



### Cohort profile: the Ho Chi Minh City Youth Cohort

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## Cohort profile: the Ho Chi Minh City Youth Cohort

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

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3 **Abstract: (271)**  
4

5 Objectives: The Ho Chi Minh Youth cohort study aimed to assess the change in nutritional  
6 status, indicators of adiposity, diet, physical activity and sedentary behaviours, home,  
7 neighbourhood and school micro-environments and their complex relationships in  
8 adolescents in urban areas of HCMC.  
9

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

19 Results: Retention rate was high (77%). Within 5 years period, the prevalence of combined  
20 overweight and obesity using IOTF cut-off values increased from 14.2% to 24.5%,  
21 representing an average annual relative increase of approximately 15%. Time spent on  
22 physical activity decreased significantly in the 5 year period from 87 minutes / day to 50  
23 minutes / day. Time spent on sedentary behaviours increased in the 5 year period from 512  
24 minutes / day to 537 minutes / day  
25

26 Conclusions:  
27

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

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2  
3 two decades the city has experienced rapid social, economic and demographic changes.  
4  
5 Parallel to these social and economic changes, overweight and obesity have emerged as  
6  
7 amongst the most significant public health issues in the city. The examination of risk factors  
8  
9 in a setting where such rapid changes are taking place provides a unique opportunity to obtain  
10  
11 a picture of how overweight and obesity emerges in children in a population undergoing  
12  
13 social and economic transition. The urban area of HCMC, with its high population density of  
14  
15 3,155 persons / km<sup>2</sup> and its rapid socioeconomic development, is an ideal setting to identify  
16  
17 risk factors for excess weight gain in adolescents because of the ease of tracking and  
18  
19 following-up students.  
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24 The present cohort study aimed to assess the change in nutritional status, indicators of  
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26 adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and  
27  
28 school micro-environments and their complex relationships in adolescents in urban areas of  
29  
30 the province. The results of this study will provide new insights into how the childhood  
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32 obesity epidemic in a transitional society differs from that in developed countries. It will also  
33  
34 provide evidence to plan and evaluate the most appropriate interventions to prevent excess  
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36 weight gain in adolescents in HCMC in the future.  
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#### 41 **Methods and analysis:**

##### 42 **Study design:**

43  
44 **Sample selection** The cohort study began from a multi-stage cluster cross sectional survey in  
45  
46 2004. This survey covered 140 secondary high schools including public and private schools,  
47  
48 of which 47 schools were from wealthy urban areas and 93 schools were of less wealthy  
49  
50 urban districts. The total number of students in wealthy urban schools was 62,853 whilst that  
51  
52 of less wealthy urban schools was 119,717. From these 140 schools, 31 clusters (schools)  
53  
54 were selected with 17 clusters (schools) selected from the list of schools in wealthy urban  
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56 districts, and 14 clusters (schools) from less wealthy urban districts, using probability  
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3 proportionate to size (PPS) sampling within each strata. In each selected school, lists of  
4 classes from grades 6 and 7 combined, and grades 8 and 9 combined were prepared. Simple  
5 random sampling was used to select one class from each group of grades. All students in the  
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9  
10 selected classes were invited to participate in the study.

11  
12 For the cohort study, systematic random sampling was used to select 18 schools from these  
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14  
15 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts.  
16  
17 The sub sample of children required for the cohort study was selected from one class from  
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19  
20 grades 6 and 7 combined in each school, resulting in 784 students of the cohort study.  
21

### 22 **Sample size**

23  
24 The study started with a cross-sectional study consisting of 1,243 students from schools in  
25  
26  
27 wealthy districts and 1,417 students from schools in less wealthy districts. This sample  
28  
29  
30 included 607 students from grade 6, 725 from grade 7, 814 from grade 8, and 514 from grade  
31  
32  
33 9. The sampling design for this survey has been described previously.[10] With an average of  
34  
35 45 students per class, the design effect was 2.01.

36  
37 The sample size estimates for the cohort study were based on expected differences in the  
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39  
40 average change of BMI between exposure groups (Insufficiently active vs. active students  
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42  
43 viewing >20 hrs TV per week vs. <20 TV viewing per week, students in the lowest quintile  
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45  
46 of nutrient intake vs. other quintiles of intake, students who ride bicycles to school vs. were  
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49 taken to school by motorcycle), using a standard deviation of 1.5 and assuming a 5%  
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52 significance level, 80% power. Sample size estimates were calculated using the PS  
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55 program,[11] with 20% drop-outs, resulting in the sample size of 720 children. This  
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58 represented approximately 60% of urban junior high school students in the cross-sectional  
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61 survey, who were invited to participate in the cohort study.

### 62 **Informed consent**

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

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

44 At each assessment round, we measured the main outcome variables (anthropometric  
45 measurements) as well as the exposure factors. In the third round, we collected biochemical  
46 data for assessing cardiovascular and metabolic disease risks.  
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53 *Measurement of outcome variables:* All the anthropometric measurements were taken using  
54 established guidelines.[12] Standing height was measured using a portable direct-reading  
55 stadiometer and body weight was measured using a digital scale. Waist and hip  
56 circumferences were measured with a non-elastic tape at the level of the umbilicus and with  
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3 maximal extension of the buttocks. Standardization exercises with the anthropometrists were  
4  
5 used every 6 months to monitor the quality of anthropometric measurements. Blood samples  
6  
7 (done in the third round) and blood pressure were measured at the end of data collection.  
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10 Height, weight and blood pressure were measured twice and the average value was used.  
11

### 12 Biochemical measurements:

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15 A sample of five millilitres of venous blood was collected from the participants' forearm by  
16  
17 experienced, trained technicians. Fasting blood glucose and the lipid profile (triglyceride,  
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19 total cholesterol, high, low and very low density cholesterol) were assayed by a photometer  
20  
21 (Hitachi 917 Japan) using a standard method at the Diagnostic Center in HCMC.  
22

23  
24 Standard internationally recommended procedures were used for the handling and processing  
25  
26 of blood specimens,[13] and the specimens were transported to the laboratory within 2 hours  
27  
28 of collection at the schools. Serum samples were stored in special plastic tubes with sealed  
29  
30 lids. Unused portions of the blood samples collected were stored at - 20<sup>0</sup> degrees in freezers  
31  
32 in the laboratories of the Diagnostic Center, HCMC in case reanalysis was needed once the  
33  
34 data was examined. These specimens were destroyed once all the data has been cleaned.  
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38 Measurement of exposure factors: The adolescents were interviewed using the *environmental*  
39  
40 *assessment, food frequency, physical activity, and television and computer usage*  
41  
42 questionnaires. The parents completed the *family habits and environment questionnaire*. Six  
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44 main groups of exposure factors were measured:  
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48 Dietary intake and diet behaviours was assessed using a validated Youth Food Frequency  
49  
50 Questionnaire [14] which allowed the study participants to be ranked by levels of food energy  
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52 and fat intake and categories of different diet patterns e.g. frequency of fast food, snacks or  
53  
54 soft drink consumption.  
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57 Physical activity and sedentary behaviours were assessed by a youth Physical Activity  
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59 Questionnaire (PAQ) [15] and a Adolescent Sedentary Activity Questionnaire (ASAQ) [16]  
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3 which were developed and validated among Australian adolescents but modified for use in  
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5 Vietnam. A validation study comparing the results from the modified PAQ with  
6  
7 accelerometer measurements showed that PAQ is a valuable tool to assess physical activity in  
8  
9 adolescents of Ho Chi Minh City.[17] They were also objectively measured by use of  
10  
11 accelerometers (Actigraph<sup>®</sup>) for each student over a one-week period to assess long term  
12  
13 physical activity patterns.[18]  
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17 The *family social environment* was assessed using the family habits and environment  
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19 questionnaire, which measured exposure to various social and physical home environmental  
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21 factors (e.g. number and location of TVs at home, and family rules on TV viewing).  
22  
23 Questionnaires were completed by the adolescents and their parents to assess exposure to  
24  
25 environmental elements at home, school and neighbourhoods. The environmental  
26  
27 questionnaire was developed from the results of *group discussions* with approximately 10 to  
28  
29 15 community members in each of four different locations of varying socioeconomic status  
30  
31 from across HCMC. These group discussions identified the key environmental elements of  
32  
33 homes, schools and neighbourhoods that needed to be included in the questionnaire. Lack of  
34  
35 pathways and dangerous traffic were amongst the reasons many parents did not allow their  
36  
37 children to walk or cycle alone. *In-depth interviews* were also conducted with selected  
38  
39 members to explore in more detail the environmental risks identified and the opportunities for  
40  
41 change. Interviews were taped, transcribed, checked for accuracy, and the content and themes  
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43 were analysed to identify how the environmental risks varied across communities, how easily  
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45 they might be modified and what methods of change were available in the different  
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47 communities. The items on the questionnaire were derived from the information gathered  
48  
49 from the qualitative data collection.[19]  
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57 *Physical environment* assessments were also taken using a questionnaire. The home  
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59 environment questionnaire was piloted in a sample of 50 respondents (adolescents and their  
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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).

