follow-up was 2.5%. In the second round of follow-up, there were 740 (94% of baseline), in the fourth round, there were 617 (81% of baseline), and in the last follow-up 585 students remained in the cohort, resulting in a retention rate of 77% (*Table 1*).

Insert table 1 here

The characteristics of the follow-up group (n=585) were compared with drops-out (n=174) on key variables that were available for all participants. These two groups did not differ by age, gender, and pubertal status, anthropometric or socio-demographic characteristics. The drop-outs in the sample were mainly attributed to the following reasons: (i) moved to another school (n= 105, 13.8 %); (ii) changed home address or migrated overseas (n=39, 5.1 %) and (iii) refused to continue in the study (n=30, 4.0 %).

The baseline data for socio-demographic and anthropometric variables are listed in *Table 2*. At baseline, the mean age of the sampled subjects was 11.8 years (±0.6). Overall 12.5% of the students were overweight and 1.7% were obese. The mothers of 52.3% of the students had completed senior high school and 58.5% of the fathers had completed senior high school.

Insert table 2 here

Figure 2 shows the geographic distribution of schools and participants' home measured by GPS. Students' houses were scattered around their schools with a mean distance from home to school of 1,450m (Interquartile Range (IQR): 680-3,030m).

Insert figure 2 here

A summary of the changes in the BMI status and time spent in moderate to vigorous physical activity and sedentary behaviours are listed in *Table 3*. Over the five year period within this cohort, the prevalence of combined overweight and obesity increased from 14.2% to 24.5% for BMI, representing an average annual relative increase of approximately 15%. Time spent in moderate to vigorous decreased significantly from 87 minutes / day to 50 minutes / day. In contrast, time in sedentary behaviours increased from 512 minutes / day to 537 minutes / day.

Insert table 3 here

Discussion:

This is the first cohort study on adolescent obesity in Vietnam, which provides a comprehensive assessment of the change in anthropometric growth, dietary intake, physical activity and environmental factors as well as their associations over the years of follow-up. This is also the first cohort in Vietnam, which has assessed a full set of potential risk factors from dietary intake, physical activity and sedentary behaviours to environmental factors, allowing a wide ranging assessment of the factors related to excess weight gain and overweight and obesity among urban Vietnamese adolescents.

In Ho Chi minh City within the five year period, the prevalence of combined overweight and obesity increased by age from 14.2% to 24.5%. The increase in the present study (with an average annual increase of 8.8% for overweight and 3.2% for obesity) was consistent with the increase revealed in 5-year follow up studies from 1999 to 2004 in urban Indonesia children (4.2% for overweight, and 1.9% for obesity) [21] and in Thai school children (the prevalence of overweight increased from 12.4% in 1992 to 21.0% in 1997 in boys).[22] Our primary findings are also consistent with the substantial age-related declines in MVPA among both adolescent boys and girls previously reported.[23-25]

This study can, through the cause-effect relationships examined, provide evidence to guide the formulation of appropriate and reasonable recommended levels of physical activity to

prevent overweight/obesity in Vietnamese adolescents. The findings will also provide evidence to help develop recommendations for dietary behaviours or future designs of schools and neighbourhoods to ensure these environments are health promoting and meet the needs of Vietnamese adolescents during an age when there is rapid body growth.

Maintaining more than 75% of the students in this cohort has helped ensure the internal validity of the study. Moreover, the measurements of key outcomes and study factors have high reliability and validity from the use of validated tools (FFQ, PAQ, environmental questionnaires) and objective measurements (accelerometers, GPS devices). The project staff, who took the measurements, was retrained throughout the study thus helping to ensure standard measurement methods were used across the cohort. We used a prospective longitudinal design from a representative sample of adolescents from HCMC and aimed to follow-up the children over five years. Each child has a health profile including anthropometric and pubertal status data as well as other exposure factors each year. The findings will be of relevance to other cities in Vietnam, which are starting to go through the same environmental and lifestyle changes that have already occurred in HCMC. The findings will also be relevant to other urban populations in East Asia and Southeast Asia where rapid economic development is leading to a nutrition transition similar to that occurring in HCMC.

Conclusion

The complete data analysis of this cohort study will allow a full exploration of the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and also identify the factors most strongly associated with excess weight gain and the appearance of overweight and obesity in different age groups of adolescents from this large city in Vietnam. This information is needed to develop evidence-based public health interventions to control and prevent this epidemic from expanding amongst the youth of Ho Chi Minh City and other cities in Vietnam.

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Authors' contributions: TNH, HKT, MJD all contributed to the conceptualisation and design of the study and all revised this manuscript critically. All authors gave final approval of the version to be published

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Data sharing statement: Access to the dataset is available from the corresponding author (nguyenhoang_doantrang@yahoo.com) or the principle investigator (hongutc@yahoo.com) in STATA format for academic researchers interested in undertaking a formally agreed collaborative research project.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5,6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*8-10*
Bias	9	Describe any efforts to address potential sources of bias	8,9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13,14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Figure 1: Map of Ho Chi Minh City, Viet Nam with studied districts

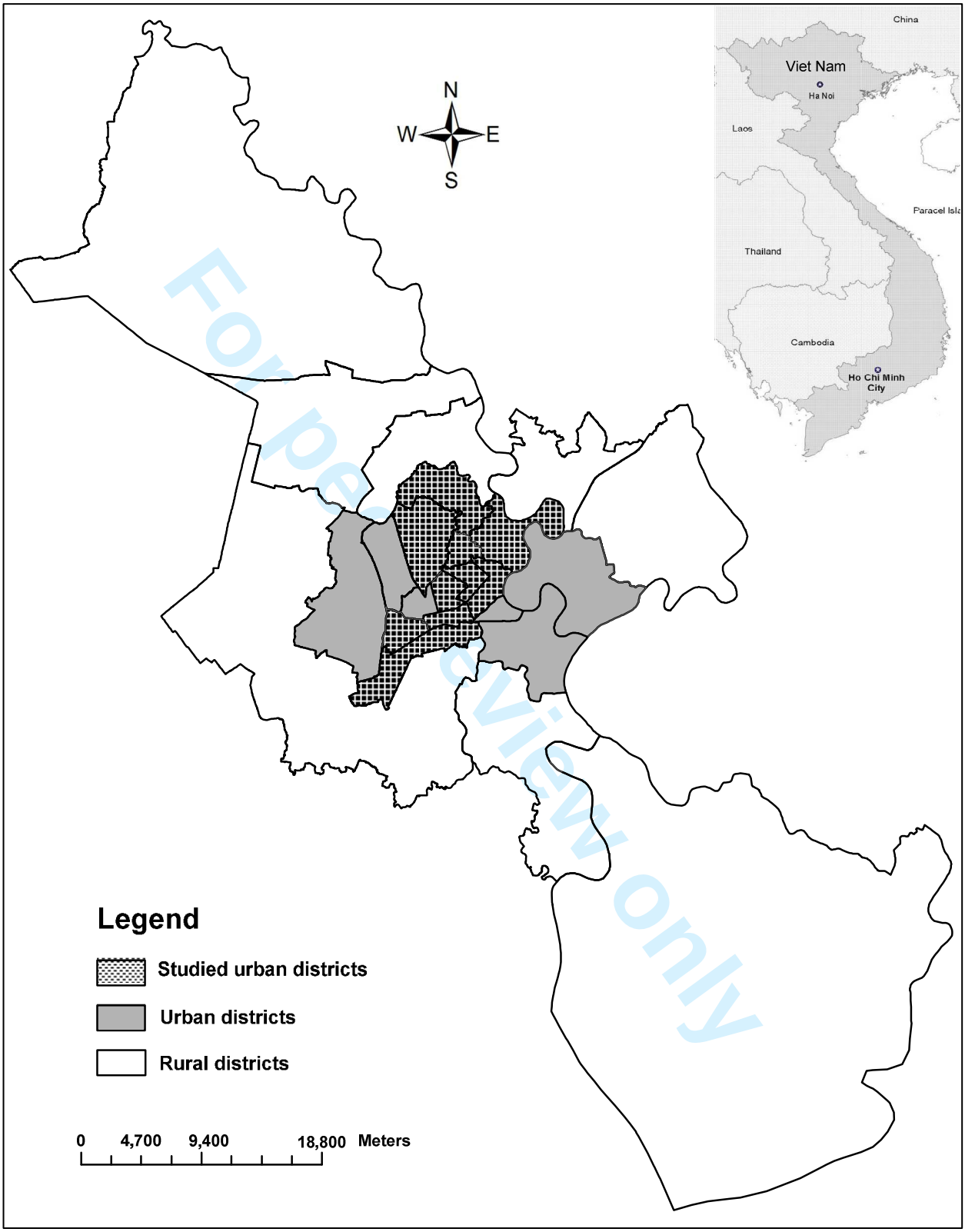
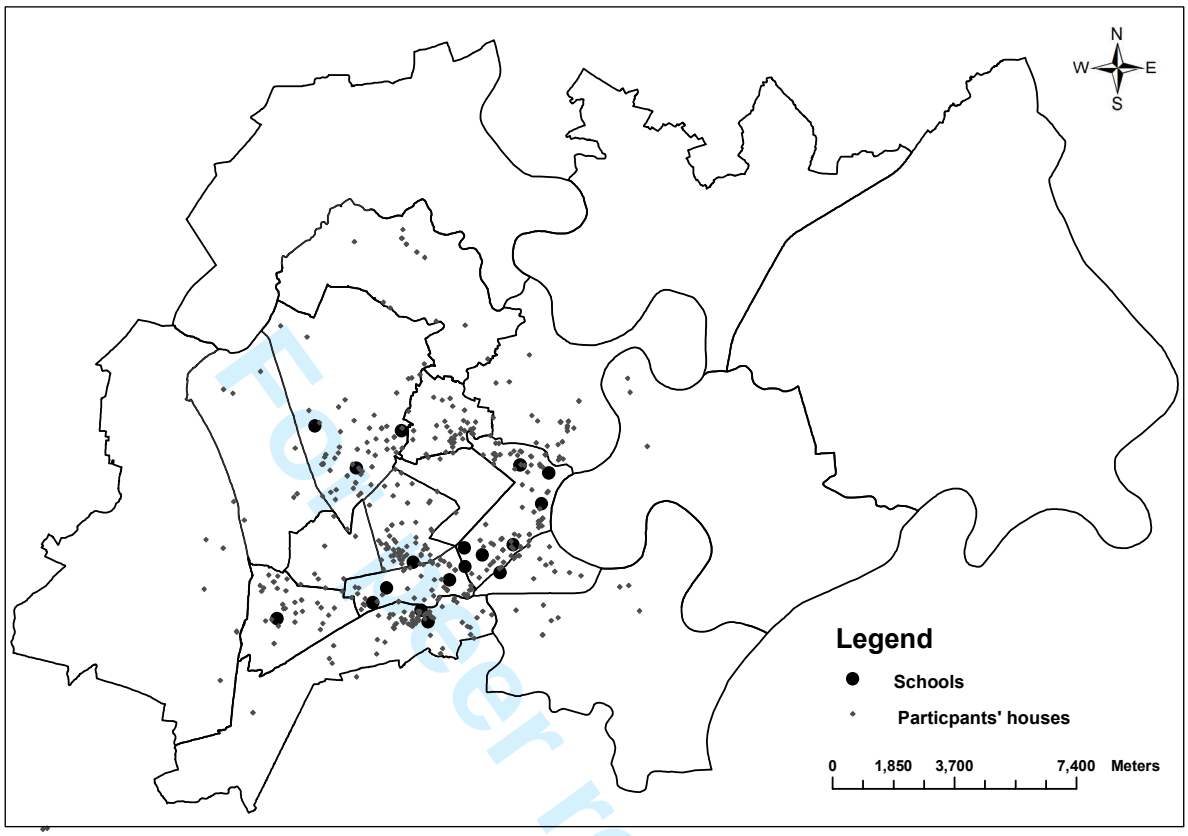