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

#### 41 **Ethics and dissemination:**

42  
43 The research proposal was approved by the Research Ethics Committee, Pham Ngoc Thach  
44 University of Medicine, Ho Chi Minh City. It was also approved by the Human Research  
45 Ethics Committee, University of Newcastle (ethics reference: H-879-0904). Informed written  
46 consent was obtained from the principals of the schools participating in the study. Consent  
47 from both the adolescents and their parents were required prior to their participation in the  
48 study.  
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## 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 ( $\pm 0.6$ ). 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*

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

### 18 **Discussion:**

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20 This is the first cohort study on adolescent obesity in Vietnam, which provides a  
21 comprehensive assessment of the change in anthropometric growth, dietary intake, physical  
22 activity and environmental factors as well as their associations over the years of follow-up.  
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25 This is also the first cohort in Vietnam, which has assessed a full set of potential risk factors  
26 from dietary intake, physical activity and sedentary behaviours to environmental factors,  
27 allowing a wide ranging assessment of the factors related to excess weight gain and  
28 overweight and obesity among urban Vietnamese adolescents.  
29

30 In Ho Chi minh City within the five year period, the prevalence of combined overweight and  
31 obesity increased by age from 14.2% to 24.5%. The increase in the present study (with an  
32 average annual increase of 8.8% for overweight and 3.2% for obesity) was consistent with the  
33 increase revealed in 5-year follow up studies from 1999 to 2004 in urban Indonesia children  
34 (4.2% for overweight, and 1.9% for obesity) [21] and in Thai school children (the prevalence  
35 of overweight increased from 12.4% in 1992 to 21.0% in 1997 in boys).[22] Our primary  
36 findings are also consistent with the substantial age-related declines in MVPA among both  
37 adolescent boys and girls previously reported.[23-25]  
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39 This study can, through the cause-effect relationships examined, provide evidence to guide  
40 the formulation of appropriate and reasonable recommended levels of physical activity to  
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3 prevent overweight/obesity in Vietnamese adolescents. The findings will also provide  
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5 evidence to help develop recommendations for dietary behaviours or future designs of  
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7 schools and neighbourhoods to ensure these environments are health promoting and meet the  
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9 needs of Vietnamese adolescents during an age when there is rapid body growth.  
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13 Maintaining more than 75% of the students in this cohort has helped ensure the internal  
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15 validity of the study. Moreover, the measurements of key outcomes and study factors have  
16  
17 high reliability and validity from the use of validated tools (FFQ, PAQ, environmental  
18  
19 questionnaires) and objective measurements (accelerometers, GPS devices). The project staff,  
20  
21 who took the measurements, was retrained throughout the study thus helping to ensure  
22  
23 standard measurement methods were used across the cohort. We used a prospective  
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25 longitudinal design from a representative sample of adolescents from HCMC and aimed to  
26  
27 follow-up the children over five years. Each child has a health profile including  
28  
29 anthropometric and pubertal status data as well as other exposure factors each year. The  
30  
31 findings will be of relevance to other cities in Vietnam, which are starting to go through the  
32  
33 same environmental and lifestyle changes that have already occurred in HCMC. The findings  
34  
35 will also be relevant to other urban populations in East Asia and Southeast Asia where rapid  
36  
37 economic development is leading to a nutrition transition similar to that occurring in HCMC.  
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### 43 **Conclusion**

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45 The complete data analysis of this cohort study will allow a full exploration of the role of  
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47 environmental and lifestyle behaviours on adolescent overweight and obesity, and also  
48  
49 identify the factors most strongly associated with excess weight gain and the appearance of  
50  
51 overweight and obesity in different age groups of adolescents from this large city in Vietnam.  
52  
53 This information is needed to develop evidence-based public health interventions to control  
54  
55 and prevent this epidemic from expanding amongst the youth of Ho Chi Minh City and other  
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57 cities in Vietnam.  
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2  
3 **Authors' contributions:** TNH, HKT, MJD all contributed to the conceptualisation and  
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5  
6 of the version to be published  
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15

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19

20  
21 **Data sharing statement:** Access to the dataset is available from the corresponding author  
22 ([nguyenhoang\\_doantrang@yahoo.com](mailto:nguyenhoang_doantrang@yahoo.com)) or the principle investigator ([hongutc@yahoo.com](mailto:hongutc@yahoo.com))  
23  
24 in STATA format for academic researchers interested in undertaking a formally agreed  
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26 collaborative research project.  
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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
<b>Introduction</b>			
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
<b>Methods</b>			
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	
<b>Results</b>			

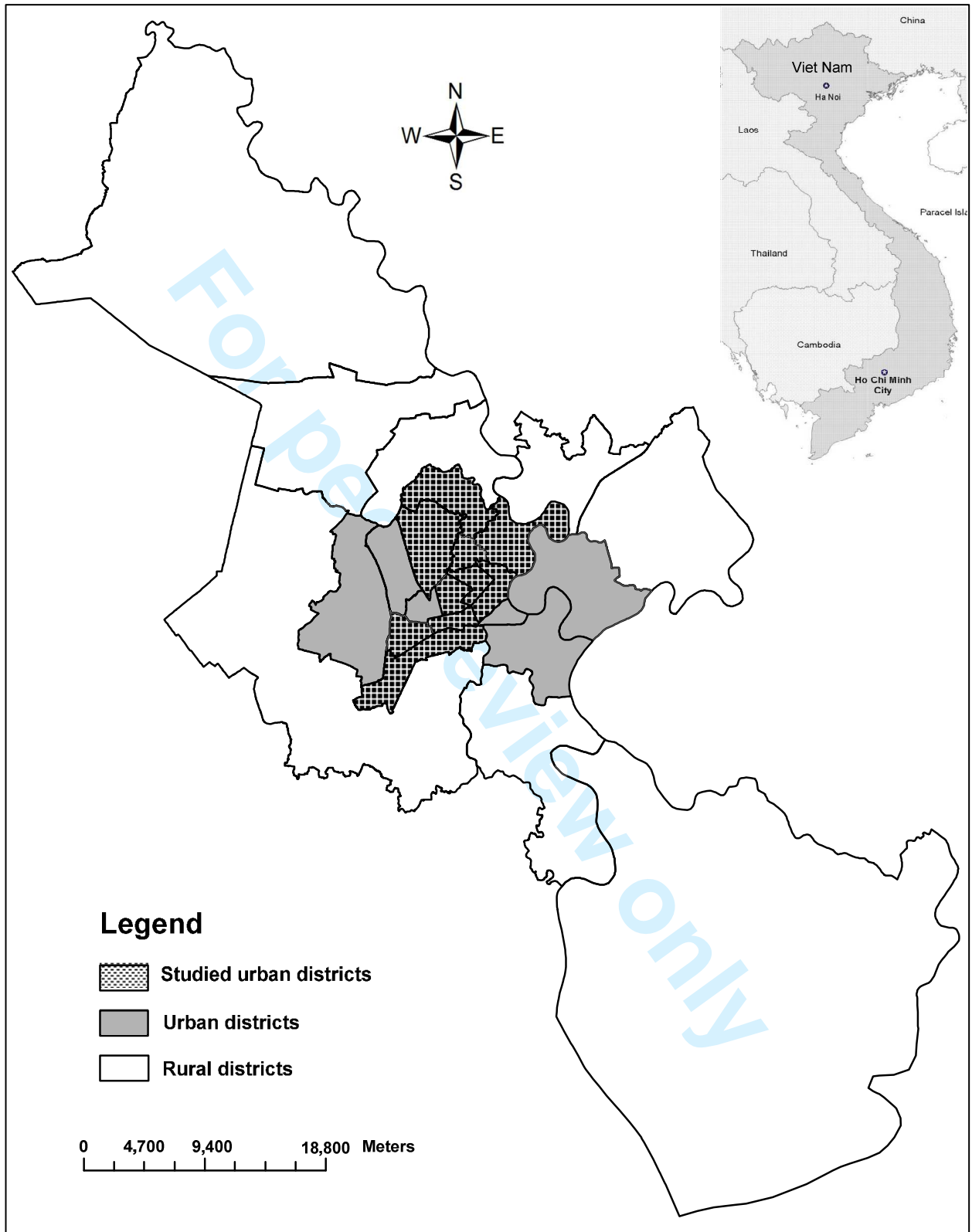
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	12
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 (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	13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	13,14
<b>Limitations</b>			
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
<b>Other information</b>			
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.

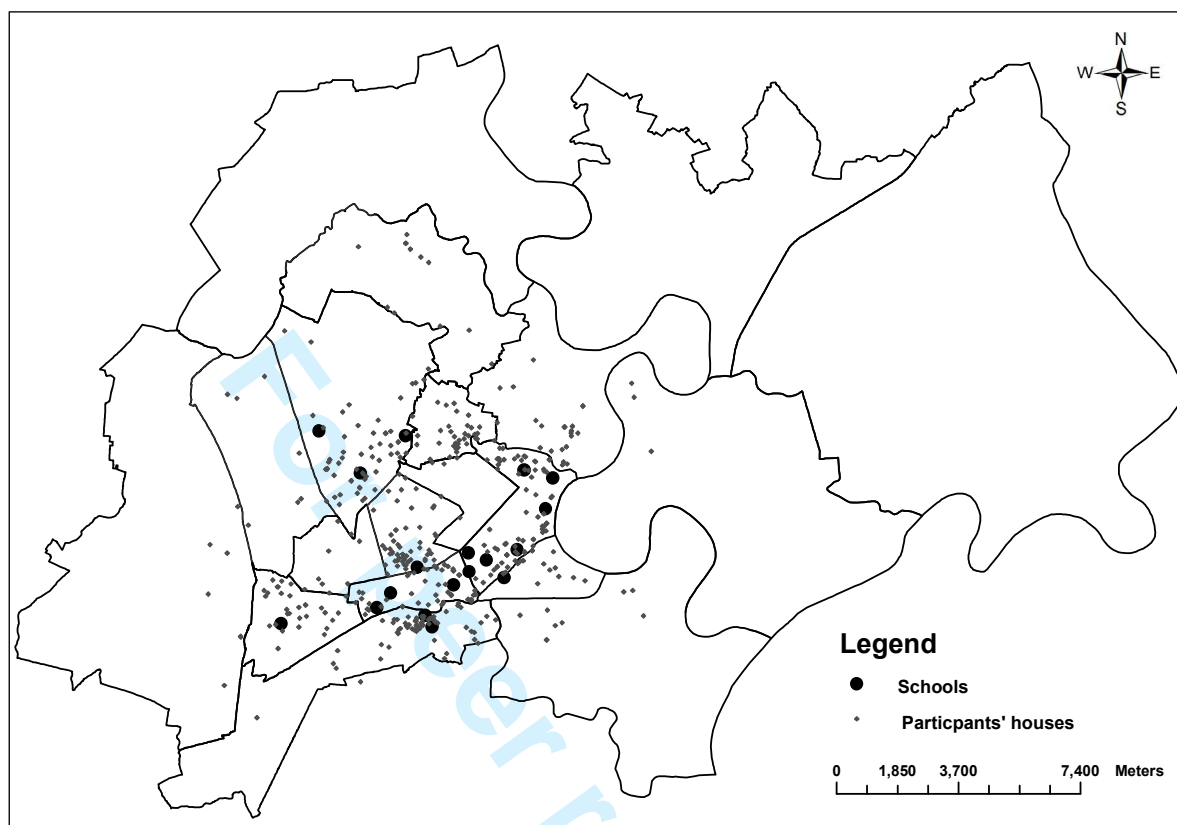
**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>,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

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**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**

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2011-000362.R1
Article Type:	Research
Date Submitted by the Author:	29-Nov-2011
Complete List of Authors:	nguyen hoang, trang; The University of Sydney, Sydney School of Public Health; Pham Ngoc Thach University of Medicine, Public Health Tang, Hong; Pham Ngoc Thach University of Medicine, Department of Public Health Dibley, Michael; The University of Sydney, Sydney School of Public Health, International Public Health
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Global health, Nutrition and metabolism
Keywords:	NUTRITION & DIETETICS, PAEDIATRICS, PUBLIC HEALTH

SCHOLARONE™  
Manuscripts



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3 **Cohort profile: Ho Chi Minh City Youth Cohort - changes in diet, physical**  
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5 **activity, sedentary behavior and relationship with overweight/obesity and**  
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7 **metabolic syndrome in adolescents**  
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46 Key words: cohort profile, Ho Chi Minh city, youth

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48 Word count: 3900 words, 2 figures, 3 tables  
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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

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

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8 **Article summary:**

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10 Article focus:

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

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22 • Prevalence of combined overweight/obesity increased from 14.2% to 21.8% in 5 year  
23 period  
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26 • Time spent on physical activity decreased significantly in the 5 year period from 87  
27 minutes / day to 50 minutes / day  
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31 • Time spent on sedentary behaviours increased in the 5 year period from 512 minutes /  
32 day to 600 minutes / day  
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35 Strengths and limitations:

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

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2  
3 two decades the city has experienced rapid social, economic and demographic changes.  
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5 Parallel to these social and economic changes, overweight and obesity have emerged as  
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7 amongst the most significant public health issues in the city. The examination of risk factors  
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9 in a setting where such rapid changes are taking place provides a unique opportunity to obtain  
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11 a picture of how overweight and obesity emerges in children in a population undergoing  
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13 social and economic transition. The urban area of HCMC, with its high population density of  
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15 3,155 persons / km<sup>2</sup> and its rapid socioeconomic development, is an ideal setting to identify  
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17 risk factors for excess weight gain in adolescents because of the ease of tracking and  
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19 following-up students.  
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23 The present cohort study aimed to assess the change in nutritional status, indicators of  
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25 adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and  
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27 school micro-environments and their complex relationships in adolescents in urban areas of  
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29 the province. The results of this study will provide new insights into how the childhood  
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31 obesity epidemic in a transitional society differs from that in developed countries. It will also  
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33 provide evidence to plan and evaluate the most appropriate interventions to prevent excess  
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35 weight gain in adolescents in HCMC in the future.  
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### 38 **Methods and analysis:**

#### 39 **Study design:**

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43 **Sample selection** The cohort study began from a multi-stage cluster cross sectional survey in  
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45 2004. This survey covered 136 public junior high schools and 4 non-public (semi public and  
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47 private) junior high schools. Of these 140 schools, 47 were from wealthy urban areas and 93  
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49 from less wealthy urban districts. This classification of urban districts was derived from the  
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51 **Statistics Review of HCMC province Department of Statistics.[10]** The total number of  
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53 students in wealthy urban schools was 62,853 whilst that of less wealthy urban schools was  
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55 119,717. From these 140 schools, 31 clusters (schools) were selected with 17 clusters  
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3 (schools) selected from the list of schools in wealthy urban districts, and 14 clusters (schools)  
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5 from less wealthy urban districts, using probability proportionate to size (PPS) sampling  
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7 within each strata. Because the number of classes and students in non-public schools are  
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9 smaller than in public schools, only 3 non-public schools were selected in the sample of the  
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11 cross-sectional survey. In each selected school, lists of classes from grades 6 and 7 combined,  
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13 and grades 8 and 9 combined were prepared. Simple random sampling was used to select one  
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15 class from each group of grades. All students in the selected classes were invited to  
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17 participate in the study.  
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21 For the cohort study, systematic random sampling was used to select 18 schools from these  
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23 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts.  
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25 The sub sample of children required for the cohort study was selected from one class from  
26  
27 grades 6 and 7 combined in each school, resulting in 784 students of the cohort study.  
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### 30 Sample size