Figure 2: Map of studied schools and student participants' homes



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Cohort profile: Ho Chi Minh City Youth Cohort - changes in diet, physical activity, sedentary behavior and relationship with overweight/obesity and metabolic syndrome in adolescents

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Cohort profile: Ho Chi Minh City Youth Cohort - changes in diet, physical activity, sedentary behavior and relationship with overweight/obesity and metabolic syndrome in adolescents

Nguyen Hoang Hanh Doan Trang [a,b*], Tang Kim Hong [a], Michael John Dibley[b]

[a] Department of Community Health, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam

[b] Sydney School of Public Health, Sydney Medical School , The University of Sydney, NSW 2006, Australia

**** Corresponding author:***

Nguyen Hoang Hanh Doan Trang

Pham Ngoc Thach University of Medicine,

86/2 Thanh Thai Street, District 10, Ho Chi Minh City, Vietnam

Tel: +84 8 8631383; +84 933191899

Fax: +84 8 8650025

E-mail: nguyenhoang_doantrang@yahoo.com; dngu6292@uni.sydney.edu.au

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Abstract: (288)

Objectives: The Ho Chi Minh Youth cohort study aimed to assess the change in nutritional status, indicators of adiposity, diet, physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of HCMC.

Design: Prospective 5 year cohort

Setting: Systematic random sampling was used to select 18 schools in urban districts.

Participants: Children were followed-up over five years with an assessment in each year. Consent, from both adolescents and their parents, was required. At baseline, 759 students were recruited into the cohort, and out of these students, 740 remained in the cohort for the 1st round of follow-up, 712 for the 2nd round, 630 for the 3rd round, and 585 students for the last follow-up.

Primary and secondary outcome measures: Anthropometric measurements were taken using established guidelines. Six main groups of exposure factors including dietary intake and behaviours, physical activity and sedentary behaviours, family social and physical environment, school environment, socioeconomic status, and parental characteristics were measured.

Results: Retention rate was high (77%). Within 5 years period, the prevalence of combined overweight and obesity using IOTF cut-off values increased from 14.2% to 21.8%. Time spent on physical activity decreased significantly in the 5 year period from 87 minutes / day to 50 minutes / day. Time spent on sedentary behaviours increased in the 5 year period from 512 minutes / day to 600 minutes / day

Conclusions: The complete data analysis of this cohort study will allow a full exploration of the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and also identify the factors most strongly associated with excess weight gain and the appearance

of overweight and obesity in different age groups of adolescents from this large city in Vietnam.

Article summary:

Article focus:

- The change in nutritional status, indicators of adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of Ho Chi Minh city

Key messages

- Prevalence of combined overweight/obesity increased from 14.2% to 21.8% in 5 year period
- Time spent on physical activity decreased significantly in the 5 year period from 87 minutes / day to 50 minutes / day
- Time spent on sedentary behaviours increased in the 5 year period from 512 minutes / day to 600 minutes / day

Strengths and limitations:

- This is the first cohort in Vietnam on adolescent obesity in Vietnam.
- This study assessed a full set of potential risk factors from dietary intake, physical activity and sedentary behaviours to environmental factors, allowing a wide ranging assessment of the factors related to excess weight gain and overweight and obesity among urban Vietnamese adolescents.
- The present longitudinal study revealed changes in anthropometric measurements, physical activity, sedentary behaviour, and diet associated with age in both genders.

Introduction

In recent years, the increasing prevalence of obesity has become one of the major health concerns in children and adolescents in developed countries, and in developing countries where an economic transition is underway.[1] Vietnam and especially Ho Chi Minh City (HCMC) - the largest city in Vietnam - is in an early 'nutrition transition' where both under-nutrition and the emerging problem of overweight and obesity can be found.[2] Evidence of this transition can be found in the results of two cross-sectional nutrition surveys, which reported an increase in the prevalence of overweight and obesity of adolescents in HCMC from 5.8% in 2002 to 13.7% in 2004, and over the same period a decline in the prevalence of underweight from 11.3% to 6.6%.[3]

It is known that adolescent obesity is associated with a range of potential medical and psychosocial complications, as well as being a risk factor for increased morbidity and premature mortality in adulthood.[4] The intermediate consequences include the development of cardiovascular risk factors and persistence of obesity into adulthood. Reviews of the evidence suggest that the risk of cardiovascular disease and all-cause mortality are elevated among adults who were overweight during childhood.[5] However, evidence on risk factors for childhood obesity is limited at present, especially for transitional societies, and most previous studies on risk factors for obesity have been unable to adequately account for confounding variables, particularly socioeconomic status.[6] Although both genetic and environmental factors are thought to cause obesity, awareness is increasing for the importance of environmental factors [7] including school, neighbourhood and home microenvironments, which play an influential role in determining unhealthy lifestyle choices.[8]

Ho Chi Minh City (HCMC) with a population of 7 million is one of the largest cities in Vietnam [9] and is located in the south east region of the country (*Figure 1*). Over the last

two decades the city has experienced rapid social, economic and demographic changes. Parallel to these social and economic changes, overweight and obesity have emerged as amongst the most significant public health issues in the city. The examination of risk factors in a setting where such rapid changes are taking place provides a unique opportunity to obtain a picture of how overweight and obesity emerges in children in a population undergoing social and economic transition. The urban area of HCMC, with its high population density of 3,155 persons / km^2 and its rapid socioeconomic development, is an ideal setting to identify risk factors for excess weight gain in adolescents because of the ease of tracking and following-up students.

The present cohort study aimed to assess the change in nutritional status, indicators of adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of the province. The results of this study will provide new insights into how the childhood obesity epidemic in a transitional society differs from that in developed countries. It will also provide evidence to plan and evaluate the most appropriate interventions to prevent excess weight gain in adolescents in HCMC in the future.

Methods and analysis:

Study design:

Sample selection The cohort study began from a multi-stage cluster cross sectional survey in 2004. This survey covered 136 public junior high schools and 4 non-public (semi public and private) junior high schools. Of these 140 schools, 47 were from wealthy urban areas and 93 from less wealthy urban districts. This classification of urban districts was derived from the Statistics Review of HCMC province Department of Statistics.[10] The total number of students in wealthy urban schools was 62,853 whilst that of less wealthy urban schools was 119,717. From these 140 schools, 31 clusters (schools) were selected with 17 clusters

(schools) selected from the list of schools in wealthy urban districts, and 14 clusters (schools) from less wealthy urban districts, using probability proportionate to size (PPS) sampling within each strata. Because the number of classes and students in non-public schools are smaller than in public schools, only 3 non-public schools were selected in the sample of the cross-sectional survey. In each selected school, lists of classes from grades 6 and 7 combined, and grades 8 and 9 combined were prepared. Simple random sampling was used to select one class from each group of grades. All students in the selected classes were invited to participate in the study.

For the cohort study, systematic random sampling was used to select 18 schools from these 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts. The sub sample of children required for the cohort study was selected from one class from grades 6 and 7 combined in each school, resulting in 784 students of the cohort study.

Sample size

The sample size estimates for the cohort study were based on expected differences in the average change of BMI between exposure groups (Insufficiently active vs. active students viewing >20 hrs TV per week vs. <20 TV viewing per week, students in the lowest quintile of nutrient intake vs. other quintiles of intake, students who ride bicycles to school vs. were taken to school by motorcycle), using a standard deviation of 1.5 and assuming a 5% significance level, 80% power. In the absence of information about relative change in BMI for HCMC children, these sample size estimates are based on the observed relative change in BMI in children exposed to an education intervention to reduce TV viewing in the United States.[11] The average change in BMI selected was 0.35 kg/m^2. Sample size estimates were calculated using the PS program,[12] resulting in an estimated required sample size of 720 children. However, since we used cluster sampling (school and class selection), all the students in a selected class were invited to participate in the cohort for logistic reasons;

yielding 784 students who were invited to participate and giving 759 who were recruited into the cohort study.

Informed consent

Informed written consent was firstly obtained from the principals of the schools participating in the study. Information about the study was distributed to the selected class by the school principals and class teachers using flyers and notices. All the students in selected classes were invited to participate in the cohort study. Discussions were held with the school principals to establish a timetable of visits to ensure project staff could meet all the children and parents. Information sheets and consent forms for the adolescents and their parents were distributed by the project staff at their first visit to the class. Project staff was also available to answer questions regarding the study on this visit. Consent from both the adolescents and their parents was required for participation in the study and collected one week apart.

Frequency of follow-up

Children were followed-up over five years with an assessment in each year. During the first three years when the study participants were in junior high schools, data was collected by class surveys. In Vietnam, junior and senior high schools are separate institutions and students from one junior high school may move to many different senior high schools. So, when the study participants moved to senior high school, follow-up was sustained with individual contact by phone calls, home visits and group surveys for those students still together in a single high school.

Data collection

At each assessment round, we measured the main outcome variables (anthropometric measurements) as well as the exposure factors. In the third round, we collected biochemical data for assessing cardiovascular and metabolic disease risks.

Measurement of outcome variables: All the anthropometric measurements were taken using established guidelines.[13] Standing height was measured using a portable direct-reading stadiometer and body weight was measured using a digital scale. Waist and hip circumferences were measured with a non-elastic tape at the level of the umbilicus and with maximal extension of the buttocks. Standardization exercises with the anthropometrists were used every 6 months to monitor the quality of anthropometric measurements. Blood samples (done in the third round) and blood pressure were measured at the end of data collection. Height, weight and blood pressure were measured twice and the average value was used.

Biochemical measurements:

A sample of five millilitres of venous blood was collected from the participants' forearm by experienced, trained technicians. Fasting blood glucose and the lipid profile (triglyceride, total cholesterol, high, low and very low density cholesterol) were assayed by a photometer (Hitachi 917 Japan) using a standard method at the Diagnostic Center in HCMC.

Standard internationally recommended procedures were used for the handling and processing of blood specimens,[14] and the specimens were transported to the laboratory within 2 hours of collection at the schools. Serum samples were stored in special plastic tubes with sealed lids. Unused portions of the blood samples collected were stored at - 20^0 degrees in freezers in the laboratories of the Diagnostic Center, HCMC in case reanalysis was needed once the data was examined. These specimens were destroyed once all the data has been cleaned.

Measurement of exposure factors: The adolescents were interviewed using the *environmental assessment*, *food frequency, physical activity, and television and computer usage* questionnaires. The parents completed the *family habits and environment questionnaire*. Six main groups of exposure factors were measured:

Dietary intake and diet behaviours was assessed using a validated Youth Food Frequency Questionnaire [15] which allowed the study participants to be ranked by levels of food energy

and fat intake and categories of different diet patterns e.g. frequency of fast food, snacks or soft drink consumption.

Physical activity and sedentary behaviours were assessed by the Adolescent Physical Activity Recall Questionnaire (APARQ) [16] and a Adolescent Sedentary Activity Questionnaire (ASAQ) [17] which were developed and validated among Australian adolescents but modified for use in Vietnam, the Vietnamese-Adolescent Physical Activity Recall Questionnaire (V-APARQ). A validation study comparing the results from the V-APARQ with accelerometer measurements showed that V-APARQ is a valuable tool to assess physical activity in adolescents of Ho Chi Minh City.[18] They were also objectively measured by use of accelerometers (Actigraph®) for each student over a one-week period to assess long term physical activity patterns.[19]

The *family social environment* was assessed using the family habits and environment questionnaire, which measured exposure to various social and physical home environmental factors (e.g. number and location of TVs at home, and family rules on TV viewing). Questionnaires were completed by the adolescents and their parents to assess exposure to environmental elements at home, school and neighbourhoods. The environmental questionnaire was developed from the results of *group discussions* with approximately 10 to 15 community members in each of four different locations of varying socioeconomic status from across HCMC. These group discussions identified the key environmental elements of homes, schools and neighbourhoods that needed to be included in the questionnaire. Lack of pathways and dangerous traffic were amongst the reasons many parents did not allow their children to walk or cycle alone. *In-depth interviews* were also conducted with selected members to explore in more detail the environmental risks identified and the opportunities for change. Interviews were taped, transcribed, checked for accuracy, and the content and themes were analysed to identify how the environmental risks varied across communities, how easily

they might be modified and what methods of change were available in the different communities. The items on the questionnaire were derived from the information gathered from the qualitative data collection.[20]

Physical environment assessments were also taken using a questionnaire. The home environment questionnaire was piloted in a sample of 50 respondents (adolescents and their parents from different areas in HCMC) and validated by direct observations by the investigators. Information regarding environmental factors at community and household levels as well as socio-demographic factors was obtained via a self-administered questionnaire for parents. The description of this questionnaire has also been published previously.[21]

Distance between the respondent's house and schools and these recreational facilities were measured using Global Positioning System (GPS). GPS readings recorded the location of fast food outlets and recreation areas within 1km surrounding the home of all participants in the cohort study. These data sources will be used to directly estimate the average distances from the respondent's home to these physical aspects of their environments, and also to estimate the average density of these environmental elements.

School environment was assessed using a self-administered questionnaire completed by the school principals, who were asked about school facilities for sport and exercise, availability of such facilities, and the foods and drinks sold in the school canteen.

Additional risk factors including self-recorded parent's weight and height, parental ethnicity, and demographic, socioeconomic status of the child and the family were assessed by structured questionnaires.

To assess economic status, ownership of an inventory of assets was used to construct a household wealth index using the principal components method to assign a weight for each asset. [22] A total of fourteen assets were assessed including bicycles, motorbikes,

televisions, radios, videos, cassette players, computers, gas stoves, CD players, cars, microwave ovens, refrigerator and telephone and air-conditioners. The basis for selecting the assets was from a report of the Bureau of Statistics of HCMC [10] listing the most common assets used among HCMC population.

Also the adolescent's pubertal status was self assessed using a form, which recorded the child's date of birth, gender, weight and height, and questions to self-assessed pubertal status. In a confidential setting, the adolescents self-reported their pubertal status using a questionnaire with photographs illustrating five stages [23] of pubertal development for pubic hair, male genitalia, or female breasts, and for female students the date of their first menstruation was also recorded.

Data analysis

Analyses were conducted using STATA 11 (STATA Corporation, College Station, TX, USA, 2009). The IOTF (International Obesity Task Force) BMI cut-off values were used to define overweight and obesity combined [24]. The wealth index was ranked and divided into tertiles and each household was assigned to one of these wealth index categories.

The general characteristics of the population were described. For continuous variables, means and standard deviations or medians and inter-quartile ranges were calculated according to the distribution of each variable. In the case of categorical variables, absolute and relative frequencies were calculated. 95% confidence intervals were also computed. Continuous variables that were not normally distributed were evaluated by the application of transformations and categorisations wherever applicable. Baseline characteristics were compared by gender and the lost to follow-up group was compared with the cohort baseline group using Pearson chi-square or Fisher's exact test for categorical data, whereas continuous data were tested with Student's t-test or Wilcoxon Mann-Whitney test. Kruskal-Wallis test was used to compare medians of time spent on MVPA and sedentary behaviours and chi-

square for trend was used to compare prevalence of BMI status by years. The "survey commands" were used to account for the multi-stage cluster sampling design. Future analyses of this cohort data that assess relationships between exposure factors and the change of BMI, physical activity, sedentary behaviours, will require mixed multiple regression models to adjust for the multi-stage cluster sampling and repeated measurements in individual study participants.

Ethics and dissemination:

The research proposal was approved by the Research Ethics Committee, Pham Ngoc Thach University of Medicine, Ho Chi Minh City. It was also approved by the Human Research Ethics Committee, University of Newcastle (ethics reference: H-879-0904). Informed written consent was obtained from the principals of the schools participating in the study. Consent from both the adolescents and their parents were required prior to their participation in the study.

Results

At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to take part in the cohort study, of which 740 participated in the first follow-up data collection including anthropometric measurements, dietary, physical activity, sedentary behaviours and environment assessment. Therefore, the attrition rate for one year follow-up was 2.5%. In the second round of follow-up, there were 712 (94% of baseline), in the fourth round, there were 630 (83% of baseline), and in the last follow-up 585 students remained in the cohort, resulting in a retention rate of 77% (*Table 1*).

Insert table 1 here

The characteristics of the follow-up group (n=585) were compared with drops-out (n=174) on key variables that were available for all participants. These two groups did not differ by age, gender, and pubertal status, anthropometric or socio-demographic characteristics. The drop-

outs in the sample were mainly attributed to the following reasons: (i) moved to another school (n= 93, 12.2 %); (ii) refused to continue in the study (n= 45, 5.9 %) and (iii) changed home address or migrated overseas (n= 36, 4.7 %).

The baseline data for socio-demographic and anthropometric variables are listed in *Table 2*. At baseline, the mean age of the sampled subjects was 11.8 years (±0.6). Overall 12.5% of the students were overweight and 1.7% were obese. The mothers of 52.3% of the students had completed senior high school and 58.5% of the fathers had completed senior high school.