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32 The sample size estimates for the cohort study were based on expected differences in the  
33  
34 average change of BMI between exposure groups (Insufficiently active vs. active students  
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36 viewing >20 hrs TV per week vs. <20 TV viewing per week, students in the lowest quintile  
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38 of nutrient intake vs. other quintiles of intake, students who ride bicycles to school vs. were  
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40 taken to school by motorcycle), using a standard deviation of 1.5 and assuming a 5%  
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42 significance level, 80% power. In the absence of information about relative change in BMI  
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44 for HCMC children, these sample size estimates are based on the observed relative change in  
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46 BMI in children exposed to an education intervention to reduce TV viewing in the United  
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48 States.[11] The average change in BMI selected was 0.35 kg/m<sup>2</sup>. Sample size estimates were  
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50 calculated using the PS program,[12] resulting in an estimated required sample size of 720  
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52 children. However, since we used cluster sampling (school and class selection), all the  
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54 students in a selected class were invited to participate in the cohort for logistic reasons;  
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3 yielding 784 students who were invited to participate and giving 759 who were recruited into  
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5 the cohort study.  
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### 7 **Informed consent**

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

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

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50 At each assessment round, we measured the main outcome variables (anthropometric  
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52 measurements) as well as the exposure factors. In the third round, we collected biochemical  
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54 data for assessing cardiovascular and metabolic disease risks.  
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3 Measurement of outcome variables: All the anthropometric measurements were taken using  
4 established guidelines.[13] Standing height was measured using a portable direct-reading  
5 stadiometer and body weight was measured using a digital scale. Waist and hip  
6 circumferences were measured with a non-elastic tape at the level of the umbilicus and with  
7 maximal extension of the buttocks. Standardization exercises with the anthropometrists were  
8 used every 6 months to monitor the quality of anthropometric measurements. Blood samples  
9 (done in the third round) and blood pressure were measured at the end of data collection.  
10 Height, weight and blood pressure were measured twice and the average value was used.

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21 Biochemical measurements:

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

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

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

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54 Dietary intake and diet behaviours was assessed using a validated Youth Food Frequency  
55 Questionnaire [15] which allowed the study participants to be ranked by levels of food energy  
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3 and fat intake and categories of different diet patterns e.g. frequency of fast food, snacks or  
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5 soft drink consumption.  
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7 Physical activity and sedentary behaviours were assessed by the Adolescent Physical  
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9 Activity Recall Questionnaire (APARQ) [16] and a Adolescent Sedentary Activity  
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11 Questionnaire (ASAQ) [17] which were developed and validated among Australian  
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13 adolescents but modified for use in Vietnam, the Vietnamese-Adolescent Physical Activity  
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15 Recall Questionnaire (V-APARQ). A validation study comparing the results from the V-  
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17 APARQ with accelerometer measurements showed that V-APARQ is a valuable tool to  
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19 assess physical activity in adolescents of Ho Chi Minh City.[18] They were also objectively  
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21 measured by use of accelerometers (Actigraph<sup>®</sup>) for each student over a one-week period to  
22  
23 assess long term physical activity patterns.[19]  
24  
25

26  
27 The family social environment was assessed using the family habits and environment  
28  
29 questionnaire, which measured exposure to various social and physical home environmental  
30  
31 factors (e.g. number and location of TVs at home, and family rules on TV viewing).  
32  
33 Questionnaires were completed by the adolescents and their parents to assess exposure to  
34  
35 environmental elements at home, school and neighbourhoods. The environmental  
36  
37 questionnaire was developed from the results of *group discussions* with approximately 10 to  
38  
39 15 community members in each of four different locations of varying socioeconomic status  
40  
41 from across HCMC. These group discussions identified the key environmental elements of  
42  
43 homes, schools and neighbourhoods that needed to be included in the questionnaire. Lack of  
44  
45 pathways and dangerous traffic were amongst the reasons many parents did not allow their  
46  
47 children to walk or cycle alone. *In-depth interviews* were also conducted with selected  
48  
49 members to explore in more detail the environmental risks identified and the opportunities for  
50  
51 change. Interviews were taped, transcribed, checked for accuracy, and the content and themes  
52  
53 were analysed to identify how the environmental risks varied across communities, how easily  
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3 they might be modified and what methods of change were available in the different  
4 communities. The items on the questionnaire were derived from the information gathered  
5 from the qualitative data collection.[20]  
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9  
10 Physical environment assessments were also taken using a questionnaire. The home  
11 environment questionnaire was piloted in a sample of 50 respondents (adolescents and their  
12 parents from different areas in HCMC) and validated by direct observations by the  
13 investigators. Information regarding environmental factors at community and household  
14 levels as well as socio-demographic factors was obtained via a self-administered  
15 questionnaire for parents. The description of this questionnaire has also been published  
16 previously.[21]  
17  
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19

20  
21 Distance between the respondent's house and schools and these recreational facilities were  
22 measured using Global Positioning System (GPS). GPS readings recorded the location of fast  
23 food outlets and recreation areas within 1km surrounding the home of all participants in the  
24 cohort study. These data sources will be used to directly estimate the average distances from  
25 the respondent's home to these physical aspects of their environments, and also to estimate  
26 the average density of these environmental elements.  
27  
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29

30  
31 School environment was assessed using a self-administered questionnaire completed by the  
32 school principals, who were asked about school facilities for sport and exercise, availability  
33 of such facilities, and the foods and drinks sold in the school canteen.  
34  
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37  
38 Additional risk factors including self-recorded parent's weight and height, parental ethnicity,  
39 and demographic, socioeconomic status of the child and the family were assessed by  
40 structured questionnaires.  
41  
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44  
45 To assess economic status, ownership of an inventory of assets was used to construct a  
46 household wealth index using the principal components method to assign a weight for each  
47 asset. [22] A total of fourteen assets were assessed including bicycles, motorbikes,  
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3 televisions, radios, videos, cassette players, computers, gas stoves, CD players, cars,  
4  
5 microwave ovens, refrigerator and telephone and air-conditioners. The basis for selecting the  
6  
7 assets was from a report of the Bureau of Statistics of HCMC [10] listing the most common  
8  
9 assets used among HCMC population.  
10

11 Also the adolescent's pubertal status was self assessed using a form, which recorded the  
12  
13 child's date of birth, gender, weight and height, and questions to self-assessed pubertal status.  
14  
15 In a confidential setting, the adolescents self-reported their pubertal status using a  
16  
17 questionnaire with photographs illustrating five stages [23] of pubertal development for pubic  
18  
19 hair, male genitalia, or female breasts, and for female students the date of their first  
20  
21 menstruation was also recorded.  
22  
23  
24

### 25 **Data analysis**

26  
27 Analyses were conducted using STATA 11 (STATA Corporation, College Station, TX, USA,  
28  
29 2009). The IOTF (International Obesity Task Force) BMI cut-off values were used to define  
30  
31 overweight and obesity combined [24]. The wealth index was ranked and divided into tertiles  
32  
33 and each household was assigned to one of these wealth index categories.  
34  
35

36 The general characteristics of the population were described. For continuous variables, means  
37  
38 and standard deviations or medians and inter-quartile ranges were calculated according to the  
39  
40 distribution of each variable. In the case of categorical variables, absolute and relative  
41  
42 frequencies were calculated. 95% confidence intervals were also computed. Continuous  
43  
44 variables that were not normally distributed were evaluated by the application of  
45  
46 transformations and categorisations wherever applicable. Baseline characteristics were  
47  
48 compared by gender and the lost to follow-up group was compared with the cohort baseline  
49  
50 group using Pearson chi-square or Fisher's exact test for categorical data, whereas continuous  
51  
52 data were tested with Student's t-test or Wilcoxon Mann-Whitney test. Kruskal-Wallis test  
53  
54 was used to compare medians of time spent on MVPA and sedentary behaviours and chi-  
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3 square for trend was used to compare prevalence of BMI status by years. The “survey  
4  
5 commands” were used to account for the multi-stage cluster sampling design. Future analyses  
6  
7 of this cohort data that assess relationships between exposure factors and the change of BMI,  
8  
9 physical activity, sedentary behaviours, will require mixed multiple regression models to  
10  
11 adjust for the multi-stage cluster sampling and repeated measurements in individual study  
12  
13 participants.