Insert table 2 here

Figure 2 shows the geographic distribution of schools and participants' home measured by GPS. Students' houses were scattered around their schools with a median distance from home to school of 1,450m (Inter-quartile Range (IQR): 680-3,030m).

Insert figure 2 here

A summary of the changes in the BMI status and time spent in moderate to vigorous physical activity and sedentary behaviours are listed in *Table 3*. Over the five year period of this cohort study, the prevalence of overweight increased from 12.5% to 16.7%, and obesity from 1.7% to 5.1%. Time spent in moderate to vigorous physical activity decreased significantly from 87 minutes / day to 50 minutes / day. In contrast, time in sedentary behaviours increased from 512 minutes / day to 600 minutes / day.

Insert table 3 here

Previous papers based on the cross sectional baseline survey have described overweight and obesity [3 25], physical inactivity [21], and metabolic syndrome [26] and associated risk factors. Another paper has used the longitudinal data from the youth cohort to describe changes in active commuting to school and risk factors for changes in commuting status [27]. More results will be presented in future papers presenting changes in physical activity, sedentary behaviour, and overweight/obesity and their associated risks factors.

Discussion:

We have successfully implemented a 5-year follow-up study in adolescents in Vietnam with a high retention rate of 77%. Over this period, we found that the prevalence of combined overweight and obesity increased significantly from 14.2% to 21.8%. Self-reported time spent on physical activity decreased significantly from 87 minutes / day to 50 minutes / day and in contrast, sedentary time increased from 512 minutes / day to 600 minutes / day. This is the first cohort study on adolescent obesity in Vietnam, which provides a comprehensive assessment of the change in anthropometric growth, dietary intake, physical activity and environmental factors as well as their associations over the years of follow-up.

An important strength of the study was maintaining more than 75% of the students in this cohort which has helped ensure the internal validity of the study. Also, the measurements of key outcomes and study factors have high reliability and validity from the use of validated tools (FFQ, V-APARQ, environmental questionnaires) and objective measurements (accelerometers, GPS devices). The project staff, who took the measurements, was retrained throughout the study thus helping to ensure standard measurement methods were used across the cohort. We used a prospective longitudinal design from a representative sample of adolescents from HCMC and aimed to follow-up the children over five years. Each child has a health profile including anthropometric and pubertal status data as well as other exposure factors each year. The findings will be of relevance to other cities in Vietnam, which are starting to go through the same environmental and lifestyle changes that have already occurred in HCMC. The findings will also be relevant to other urban populations in East Asia and Southeast Asia where rapid economic development is leading to a nutrition transition similar to that occurring in HCMC.

The relatively small sample size is one limitation of the study restricting examination of all potential relationships because of the limited sample in some subgroups. However, the sample size was adequate to detect changes in BMI over time and changes in key study factors such as physical activity and screen time which was used as a proxy for sedentary time. Despite this restriction, this study remains important because it is one of very few longitudinal studies in Vietnam and South East Asia to explore obesity and changes in obesity-related risk factors in adolescents.

Although there was only one non-public school in this study, this reflected the small proportion of the school population enrolled in this type of school in HCMC. We found no important differences between public and private schools for the main study factors and outcomes, such as socioeconomic status. Unlike the situation in many developed countries, in Vietnam, non-public schools are not popular and students usually enter these schools when they cannot secure a place in a public school. Thus, we believe the sampling of this study was not biased and is representative of HCMC adolescents at school.

In Ho Chi Minh City over the five year period, the prevalence of overweight increased from 12.5% to 16.7% and obesity increased from 1.7% to 5.1%. This increase in overweight and obesity was consistent with the increases found in 5-year follow up studies from 1999 to 2004 in urban Indonesian children where the prevalence of overweight increased from 4.2% in children to 8.8% in adolescents, and similarly obesity increased from 1.9% to 3.2% [28]. Similar findings have been reported from a 5-year follow-up study in Thai school children where the prevalence of overweight in boys increased from 12.4% in 1992 to 21.0% in 1997.[29]

The primary findings of this study are also consistent with the substantial age-related declines in MVPA among both adolescent boys and girls previously reported in the US [30-31], and Finland [32]. These results also showed that daily MVPA decreased of 42% over a five year

period when adolescents were aged 12 years to 16 years, which was similar to the 45% decline reported for American adolescents in the CATCH study [33]. Furthermore, the increase in sedentary time with age found in the present study is similar to increases reported by longitudinal studies in developed countries [34-35].

This study can, through the cause-effect relationships examined, provide evidence to guide the formulation of appropriate and reasonable recommended levels of physical activity to prevent overweight/obesity in Vietnamese adolescents. The findings will also provide evidence to help develop recommendations for dietary behaviours or future designs of schools and neighbourhoods to ensure these environments are health promoting and meet the needs of Vietnamese adolescents during an age when there is rapid body growth.

Conclusion

The rapidly increasing prevalence of obesity as well as the significant decrease in time on moderate to vigorous activity and increase in sedentary time in adolescents in Ho Chi Minh City suggesting that this population is at increased future risk of non-communicable diseases. There is an urgent need to develop interventions to target this population to promote physical activity and decrease sedentary behaviour in order to prevent overweight/obesity. The complete data analysis of this cohort study will allow a full exploration of the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and also identify the factors most strongly associated with excess weight gain and the appearance of overweight and obesity in different age groups of adolescents from this large city in Vietnam. This information is needed to develop evidence-based public health interventions to control and prevent this epidemic from expanding amongst the youth of Ho Chi Minh City and other cities in Vietnam.

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Data sharing statement: Access to the dataset is available from the corresponding author (nguyenhoang_doantrang@yahoo.com) or the principle investigator (hongutc@yahoo.com) in STATA format for academic researchers interested in undertaking a formally agreed collaborative research project.

Figure 1: Map of Ho Chi Minh City, Viet Nam with studied districts

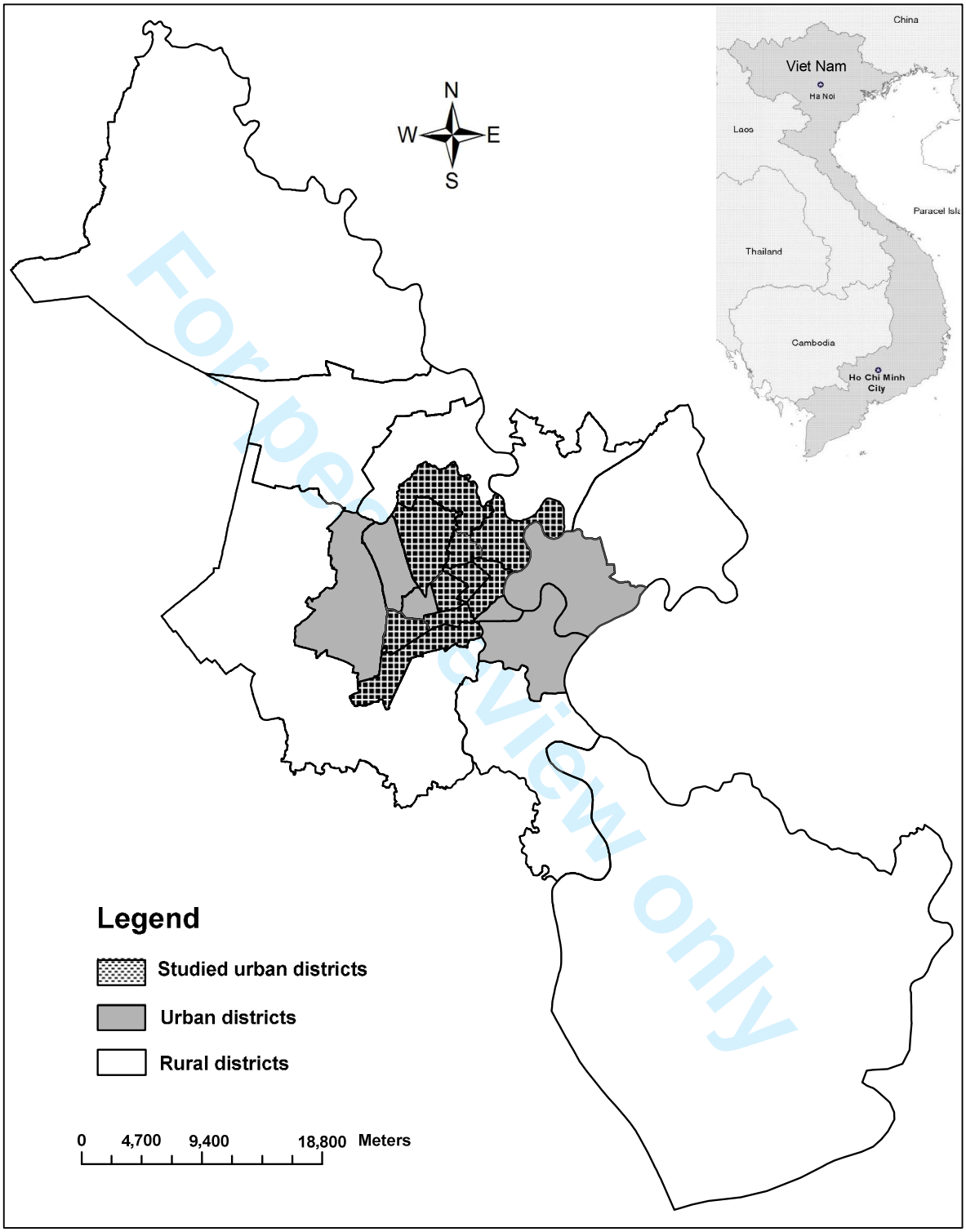
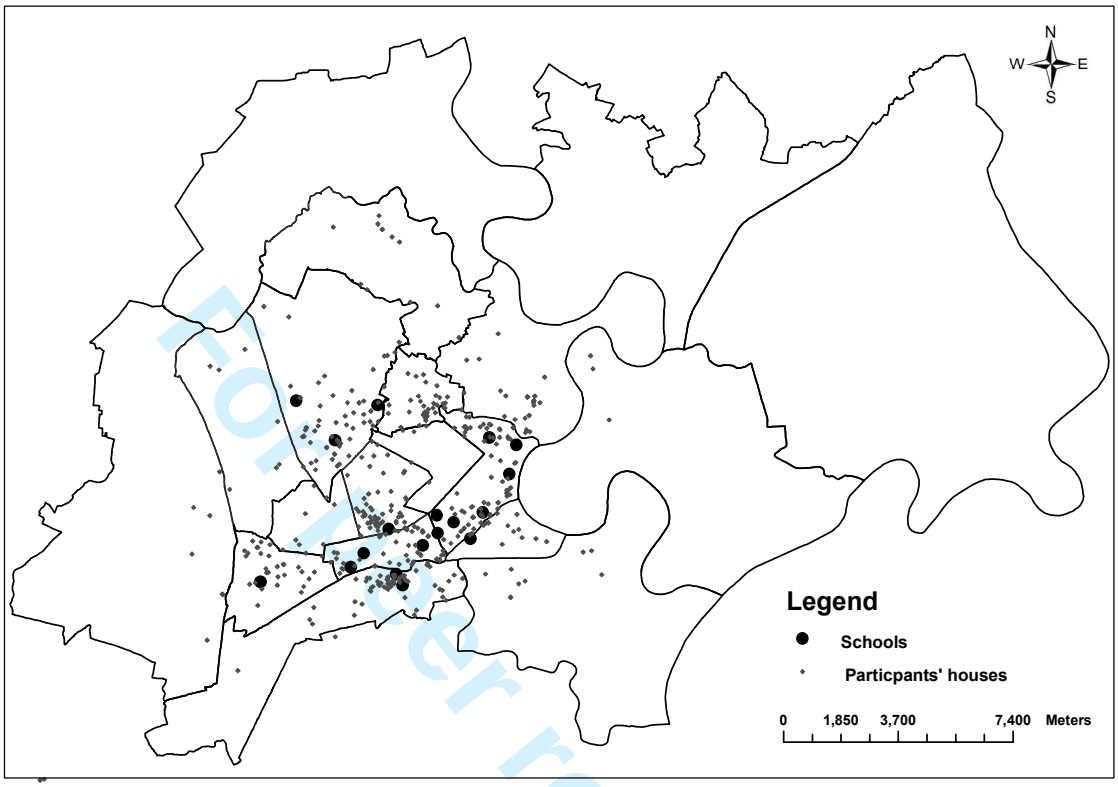