### 14 15 **Ethics and dissemination:**

16  
17 The research proposal was approved by the Research Ethics Committee, Pham Ngoc Thach  
18  
19 University of Medicine, Ho Chi Minh City. It was also approved by the Human Research  
20  
21 Ethics Committee, University of Newcastle (ethics reference: H-879-0904). Informed written  
22  
23 consent was obtained from the principals of the schools participating in the study. Consent  
24  
25 from both the adolescents and their parents were required prior to their participation in the  
26  
27 study.  
28  
29

### 30 31 **Results**

32  
33 At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to  
34  
35 take part in the cohort study, of which 740 participated in the first follow-up data collection  
36  
37 including anthropometric measurements, dietary, physical activity, sedentary behaviours and  
38  
39 environment assessment. Therefore, the attrition rate for one year follow-up was 2.5%. In the  
40  
41 second round of follow-up, there were 712 (94% of baseline), in the fourth round, there were  
42  
43 630 (83% of baseline), and in the last follow-up 585 students remained in the cohort,  
44  
45 resulting in a retention rate of 77% (Table 1).  
46  
47

48  
49 *Insert table 1 here*

50  
51 The characteristics of the follow-up group (n=585) were compared with drops-out (n=174) on  
52  
53 key variables that were available for all participants. These two groups did not differ by age,  
54  
55 gender, and pubertal status, anthropometric or socio-demographic characteristics. The drop-  
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3 outs in the sample were mainly attributed to the following reasons: (i) moved to another  
4 school (n= 93, 12.2 %); (ii) refused to continue in the study (n= 45, 5.9 %) and (iii) changed  
5 home address or migrated overseas (n= 36, 4.7 %).  
6  
7

8  
9 The baseline data for socio-demographic and anthropometric variables are listed in *Table 2*.  
10  
11 At baseline, the mean age of the sampled subjects was 11.8 years ( $\pm 0.6$ ). Overall 12.5% of  
12 the students were overweight and 1.7% were obese. The mothers of 52.3% of the students  
13 had completed senior high school and 58.5% of the fathers had completed senior high school.  
14

15  
16  
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18  
19 *Insert table 2 here*

20  
21 Figure 2 shows the geographic distribution of schools and participants' home measured by  
22 GPS. Students' houses were scattered around their schools with a median distance from home  
23 to school of 1,450m (Inter-quartile Range (IQR): 680-3,030m).  
24  
25

26  
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29 *Insert figure 2 here*

30  
31 A summary of the changes in the BMI status and time spent in moderate to vigorous physical  
32 activity and sedentary behaviours are listed in *Table 3*. Over the five year period of this  
33 cohort study, the prevalence of overweight increased from 12.5% to 16.7%, and obesity from  
34 1.7% to 5.1%. Time spent in moderate to vigorous physical activity decreased significantly  
35 from 87 minutes / day to 50 minutes / day. In contrast, time in sedentary behaviours increased  
36 from 512 minutes / day to 600 minutes / day.  
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60 *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.

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

10  
11 Although there was only one non-public school in this study, this reflected the small  
12 proportion of the school population enrolled in this type of school in HCMC. We found no  
13 important differences between public and private schools for the main study factors and  
14 outcomes, such as socioeconomic status. Unlike the situation in many developed countries, in  
15 Vietnam, non-public schools are not popular and students usually enter these schools when  
16 they cannot secure a place in a public school. Thus, we believe the sampling of this study was  
17 not biased and is representative of HCMC adolescents at school.

18  
19 In Ho Chi Minh City over the five year period, the prevalence of overweight increased from  
20 12.5% to 16.7% and obesity increased from 1.7% to 5.1%. This increase in overweight and  
21 obesity was consistent with the increases found in 5-year follow up studies from 1999 to  
22 2004 in urban Indonesian children where the prevalence of overweight increased from 4.2%  
23 in children to 8.8% in adolescents, and similarly obesity increased from 1.9% to 3.2% [28].  
24 Similar findings have been reported from a 5-year follow-up study in Thai school children  
25 where the prevalence of overweight in boys increased from 12.4% in 1992 to 21.0% in  
26 1997.[29]

27  
28 The primary findings of this study are also consistent with the substantial age-related declines  
29 in MVPA among both adolescent boys and girls previously reported in the US [30-31], and  
30 Finland [32]. These results also showed that daily MVPA decreased of 42% over a five year  
31

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3 period when adolescents were aged 12 years to 16 years, which was similar to the 45%  
4  
5 decline reported for American adolescents in the CATCH study [33]. Furthermore, the  
6  
7 increase in sedentary time with age found in the present study is similar to increases reported  
8  
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10 by longitudinal studies in developed countries [34-35].

11  
12 This study can, through the cause-effect relationships examined, provide evidence to guide  
13  
14 the formulation of appropriate and reasonable recommended levels of physical activity to  
15  
16 prevent overweight/obesity in Vietnamese adolescents. The findings will also provide  
17  
18 evidence to help develop recommendations for dietary behaviours or future designs of  
19  
20 schools and neighbourhoods to ensure these environments are health promoting and meet the  
21  
22 needs of Vietnamese adolescents during an age when there is rapid body growth.  
23  
24

### 25 **Conclusion**

26  
27 The rapidly increasing prevalence of obesity as well as the significant decrease in time on  
28  
29 moderate to vigorous activity and increase in sedentary time in adolescents in Ho Chi Minh  
30  
31 City suggesting that this population is at increased future risk of non-communicable diseases.  
32  
33 There is an urgent need to develop interventions to target this population to promote physical  
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35 activity and decrease sedentary behaviour in order to prevent overweight/obesity. The  
36  
37 complete data analysis of this cohort study will allow a full exploration of the role of  
38  
39 environmental and lifestyle behaviours on adolescent overweight and obesity, and also  
40  
41 identify the factors most strongly associated with excess weight gain and the appearance of  
42  
43 overweight and obesity in different age groups of adolescents from this large city in Vietnam.  
44  
45 This information is needed to develop evidence-based public health interventions to control  
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47 and prevent this epidemic from expanding amongst the youth of Ho Chi Minh City and other  
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49 cities in Vietnam.  
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3 **Authors' contributions:** TNH, HKT, MJD all contributed to the conceptualisation, design  
4 and management of the study and all revised this manuscript critically. All authors gave final  
5 approval of the version to be published  
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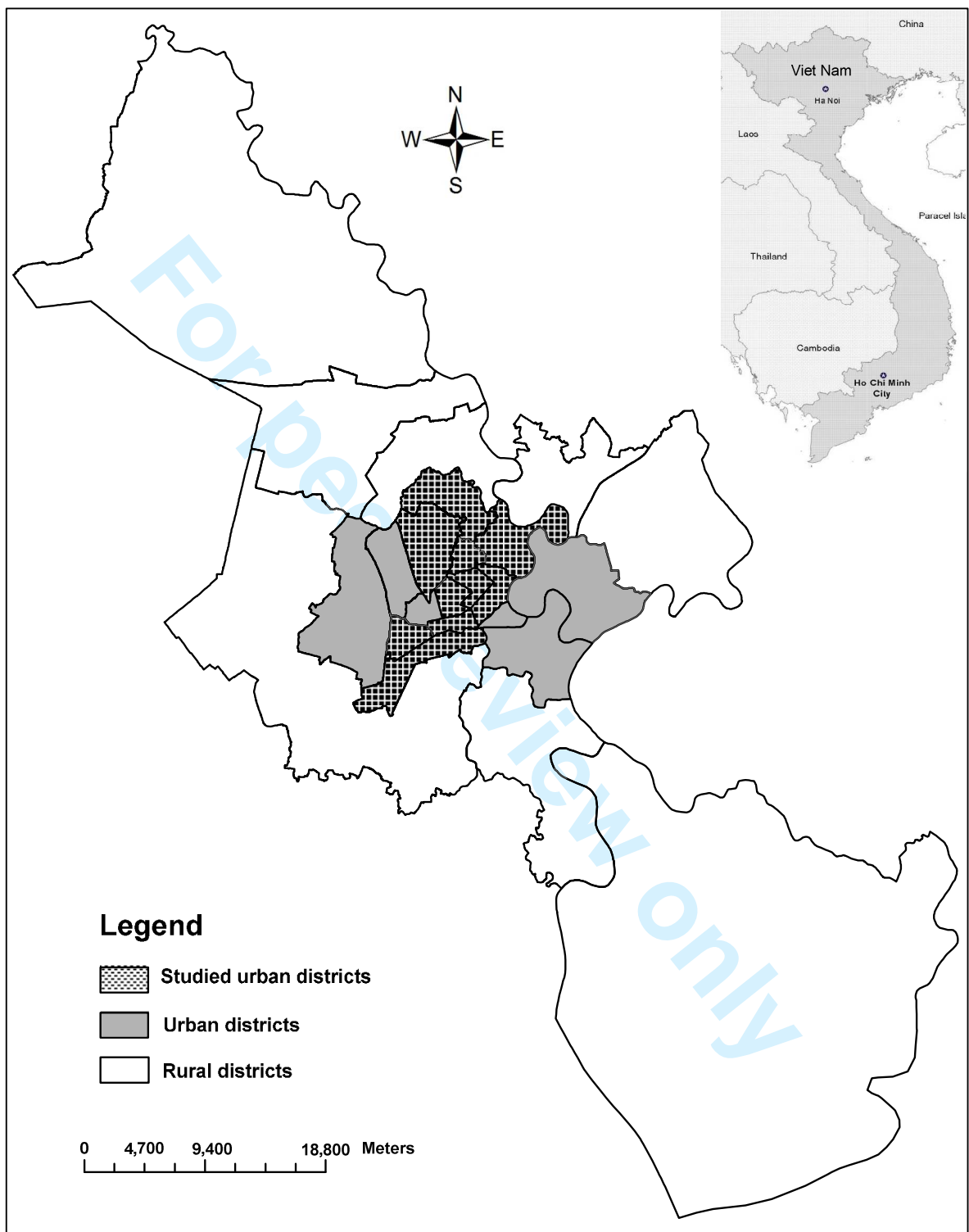
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11  
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13 this paper.  
14