Figure 2: Map of studied schools and student participants' homes



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5,6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*8-10*
Bias	9	Describe any efforts to address potential sources of bias	8,9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13,14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Cohort profile: Ho Chi Minh City Youth Cohort - changes in diet, physical activity, sedentary behavior and relationship with overweight/obesity in adolescents

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Cohort profile: Ho Chi Minh City Youth Cohort - changes in diet, physical activity, sedentary behavior and relationship with overweight/obesity in adolescents

Nguyen Hoang Hanh Doan Trang [a,b*], Tang Kim Hong [a], Michael John Dibley[b]

[a] Department of Community Health, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam

[b] Sydney School of Public Health, Sydney Medical School , The University of Sydney, NSW 2006, Australia

**** Corresponding author:***

Nguyen Hoang Hanh Doan Trang

Pham Ngoc Thach University of Medicine,

86/2 Thanh Thai Street, District 10, Ho Chi Minh City, Vietnam

Tel: +84 8 8631383; +84 933191899

Fax: +84 8 8650025

E-mail: nguyenhoang_doantrang@yahoo.com; dngu6292@uni.sydney.edu.au

Key words: cohort profile, Ho Chi Minh city, youth

Word count: 3900 words, 2 figures, 3 tables

Abstract: (288)

Objectives: The Ho Chi Minh Youth cohort study aimed to assess the change in nutritional status, indicators of adiposity, diet, physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of HCMC.

Design: Prospective 5 year cohort

Setting: Systematic random sampling was used to select 18 schools in urban districts.

Participants: Children were followed-up over five years with an assessment in each year. Consent, from both adolescents and their parents, was required. At baseline, 759 students were recruited into the cohort, and out of these students, 740 remained in the cohort for the 1st round of follow-up, 712 for the 2nd round, 630 for the 3rd round, and 585 students for the last follow-up.

Primary and secondary outcome measures: Anthropometric measurements were taken using established guidelines. Six main groups of exposure factors including dietary intake and behaviours, physical activity and sedentary behaviours, family social and physical environment, school environment, socioeconomic status, and parental characteristics were measured.

Results: Retention rate was high (77%). Within 5 years period, the prevalence of combined overweight and obesity using IOTF cut-off values increased from 14.2% to 21.8%. Time spent on physical activity decreased significantly in the 5 year period from 87 minutes / day to 50 minutes / day. Time spent on sedentary behaviours increased in the 5 year period from 512 minutes / day to 600 minutes / day

Conclusions: The complete data analysis of this cohort study will allow a full exploration of the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and also identify the factors most strongly associated with excess weight gain and the appearance

of overweight and obesity in different age groups of adolescents from this large city in Vietnam.

Article summary:

Article focus:

- The change in nutritional status, indicators of adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of Ho Chi Minh city

Key messages

- Prevalence of combined overweight/obesity increased from 14.2% to 21.8% in 5 year period
- Time spent on physical activity decreased significantly in the 5 year period from 87 minutes / day to 50 minutes / day
- Time spent on sedentary behaviours increased in the 5 year period from 512 minutes / day to 600 minutes / day

Strengths and limitations:

- This is the first cohort in Vietnam on adolescent obesity in Vietnam.
- This study assessed a full set of potential risk factors from dietary intake, physical activity and sedentary behaviours to environmental factors, allowing a wide ranging assessment of the factors related to excess weight gain and overweight and obesity among urban Vietnamese adolescents.
- The present longitudinal study revealed changes in anthropometric measurements, physical activity, sedentary behaviour, and diet associated with age in both genders.

Introduction

In recent years, the increasing prevalence of obesity has become one of the major health concerns in children and adolescents in developed countries, and in developing countries where an economic transition is underway.[1] Vietnam and especially Ho Chi Minh City (HCMC) - the largest city in Vietnam - is in an early 'nutrition transition' where both under-nutrition and the emerging problem of overweight and obesity can be found.[2] Evidence of this transition can be found in the results of two cross-sectional nutrition surveys, which reported an increase in the prevalence of overweight and obesity of adolescents in HCMC from 5.8% in 2002 to 13.7% in 2004, and over the same period a decline in the prevalence of underweight from 11.3% to 6.6%.[3]

It is known that adolescent obesity is associated with a range of potential medical and psychosocial complications, as well as being a risk factor for increased morbidity and premature mortality in adulthood.[4] The intermediate consequences include the development of cardiovascular risk factors and persistence of obesity into adulthood. Reviews of the evidence suggest that the risk of cardiovascular disease and all-cause mortality are elevated among adults who were overweight during childhood.[5] However, evidence on risk factors for childhood obesity is limited at present, especially for transitional societies, and most previous studies on risk factors for obesity have been unable to adequately account for confounding variables, particularly socioeconomic status.[6] Although both genetic and environmental factors are thought to cause obesity, awareness is increasing for the importance of environmental factors [7] including school, neighbourhood and home microenvironments, which play an influential role in determining unhealthy lifestyle choices.[8]

Ho Chi Minh City (HCMC) with a population of 7 million is one of the largest cities in Vietnam [9] and is located in the south east region of the country (*Figure 1*). Over the last

two decades the city has experienced rapid social, economic and demographic changes. Parallel to these social and economic changes, overweight and obesity have emerged as amongst the most significant public health issues in the city. The examination of risk factors in a setting where such rapid changes are taking place provides a unique opportunity to obtain a picture of how overweight and obesity emerges in children in a population undergoing social and economic transition. The urban area of HCMC, with its high population density of 3,155 persons / km^2 and its rapid socioeconomic development, is an ideal setting to identify risk factors for excess weight gain in adolescents because of the ease of tracking and following-up students.

The present cohort study aimed to assess the change in nutritional status, indicators of adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and school micro-environments and their complex relationships in adolescents in urban areas of the province. The results of this study will provide new insights into how the childhood obesity epidemic in a transitional society differs from that in developed countries. It will also provide evidence to plan and evaluate the most appropriate interventions to prevent excess weight gain in adolescents in HCMC in the future.

Methods and analysis:

Study design:

Sample selection The cohort study began from a multi-stage cluster cross sectional survey in 2004. This survey covered 136 public junior high schools and 4 non-public (semi public and private) junior high schools. Of these 140 schools, 47 were from wealthy urban areas and 93 from less wealthy urban districts. This classification of urban districts was derived from the Statistics Review of HCMC province Department of Statistics.[10]

Non-wealthy districts were categorized as having more than 50% households below the wealthy threshold (non-wealthy household). Non-wealthy household in Ho Chi Minh City in

2004 was identified as having average personal income less than 6.000.000 Vietnam Dong/person/year.[11]

The total number of students in wealthy urban schools was 62,853 whilst that of less wealthy urban schools was 119,717. From these 140 schools, 31 clusters (schools) were selected with 17 clusters (schools) selected from the list of schools in wealthy urban districts, and 14 clusters (schools) from less wealthy urban districts, using probability proportionate to size (PPS) sampling within each strata. Because the number of classes and students in non-public schools are smaller than in public schools, only 3 non-public schools were selected in the sample of the cross-sectional survey. In each selected school, lists of classes from grades 6 and 7 combined, and grades 8 and 9 combined were prepared. Simple random sampling was used to select one class from each group of grades. All students in the selected classes were invited to participate in the study.