15  
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18 PhD scholarships. We also thank the participating schools, students, parents and the study  
19 staffs involving in this study and the support from Nutrition Center.  
20  
21

22  
23 **Data sharing statement:** Access to the dataset is available from the corresponding author  
24 ([nguyenhoang\\_doantrang@yahoo.com](mailto:nguyenhoang_doantrang@yahoo.com)) or the principle investigator ([hongutc@yahoo.com](mailto:hongutc@yahoo.com))  
25 in STATA format for academic researchers interested in undertaking a formally agreed  
26 collaborative research project.  
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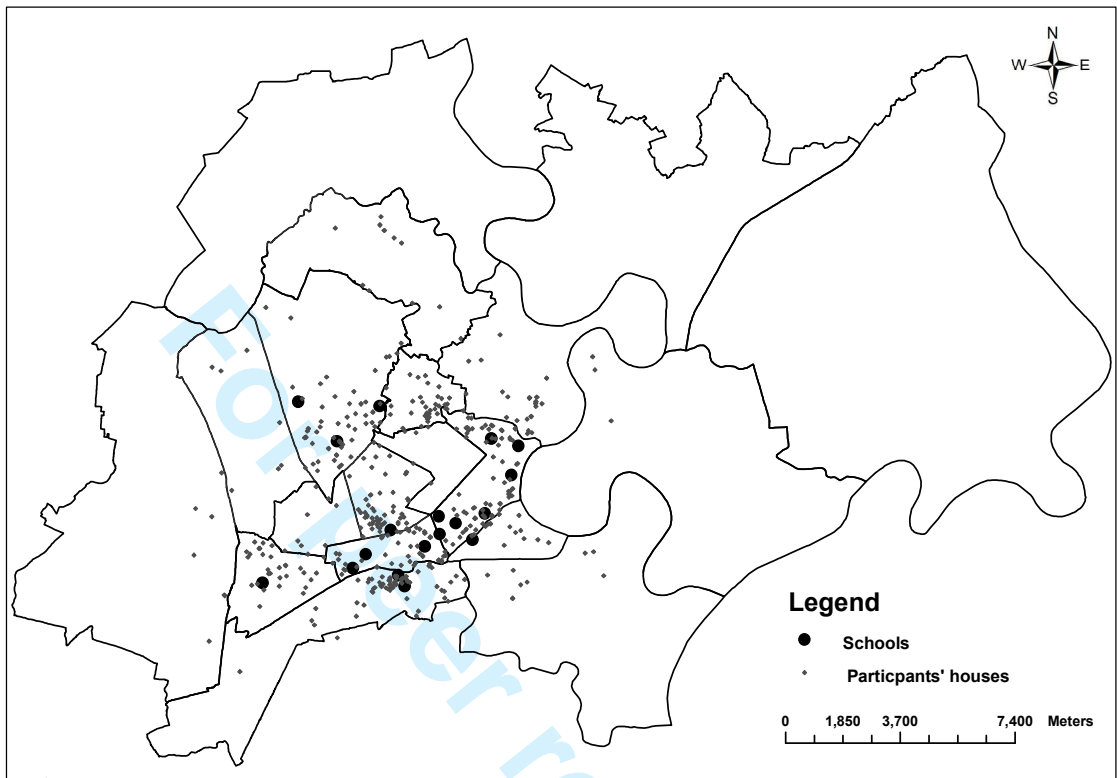
**Figure 1:** Map of Ho Chi Minh City, Viet Nam with studied districts



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**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
<b>Introduction</b>			
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
<b>Methods</b>			
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	
<b>Results</b>			



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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	12
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 (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	13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	13,14
<b>Limitations</b>			
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
<b>Other information</b>			
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](http://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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Keywords:	NUTRITION & DIETETICS, PAEDIATRICS, PUBLIC HEALTH

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Manuscripts

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3 **Cohort profile: Ho Chi Minh City Youth Cohort - changes in diet, physical**  
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5 **activity, sedentary behavior and relationship with overweight/obesity in**  
6  
7 **adolescents**  
8  
9

10  
11 **Nguyen Hoang Hanh Doan Trang<sup>a,b\*</sup>, Tang Kim Hong<sup>a</sup>, Michael John Dibley<sup>b</sup>**

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

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48 Word count: 3900 words, 2 figures, 3 tables  
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3 **Abstract: (288)**  
4

5 Objectives: The Ho Chi Minh Youth cohort study aimed to assess the change in nutritional  
6 status, indicators of adiposity, diet, physical activity and sedentary behaviours, home,  
7 neighbourhood and school micro-environments and their complex relationships in  
8 adolescents in urban areas of HCMC.  
9

10  
11  
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13  
14 Design: Prospective 5 year cohort

15  
16 Setting: Systematic random sampling was used to select 18 schools in urban districts.

17  
18 Participants: Children were followed-up over five years with an assessment in each year.

19  
20 Consent, from both adolescents and their parents, was required. At baseline, 759 students  
21 were recruited into the cohort, and out of these students, 740 remained in the cohort for the  
22 1st round of follow-up, 712 for the 2nd round, 630 for the 3rd round, and 585 students for the  
23 last follow-up.  
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25  
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28  
29 Primary and secondary outcome measures: Anthropometric measurements were taken using  
30 established guidelines. Six main groups of exposure factors including dietary intake and  
31 behaviours, physical activity and sedentary behaviours, family social and physical  
32 environment, school environment, socioeconomic status, and parental characteristics were  
33 measured.  
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41 Results: Retention rate was high (77%). Within 5 years period, the prevalence of combined  
42 overweight and obesity using IOTF cut-off values increased from 14.2% to 21.8%. Time  
43 spent on physical activity decreased significantly in the 5 year period from 87 minutes / day  
44 to 50 minutes / day. Time spent on sedentary behaviours increased in the 5 year period from  
45 512 minutes / day to 600 minutes / day  
46  
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51  
52 Conclusions: The complete data analysis of this cohort study will allow a full exploration of  
53 the role of environmental and lifestyle behaviours on adolescent overweight and obesity, and  
54 also identify the factors most strongly associated with excess weight gain and the appearance  
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3 of overweight and obesity in different age groups of adolescents from this large city in  
4  
5 Vietnam.

6  
7  
8 **Article summary:**

9  
10 Article focus:

- 11  
12  
13 • The change in nutritional status, indicators of adiposity, diet and physical activity and  
14  
15 sedentary behaviours, home, neighbourhood and school micro-environments and their  
16  
17 complex relationships in adolescents in urban areas of Ho Chi Minh city

18  
19 Key messages

- 20  
21  
22 • Prevalence of combined overweight/obesity increased from 14.2% to 21.8% in 5 year  
23  
24 period  
25  
26 • Time spent on physical activity decreased significantly in the 5 year period from 87  
27  
28 minutes / day to 50 minutes / day  
29  
30  
31 • Time spent on sedentary behaviours increased in the 5 year period from 512 minutes /  
32  
33 day to 600 minutes / day

34  
35 Strengths and limitations:

- 36  
37  
38 • This is the first cohort in Vietnam on adolescent obesity in Vietnam.  
39  
40  
41 • This study assessed a full set of potential risk factors from dietary intake, physical  
42  
43 activity and sedentary behaviours to environmental factors, allowing a wide ranging  
44  
45 assessment of the factors related to excess weight gain and overweight and obesity  
46  
47 among urban Vietnamese adolescents.  
48  
49 • The present longitudinal study revealed changes in anthropometric measurements,  
50  
51 physical activity, sedentary behaviour, and diet associated with age in both genders.  
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## **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

1  
2  
3 two decades the city has experienced rapid social, economic and demographic changes.  
4  
5 Parallel to these social and economic changes, overweight and obesity have emerged as  
6  
7 amongst the most significant public health issues in the city. The examination of risk factors  
8  
9 in a setting where such rapid changes are taking place provides a unique opportunity to obtain  
10  
11 a picture of how overweight and obesity emerges in children in a population undergoing  
12  
13 social and economic transition. The urban area of HCMC, with its high population density of  
14  
15 3,155 persons / km<sup>2</sup> and its rapid socioeconomic development, is an ideal setting to identify  
16  
17 risk factors for excess weight gain in adolescents because of the ease of tracking and  
18  
19 following-up students.  
20  
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22  
23 The present cohort study aimed to assess the change in nutritional status, indicators of  
24  
25 adiposity, diet and physical activity and sedentary behaviours, home, neighbourhood and  
26  
27 school micro-environments and their complex relationships in adolescents in urban areas of  
28  
29 the province. The results of this study will provide new insights into how the childhood  
30  
31 obesity epidemic in a transitional society differs from that in developed countries. It will also  
32  
33 provide evidence to plan and evaluate the most appropriate interventions to prevent excess  
34  
35 weight gain in adolescents in HCMC in the future.  
36  
37

### 38 **Methods and analysis:**

#### 39 **Study design:**

40  
41  
42  
43 **Sample selection** The cohort study began from a multi-stage cluster cross sectional survey in  
44  
45 2004. This survey covered 136 public junior high schools and 4 non-public (semi public and  
46  
47 private) junior high schools. Of these 140 schools, 47 were from wealthy urban areas and 93  
48  
49 from less wealthy urban districts. This classification of urban districts was derived from the  
50  
51 Statistics Review of HCMC province Department of Statistics.[10]  
52

53  
54 **Non-wealthy districts were categorized as having more than 50% households below the**  
55  
56 **wealthy threshold (non-wealthy household). Non-wealthy household in Ho Chi Minh City in**  
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3 2004 was identified as having average personal income less than 6.000.000 Vietnam  
4  
5 Dong/person/year.[11]  
6

7  
8 The total number of students in wealthy urban schools was 62,853 whilst that of less wealthy  
9 urban schools was 119,717. From these 140 schools, 31 clusters (schools) were selected with  
10 17 clusters (schools) selected from the list of schools in wealthy urban districts, and 14  
11 clusters (schools) from less wealthy urban districts, using probability proportionate to size  
12 (PPS) sampling within each strata. Because the number of classes and students in non-public  
13 schools are smaller than in public schools, only 3 non-public schools were selected in the  
14 sample of the cross-sectional survey. In each selected school, lists of classes from grades 6  
15 and 7 combined, and grades 8 and 9 combined were prepared. Simple random sampling was  
16 used to select one class from each group of grades. All students in the selected classes were  
17 invited to participate in the study.  
18  
19

20  
21 For the cohort study, systematic random sampling was used to select 18 schools from these  
22 31 schools, of which 11 were from wealthy districts and 7 were from less wealthy districts.  
23  
24 The sub sample of children required for the cohort study was selected from one class from  
25 grades 6 and 7 combined in each school, resulting in 784 students of the cohort study.  
26  
27

### 28 Sample size

29  
30 The sample size estimates for the cohort study were based on expected differences in the  
31 average change of BMI between exposure groups (Insufficiently active vs. active students  
32 viewing >20 hrs TV per week vs. <20 TV viewing per week, students in the lowest quintile  
33 of nutrient intake vs. other quintiles of intake, students who ride bicycles to school vs. were  
34 taken to school by motorcycle), using a standard deviation of 1.5 and assuming a 5%  
35 significance level, 80% power. In the absence of information about relative change in BMI  
36 for HCMC children, these sample size estimates are based on the observed relative change in  
37 BMI in children exposed to an education intervention to reduce TV viewing in the United  
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3 States.[12] The average change in BMI selected was 0.35 kg/m<sup>2</sup>. Sample size estimates were  
4  
5 calculated using the PS program,[13] resulting in an estimated required sample size of 720  
6  
7 children. However, since we used cluster sampling (school and class selection), all the  
8  
9 students in a selected class were invited to participate in the cohort for logistic reasons;  
10  
11 yielding 784 students who were invited to participate and giving 759 who were recruited into  
12  
13 the cohort study.  
14

### 15 16 **Informed consent**

17  
18 Informed written consent was firstly obtained from the principals of the schools participating  
19  
20 in the study. Information about the study was distributed to the selected class by the school  
21  
22 principals and class teachers using flyers and notices. All the students in selected classes were  
23  
24 invited to participate in the cohort study. Discussions were held with the school principals to  
25  
26 establish a timetable of visits to ensure project staff could meet all the children and parents.  
27  
28 Information sheets and consent forms for the adolescents and their parents were distributed  
29  
30 by the project staff at their first visit to the class. Project staff was also available to answer  
31  
32 questions regarding the study on this visit. Consent from both the adolescents and their  
33  
34 parents was required for participation in the study and collected one week apart.  
35  
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37

### 38 39 **Frequency of follow-up**

40  
41 Children were followed-up over five years with an assessment in each year. During the first  
42  
43 three years when the study participants were in junior high schools, data was collected by  
44  
45 class surveys. In Vietnam, junior and senior high schools are separate institutions and  
46  
47 students from one junior high school may move to many different senior high schools. So,  
48  
49 when the study participants moved to senior high school, follow-up was sustained with  
50  
51 individual contact by phone calls, home visits and group surveys for those students still  
52  
53 together in a single high school.  
54

### 55 56 **Data collection**

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2  
3 At each assessment round, we measured the main outcome variables (anthropometric  
4 measurements) as well as the exposure factors. In the third round, we collected biochemical  
5 data for assessing cardiovascular and metabolic disease risks.  
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8  
9  
10 Measurement of outcome variables: All the anthropometric measurements were taken using  
11 established guidelines.[14] Standing height was measured using a portable direct-reading  
12 stadiometer and body weight was measured using a digital scale. Waist and hip  
13 circumferences were measured with a non-elastic tape at the level of the umbilicus and with  
14 maximal extension of the buttocks. Standardization exercises with the anthropometrists were  
15 used every 6 months to monitor the quality of anthropometric measurements. Blood samples  
16 (done in the third round) and blood pressure were measured at the end of data collection.  
17  
18 Height, weight and blood pressure were measured twice and the average value was used.  
19  
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27 Biochemical measurements:

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29 A sample of five millilitres of venous blood was collected from the participants' forearm by  
30 experienced, trained technicians. Fasting blood glucose and the lipid profile (triglyceride,  
31 total cholesterol, high, low and very low density cholesterol) were assayed by a photometer  
32 (Hitachi 917 Japan) using a standard method at the Diagnostic Center in HCMC.  
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38 Standard internationally recommended procedures were used for the handling and processing  
39 of blood specimens,[15] and the specimens were transported to the laboratory within 2 hours  
40 of collection at the schools. Serum samples were stored in special plastic tubes with sealed  
41 lids. Unused portions of the blood samples collected were stored at - 20<sup>0</sup> degrees in freezers  
42 in the laboratories of the Diagnostic Center, HCMC in case reanalysis was needed once the  
43 data was examined. These specimens were destroyed once all the data has been cleaned.  
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52 Measurement of exposure factors: The adolescents were interviewed using the *environmental*  
53 *assessment, food frequency, physical activity, and television and computer usage*  
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3 questionnaires. The parents completed the *family habits and environment questionnaire*. Six  
4  
5 main groups of exposure factors were measured:  
6

7 *Dietary intake and diet behaviours* was assessed using a validated Youth Food Frequency  
8  
9 Questionnaire [16] which allowed the study participants to be ranked by levels of food energy  
10  
11 and fat intake and categories of different diet patterns e.g. frequency of fast food, snacks or  
12  
13 soft drink consumption.  
14