For the cohort study, systematic random sampling was used to select 18 schools from these 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts. The sub sample of children required for the cohort study was selected from one class from grades 6 and 7 combined in each school, resulting in 784 students of the cohort study.

Sample size

The sample size estimates for the cohort study were based on expected differences in the average change of BMI between exposure groups (Insufficiently active vs. active students viewing >20 hrs TV per week vs. <20 TV viewing per week, students in the lowest quintile of nutrient intake vs. other quintiles of intake, students who ride bicycles to school vs. were taken to school by motorcycle), using a standard deviation of 1.5 and assuming a 5% significance level, 80% power. In the absence of information about relative change in BMI for HCMC children, these sample size estimates are based on the observed relative change in BMI in children exposed to an education intervention to reduce TV viewing in the United

States.[12] The average change in BMI selected was 0.35 kg/m^2. Sample size estimates were calculated using the PS program,[13] resulting in an estimated required sample size of 720 children. However, since we used cluster sampling (school and class selection), all the students in a selected class were invited to participate in the cohort for logistic reasons; yielding 784 students who were invited to participate and giving 759 who were recruited into the cohort study.

Informed consent

Informed written consent was firstly obtained from the principals of the schools participating in the study. Information about the study was distributed to the selected class by the school principals and class teachers using flyers and notices. All the students in selected classes were invited to participate in the cohort study. Discussions were held with the school principals to establish a timetable of visits to ensure project staff could meet all the children and parents. Information sheets and consent forms for the adolescents and their parents were distributed by the project staff at their first visit to the class. Project staff was also available to answer questions regarding the study on this visit. Consent from both the adolescents and their parents was required for participation in the study and collected one week apart.

Frequency of follow-up

Children were followed-up over five years with an assessment in each year. During the first three years when the study participants were in junior high schools, data was collected by class surveys. In Vietnam, junior and senior high schools are separate institutions and students from one junior high school may move to many different senior high schools. So, when the study participants moved to senior high school, follow-up was sustained with individual contact by phone calls, home visits and group surveys for those students still together in a single high school.

Data collection

At each assessment round, we measured the main outcome variables (anthropometric measurements) as well as the exposure factors. In the third round, we collected biochemical data for assessing cardiovascular and metabolic disease risks.

Measurement of outcome variables: All the anthropometric measurements were taken using established guidelines.[14] Standing height was measured using a portable direct-reading stadiometer and body weight was measured using a digital scale. Waist and hip circumferences were measured with a non-elastic tape at the level of the umbilicus and with maximal extension of the buttocks. Standardization exercises with the anthropometrists were used every 6 months to monitor the quality of anthropometric measurements. Blood samples (done in the third round) and blood pressure were measured at the end of data collection. Height, weight and blood pressure were measured twice and the average value was used.

Biochemical measurements:

A sample of five millilitres of venous blood was collected from the participants' forearm by experienced, trained technicians. Fasting blood glucose and the lipid profile (triglyceride, total cholesterol, high, low and very low density cholesterol) were assayed by a photometer (Hitachi 917 Japan) using a standard method at the Diagnostic Center in HCMC.

Standard internationally recommended procedures were used for the handling and processing of blood specimens,[15] and the specimens were transported to the laboratory within 2 hours of collection at the schools. Serum samples were stored in special plastic tubes with sealed lids. Unused portions of the blood samples collected were stored at - 20^0 degrees in freezers in the laboratories of the Diagnostic Center, HCMC in case reanalysis was needed once the data was examined. These specimens were destroyed once all the data has been cleaned.

Measurement of exposure factors: The adolescents were interviewed using the *environmental assessment*, *food frequency, physical activity, and television and computer usage*

questionnaires. The parents completed the *family habits and environment questionnaire*. Six main groups of exposure factors were measured:

Dietary intake and diet behaviours was assessed using a validated Youth Food Frequency Questionnaire [16] which allowed the study participants to be ranked by levels of food energy and fat intake and categories of different diet patterns e.g. frequency of fast food, snacks or soft drink consumption.

Physical activity and sedentary behaviours were assessed by the Adolescent Physical Activity Recall Questionnaire (APARQ) [17] which was developed and validated among Australian adolescents but modified for use in Vietnam, the Vietnamese-Adolescent Physical Activity Recall Questionnaire (V-APARQ) and a Adolescent Sedentary Activity Questionnaire (ASAQ) [18]. A validation study comparing the results from the V-APARQ with accelerometer measurements showed that V-APARQ is a valuable tool to assess physical activity in adolescents of Ho Chi Minh City.[19] They were also objectively measured by use of accelerometers (Actigraph®) for each student over a one-week period to assess long term physical activity patterns.[20]

The *family social environment* was assessed using the family habits and environment questionnaire, which measured exposure to various social and physical home environmental factors (e.g. number and location of TVs at home, and family rules on TV viewing). Questionnaires were completed by the adolescents and their parents to assess exposure to environmental elements at home, school and neighbourhoods. The environmental questionnaire was developed from the results of *group discussions* with approximately 10 to 15 community members in each of four different locations of varying socioeconomic status from across HCMC. These group discussions identified the key environmental elements of homes, schools and neighbourhoods that needed to be included in the questionnaire. Lack of pathways and dangerous traffic were amongst the reasons many parents did not allow their

children to walk or cycle alone. *In-depth interviews* were also conducted with selected members to explore in more detail the environmental risks identified and the opportunities for change. Interviews were taped, transcribed, checked for accuracy, and the content and themes were analysed to identify how the environmental risks varied across communities, how easily they might be modified and what methods of change were available in the different communities. The items on the questionnaire were derived from the information gathered from the qualitative data collection.[21]

Physical environment assessments were also taken using a questionnaire. The home environment questionnaire was piloted in a sample of 50 respondents (adolescents and their parents from different areas in HCMC) and validated by direct observations by the investigators. Information regarding environmental factors at community and household levels as well as socio-demographic factors was obtained via a self-administered questionnaire for parents. The description of this questionnaire has also been published previously.[22]

Distance between the respondent's house and schools and these recreational facilities were measured using Global Positioning System (GPS). GPS readings recorded the location of fast food outlets and recreation areas within 1km surrounding the home of all participants in the cohort study. These data sources will be used to directly estimate the average distances from the respondent's home to these physical aspects of their environments, and also to estimate the average density of these environmental elements.

School environment was assessed using a self-administered questionnaire completed by the school principals, who were asked about school facilities for sport and exercise, availability of such facilities, and the foods and drinks sold in the school canteen.

Additional risk factors including self-recorded parent's weight and height, parental ethnicity, and demographic, socioeconomic status of the child and the family were assessed by structured questionnaires.

To assess economic status, ownership of an inventory of assets was used to construct a household wealth index using the principal components method to assign a weight for each asset. [23] A total of fourteen assets were assessed including bicycles, motorbikes, televisions, radios, videos, cassette players, computers, gas stoves, CD players, cars, microwave ovens, refrigerator and telephone and air-conditioners. The basis for selecting the assets was from a report of the Bureau of Statistics of HCMC [10] listing the most common assets used among HCMC population.

Also the adolescent's pubertal status was self assessed using a form, which recorded the child's date of birth, gender, weight and height, and questions to self-assessed pubertal status. In a confidential setting, the adolescents self-reported their pubertal status using a questionnaire with photographs illustrating five stages [24] of pubertal development for pubic hair, male genitalia, or female breasts, and for female students the date of their first menstruation was also recorded.

Data analysis

Analyses were conducted using STATA 11 (STATA Corporation, College Station, TX, USA, 2009). The IOTF (International Obesity Task Force) BMI cut-off values were used to define overweight and obesity combined [25]. The wealth index was ranked and divided into tertiles and each household was assigned to one of these wealth index categories.

The general characteristics of the population were described. For continuous variables, means and standard deviations or medians and inter-quartile ranges were calculated according to the distribution of each variable. In the case of categorical variables, absolute and relative frequencies were calculated. 95% confidence intervals were also computed. Continuous

variables that were not normally distributed were evaluated by the application of transformations and categorisations wherever applicable. Baseline characteristics were compared by gender and the lost to follow-up group was compared with the cohort baseline group using Pearson chi-square or Fisher's exact test for categorical data, whereas continuous data were tested with Student's t-test or Wilcoxon Mann-Whitney test. Kruskal-Wallis test was used to compare medians of time spent on MVPA and sedentary behaviours and chi-square for trend was used to compare prevalence of BMI status by years. The "survey commands" were used to account for the multi-stage cluster sampling design. Future analyses of this cohort data that assess relationships between exposure factors and the change of BMI, physical activity, sedentary behaviours, will require mixed multiple regression models to adjust for the multi-stage cluster sampling and repeated measurements in individual study participants.

Ethics and dissemination:

The research proposal was approved by the Research Ethics Committee, Pham Ngoc Thach University of Medicine, Ho Chi Minh City. It was also approved by the Human Research Ethics Committee, University of Newcastle (ethics reference: H-879-0904). Informed written consent was obtained from the principals of the schools participating in the study. Consent from both the adolescents and their parents were required prior to their participation in the study.

Results

At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to take part in the cohort study, of which 740 participated in the first follow-up data collection including anthropometric measurements, dietary, physical activity, sedentary behaviours and environment assessment. Therefore, the attrition rate for one year follow-up was 2.5%. In the second round of follow-up, there were 712 (94% of baseline), in the fourth round, there were

630 (83% of baseline), and in the last follow-up 585 students remained in the cohort, resulting in a retention rate of 77% (*Table 1*).

Insert table 1 here

The characteristics of the follow-up group (n=585) were compared with drops-out (n=174) on key variables that were available for all participants. These two groups did not differ by age, gender, and pubertal status, anthropometric or socio-demographic characteristics. The drop-outs in the sample were mainly attributed to the following reasons: (i) moved to another school (n= 93, 12.2 %); (ii) refused to continue in the study (n= 45, 5.9 %) and (iii) changed home address or migrated overseas (n= 36, 4.7 %).

The baseline data for socio-demographic and anthropometric variables are listed in *Table 2*. At baseline, the mean age of the sampled subjects was 11.8 years (±0.6). Overall 12.5% of the students were overweight and 1.7% were obese. The mothers of 52.3% of the students had completed senior high school and 58.5% of the fathers had completed senior high school.

Insert table 2 here

Figure 2 shows the geographic distribution of schools and participants' home measured by GPS. Students' houses were scattered around their schools with a median distance from home to school of 1,450m (Inter-quartile Range (IQR): 680-3,030m).

Insert figure 2 here

A summary of the changes in the BMI status and time spent in moderate to vigorous physical activity and sedentary behaviours are listed in *Table 3*. Over the five year period of this cohort study, the prevalence of overweight increased from 12.5% to 16.7%, and obesity from 1.7% to 5.1%. Time spent in moderate to vigorous physical activity decreased significantly from 87 minutes / day to 50 minutes / day. In contrast, time in sedentary behaviours increased from 512 minutes / day to 600 minutes / day.

Insert table 3 here

Previous papers based on the cross sectional baseline survey have described overweight and obesity [3 26], physical inactivity [22], and metabolic syndrome [27] and associated risk factors. Another paper has used the longitudinal data from the youth cohort to describe changes in active commuting to school and risk factors for changes in commuting status [28]. More results will be presented in future papers presenting changes in physical activity, sedentary behaviour, and overweight/obesity and their associated risks factors.

Discussion:

We have successfully implemented a 5-year follow-up study in adolescents in Vietnam with a high retention rate of 77%. Over this period, we found that the prevalence of combined overweight and obesity increased significantly from 14.2% to 21.8%. Self-reported time spent on physical activity decreased significantly from 87 minutes / day to 50 minutes / day and in contrast, sedentary time increased from 512 minutes / day to 600 minutes / day. This is the first cohort study on adolescent obesity in Vietnam, which provides a comprehensive assessment of the change in anthropometric growth, dietary intake, physical activity and environmental factors as well as their associations over the years of follow-up.

An important strength of the study was maintaining more than 75% of the students in this cohort which has helped ensure the internal validity of the study. Also, the measurements of key outcomes and study factors have high reliability and validity from the use of validated tools (FFQ, V-APARQ, environmental questionnaires) and objective measurements (accelerometers, GPS devices). The project staff, who took the measurements, was retrained throughout the study thus helping to ensure standard measurement methods were used across the cohort. We used a prospective longitudinal design from a representative sample of adolescents from HCMC and aimed to follow-up the children over five years. Each child has a health profile including anthropometric and pubertal status data as well as other exposure

factors each year. The findings will be of relevance to other cities in Vietnam, which are starting to go through the same environmental and lifestyle changes that have already occurred in HCMC. The findings will also be relevant to other urban populations in East Asia and Southeast Asia where rapid economic development is leading to a nutrition transition similar to that occurring in HCMC.

The relatively small sample size is one limitation of the study restricting examination of all potential relationships because of the limited sample in some subgroups. However, the sample size was adequate to detect changes in BMI over time and changes in key study factors such as physical activity and screen time which was used as a proxy for sedentary time. Despite this restriction, this study remains important because it is one of very few longitudinal studies in Vietnam and South East Asia to explore obesity and changes in obesity-related risk factors in adolescents.

Although there was only one non-public school in this study, this reflected the small proportion of the school population enrolled in this type of school in HCMC. We found no important differences between public and private schools for the main study factors and outcomes, such as socioeconomic status. Unlike the situation in many developed countries, in Vietnam, non-public schools are not popular and students usually enter these schools when they cannot secure a place in a public school. Thus, we believe the sampling of this study was not biased and is representative of HCMC adolescents at school.

In Ho Chi Minh City over the five year period, the prevalence of overweight increased from 12.5% to 16.7% and obesity increased from 1.7% to 5.1%. This increase in overweight and obesity was consistent with the increases found in 5-year follow up studies from 1999 to 2004 in urban Indonesian children where the prevalence of overweight increased from 4.2% in children to 8.8% in adolescents, and similarly obesity increased from 1.9% to 3.2% [29]. Similar findings have been reported from a 5-year follow-up study in Thai school children

where the prevalence of overweight in boys increased from 12.4% in 1992 to 21.0% in 1997.[30]

The primary findings of this study are also consistent with the substantial age-related declines in MVPA among both adolescent boys and girls previously reported in the US [31-32], and Finland [33]. These results also showed that daily MVPA decreased of 42% over a five year period when adolescents were aged 12 years to 16 years, which was similar to the 45% decline reported for American adolescents in the CATCH study [34]. Furthermore, the increase in sedentary time with age found in the present study is similar to increases reported by longitudinal studies in developed countries [35-36].

This study can, through the cause-effect relationships examined, provide evidence to guide the formulation of appropriate and reasonable recommended levels of physical activity to prevent overweight/obesity in Vietnamese adolescents. The findings will also provide evidence to help develop recommendations for dietary behaviours or future designs of schools and neighbourhoods to ensure these environments are health promoting and meet the needs of Vietnamese adolescents during an age when there is rapid body growth.

Conclusion

The rapidly increasing prevalence of obesity as well as the significant decrease in time on moderate to vigorous activity and increase in sedentary time in adolescents in Ho Chi Minh City suggesting that this population is at increased future risk of non-communicable diseases. There is an urgent need to develop interventions to target this population to promote physical activity and decrease sedentary behaviour in order to prevent overweight/obesity. The complete data analysis of this cohort study will allow a full exploration of the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and also identify the factors most strongly associated with excess weight gain and the appearance of overweight and obesity in different age groups of adolescents from this large city in Vietnam.

This information is needed to develop evidence-based public health interventions to control and prevent this epidemic from expanding amongst the youth of Ho Chi Minh City and other cities in Vietnam.

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Data sharing statement: Access to the dataset is available from the corresponding author (nguyenhoang_doantrang@yahoo.com) or the principle investigator (hongutc@yahoo.com) in STATA format for academic researchers interested in undertaking a formally agreed collaborative research project.

Table 1: Number of student participants at the start of each year in the cohort study and the percentage retention at each year of follow-up

Year of Measurement	2004/05	2005/06	2006/07	2007/08	2008/09
Number of students at start of year	759	740	712	630	585
Number lost to follow-up (n=174)	174	19	28	82	45
Moved to another schools (n=93)		9	5	63	16
Changed home address or migrated overseas (n=36)		9	4	9	14
Refused to continue in the study (n=45)		1	19	10	15
Percentage of students retained compared to 2004		97%	94%	83%	77%

Table 2: Baseline characteristics of the study participants by gender

	Boys		Girls		Total		
	Mean	SD	Mean	SD	Mean	SD	P*
	(n=364)		(n=395)		(n=759)		
Age in years	11.8	0.6	11.9	0.7	11.8	0.6	0.5
Height in cm	155.7	9.7	153.4	8.1	154.5	9.0	<0.001
Weight in kg	44.6	9.6	41.0	7.4	42.7	8.7	<0.001
BMI	20.1	3.9	18.1	3.1	19.1	3.7	<0.001
	%	*CI 95%*	*%*	*CI 95%*	*%*	*CI 95%*	
BMI status	(n=364)		(n=395)		(n=759)		0.0001
Normal	80.8	76.6, 85.0	90.3	87.4, 93.3	85.8	83.3, 88.4	
Overweight non obese	16.9	12.9, 20.8	8.6	5.8, 11.4	12.5	10.1, 14.9	
Obese	2.3	0.7, 3.9	1.0	0.0, 2.1	1.7	0.7, 2.6	
Pubertal status							<0.001
Prepubescent	45.9	40.6, 51.2	22.1	18.0, 26.3	33.6	29.9, 36.8	
Pubescent	54.1	48.8, 59.4	77.9	73.7, 82.0	66.6	63.2, 70.1	
Maternal education	(n=329)		(n=367)		(n=696)		0.4
No school or incomplete primary school	6.1	3.5, 8.7	7.4	4.7, 10.0	6.7	4.9, 8.6	
Incomplete junior high school	18.5	14.3, 22.8	19.3	15.3, 23.4	19.0	16.0, 21.9	
Incomplete senior high school	21.6	17.1, 26.0	22.3	18.1, 26.6	22.0	18.9, 25.1	
Complete senior high school or higher	53.8	48.4, 59.2	50.9	45.8, 56.1	52.3	48.6, 56.0	
Paternal education	(n=329)		(n=367)		(n=696)		0.2
No school or incomplete primary school	5.8	3.2, 8.3	7.1	4.4, 9.7	6.5	4.6, 8.3	
Incomplete junior high school	13.4	9.7, 17.1	15.5	11.8, 19.2	14.5	11.9, 17.1	
Incomplete senior high school	20.1	15.7, 24.4	21.0	16.8, 25.2	20.5	17.5, 23.5	
Complete senior high school or higher	60.8	55.5, 66.1	56.4	51.2, 61.5	58.5	54.8, 62.1	
BMI status of parents	(n=291)		(n=326)		(n=617)		0.9
Both not overweight/obese	71.1	65.9, 76.4	72.1	67.2, 77.0	71.6	68.1, 75.2	
Father Overweight/obese	7.6	4.5, 10.6	7.1	4.3, 9.8	7.3	5.2, 9.4	
Mother Overweight/obese	17.9	13.4, 22.3	16.6	12.5, 20.6	17.2	14.2, 20.2	
Both overweight/obese	3.4	1.3, 5.5	4.3	2.1, 6.5	3.9	2.3, 5.4	
Socioeconomic status	(n=364)		(n=395)		(n=758)		0.4
Poorest (1st tertile)	33.6	28.7, 38.5	33.1	28.4, 37.7	33.4	30.0, 36.7	
2nd tertile	31.4	26.6, 36.2	35.9	31.2, 40.7	33.8	30.4, 37.1	
Richest (3rd tertile)	35.0	30.1, 39.9	30.9	26.3, 35.5	32.8	29.5, 36.2	

**test compared characteristics between boys and girls*

Table 3: Changes of anthropometric data, self-reported time in MVPA*and sedentary behaviours, 2004-2009

	Year 2004/05	Year 2005/06	Year 2006/07	Year 2007/08	Year 2008/09	p+
	% (CI 95%)	% (CI 95%)	% (CI 95%)	% (CI 95%)	% (CI 95%)	
BMI status						
Not overweight/obese	85.8 (83.3, 88.4)	84.8 (82.2, 87.4)	83.9 (81.2, 86.6)	81.3 (78.2, 84.5)	78.2 (71.8, 84.6)	0.003
Overweight	12.5 (10.1, 14.9)	12.7 (10.3, 15.1)	12.9 (10.5, 15.4)	14.5 (11.6, 17.3)	16.7 (13.6, 19.8)	
Obese	1.7 (0.7, 2.6)	2.5 (1.3, 3.6)	3.2 (1.8, 4.4)	4.2 (2.6, 5.8)	5.1 (3.3, 7.0)	
	Median (25th, 75th)	Median (25th, 75th)	Median (25th, 75th)	Median (25th, 75th)	Median (25th, 75th)	
Time spent on MVPA*/day (data from V-APARQ**)	86.5 (48.0, 255.4)	79.9 (36.0, 228.1)	64.4 (29.5, 198.5)	57.3 (24.1, 209.6)	50.3 (25.5, 161.3)	0.0001
Time spent on sedentary behaviours (data from ASAQ$)	512 362, 632	554 412, 658	596 436, 699	607 443, 707	600 424, 682	0.001

**MVPA: moderate to vigorous physical activity; ** V-APARQ: Vietnamese- Adolescent Physical Activity Recall Questionnaire; $ASAQ: Adolescent Sedentary Activity Questionnaire*
+ test for changes

Figure 1: Map of Ho Chi Minh City, Viet Nam with studied districts

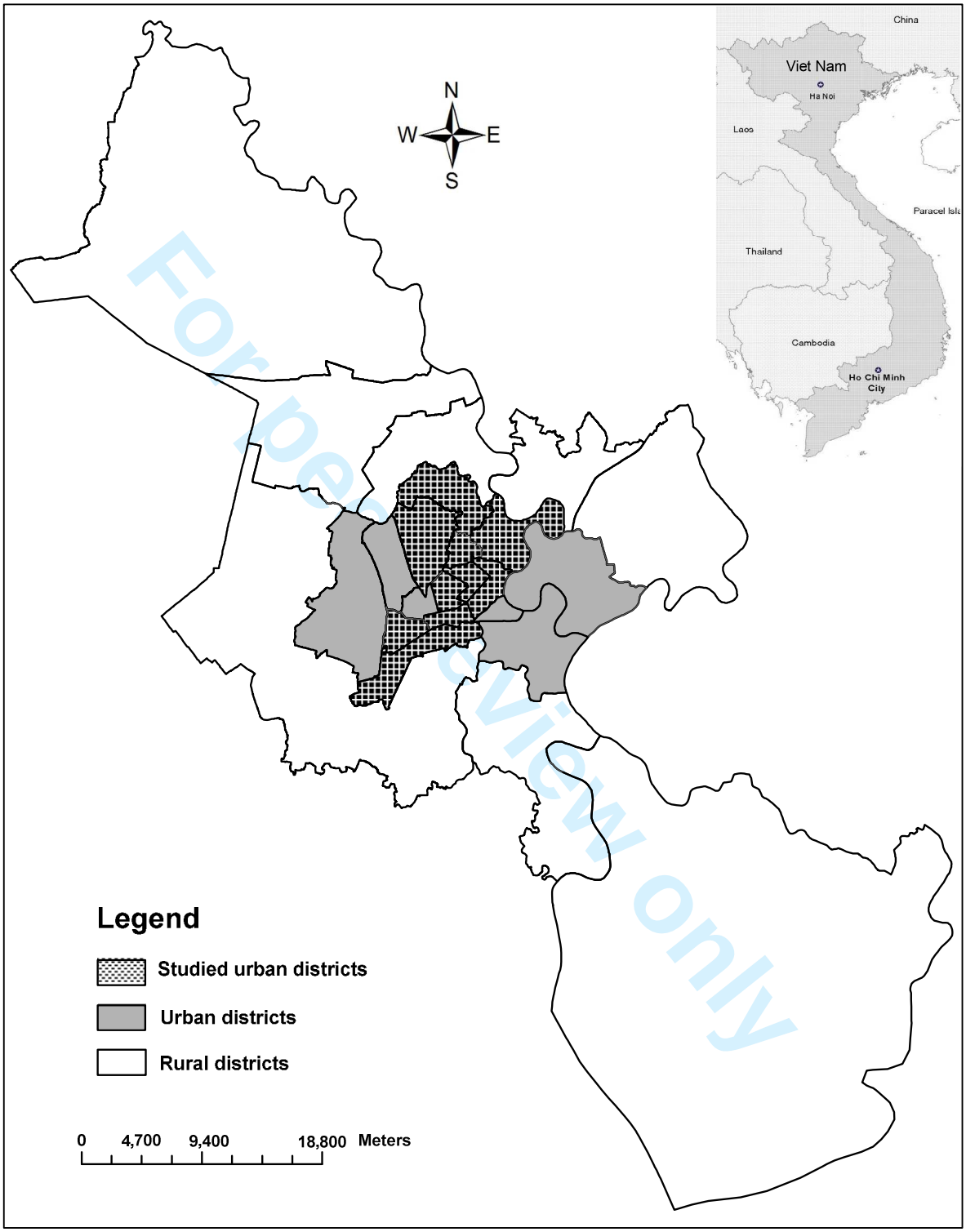
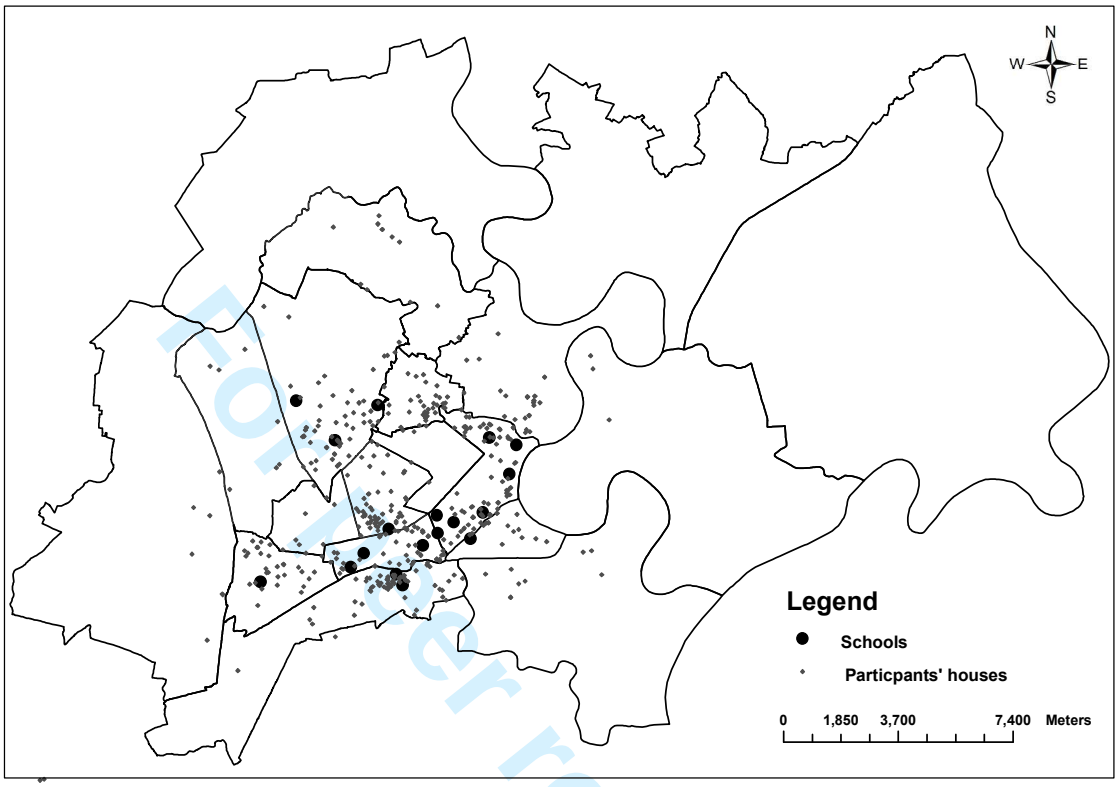


Figure 2: Map of studied schools and student participants' homes



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5,6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*8-10*
Bias	9	Describe any efforts to address potential sources of bias	8,9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13,14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.