15  
16 *Physical activity and sedentary behaviours* were assessed by the Adolescent Physical  
17  
18 Activity Recall Questionnaire (APARQ) [17] which was developed and validated among  
19  
20 Australian adolescents but modified for use in Vietnam, the Vietnamese-Adolescent Physical  
21  
22 Activity Recall Questionnaire (V-APARQ) and a Adolescent Sedentary Activity  
23  
24 Questionnaire (ASAQ) [18]. A validation study comparing the results from the V-APARQ  
25  
26 with accelerometer measurements showed that V-APARQ is a valuable tool to assess  
27  
28 physical activity in adolescents of Ho Chi Minh City.[19] They were also objectively  
29  
30 measured by use of accelerometers (Actigraph<sup>®</sup>) for each student over a one-week period to  
31  
32 assess long term physical activity patterns.[20]  
33  
34

35  
36 The *family social environment* was assessed using the family habits and environment  
37  
38 questionnaire, which measured exposure to various social and physical home environmental  
39  
40 factors (e.g. number and location of TVs at home, and family rules on TV viewing).  
41  
42 Questionnaires were completed by the adolescents and their parents to assess exposure to  
43  
44 environmental elements at home, school and neighbourhoods. The environmental  
45  
46 questionnaire was developed from the results of *group discussions* with approximately 10 to  
47  
48 15 community members in each of four different locations of varying socioeconomic status  
49  
50 from across HCMC. These group discussions identified the key environmental elements of  
51  
52 homes, schools and neighbourhoods that needed to be included in the questionnaire. Lack of  
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54 pathways and dangerous traffic were amongst the reasons many parents did not allow their  
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3 children to walk or cycle alone. *In-depth interviews* were also conducted with selected  
4  
5 members to explore in more detail the environmental risks identified and the opportunities for  
6  
7 change. Interviews were taped, transcribed, checked for accuracy, and the content and themes  
8  
9 were analysed to identify how the environmental risks varied across communities, how easily  
10  
11 they might be modified and what methods of change were available in the different  
12  
13 communities. The items on the questionnaire were derived from the information gathered  
14  
15 from the qualitative data collection.[21]

16  
17  
18 Physical environment assessments were also taken using a questionnaire. The home  
19  
20 environment questionnaire was piloted in a sample of 50 respondents (adolescents and their  
21  
22 parents from different areas in HCMC) and validated by direct observations by the  
23  
24 investigators. Information regarding environmental factors at community and household  
25  
26 levels as well as socio-demographic factors was obtained via a self-administered  
27  
28 questionnaire for parents. The description of this questionnaire has also been published  
29  
30 previously.[22]

31  
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33  
34 Distance between the respondent's house and schools and these recreational facilities were  
35  
36 measured using Global Positioning System (GPS). GPS readings recorded the location of fast  
37  
38 food outlets and recreation areas within 1km surrounding the home of all participants in the  
39  
40 cohort study. These data sources will be used to directly estimate the average distances from  
41  
42 the respondent's home to these physical aspects of their environments, and also to estimate  
43  
44 the average density of these environmental elements.

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46  
47 School environment was assessed using a self-administered questionnaire completed by the  
48  
49 school principals, who were asked about school facilities for sport and exercise, availability  
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51 of such facilities, and the foods and drinks sold in the school canteen.  
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3 Additional risk factors including self-recorded parent's weight and height, parental ethnicity,  
4 and demographic, socioeconomic status of the child and the family were assessed by  
5 structured questionnaires.  
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8  
9 To assess economic status, ownership of an inventory of assets was used to construct a  
10 household wealth index using the principal components method to assign a weight for each  
11 asset. [23] A total of fourteen assets were assessed including bicycles, motorbikes,  
12 televisions, radios, videos, cassette players, computers, gas stoves, CD players, cars,  
13 microwave ovens, refrigerator and telephone and air-conditioners. The basis for selecting the  
14 assets was from a report of the Bureau of Statistics of HCMC [10] listing the most common  
15 assets used among HCMC population.  
16  
17

18 Also the adolescent's pubertal status was self assessed using a form, which recorded the  
19 child's date of birth, gender, weight and height, and questions to self-assessed pubertal status.  
20  
21

22 In a confidential setting, the adolescents self-reported their pubertal status using a  
23 questionnaire with photographs illustrating five stages [24] of pubertal development for pubic  
24 hair, male genitalia, or female breasts, and for female students the date of their first  
25 menstruation was also recorded.  
26  
27

### 28 **Data analysis**

29 Analyses were conducted using STATA 11 (STATA Corporation, College Station, TX, USA,  
30 2009). The IOTF (International Obesity Task Force) BMI cut-off values were used to define  
31 overweight and obesity combined [25]. The wealth index was ranked and divided into tertiles  
32 and each household was assigned to one of these wealth index categories.  
33  
34

35 The general characteristics of the population were described. For continuous variables, means  
36 and standard deviations or medians and inter-quartile ranges were calculated according to the  
37 distribution of each variable. In the case of categorical variables, absolute and relative  
38 frequencies were calculated. 95% confidence intervals were also computed. Continuous  
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3 variables that were not normally distributed were evaluated by the application of  
4  
5 transformations and categorisations wherever applicable. Baseline characteristics were  
6  
7 compared by gender and the lost to follow-up group was compared with the cohort baseline  
8  
9 group using Pearson chi-square or Fisher's exact test for categorical data, whereas continuous  
10  
11 data were tested with Student's t-test or Wilcoxon Mann-Whitney test. Kruskal-Wallis test  
12  
13 was used to compare medians of time spent on MVPA and sedentary behaviours and chi-  
14  
15 square for trend was used to compare prevalence of BMI status by years. The "survey  
16  
17 commands" were used to account for the multi-stage cluster sampling design. Future analyses  
18  
19 of this cohort data that assess relationships between exposure factors and the change of BMI,  
20  
21 physical activity, sedentary behaviours, will require mixed multiple regression models to  
22  
23 adjust for the multi-stage cluster sampling and repeated measurements in individual study  
24  
25 participants.  
26  
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28

### 29 **Ethics and dissemination:**

30  
31 The research proposal was approved by the Research Ethics Committee, Pham Ngoc Thach  
32  
33 University of Medicine, Ho Chi Minh City. It was also approved by the Human Research  
34  
35 Ethics Committee, University of Newcastle (ethics reference: H-879-0904). Informed written  
36  
37 consent was obtained from the principals of the schools participating in the study. Consent  
38  
39 from both the adolescents and their parents were required prior to their participation in the  
40  
41 study.  
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44

### 45 **Results**

46  
47 At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to  
48  
49 take part in the cohort study, of which 740 participated in the first follow-up data collection  
50  
51 including anthropometric measurements, dietary, physical activity, sedentary behaviours and  
52  
53 environment assessment. Therefore, the attrition rate for one year follow-up was 2.5%. In the  
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55 second round of follow-up, there were 712 (94% of baseline), in the fourth round, there were  
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3 630 (83% of baseline), and in the last follow-up 585 students remained in the cohort,  
4  
5 resulting in a retention rate of 77% (Table 1).  
6

7 *Insert table 1 here*  
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9  
10 The characteristics of the follow-up group (n=585) were compared with drops-out (n=174) on  
11 key variables that were available for all participants. These two groups did not differ by age,  
12 gender, and pubertal status, anthropometric or socio-demographic characteristics. The drop-  
13 outs in the sample were mainly attributed to the following reasons: (i) moved to another  
14 school (n= 93, 12.2 %); (ii) refused to continue in the study (n= 45, 5.9 %) and (iii) changed  
15 home address or migrated overseas (n= 36, 4.7 %).  
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22 The baseline data for socio-demographic and anthropometric variables are listed in Table 2.  
23 At baseline, the mean age of the sampled subjects was 11.8 years ( $\pm 0.6$ ). Overall 12.5% of  
24 the students were overweight and 1.7% were obese. The mothers of 52.3% of the students  
25 had completed senior high school and 58.5% of the fathers had completed senior high school.  
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32 *Insert table 2 here*  
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34 Figure 2 shows the geographic distribution of schools and participants' home measured by  
35 GPS. Students' houses were scattered around their schools with a median distance from home  
36 to school of 1,450m (Inter-quartile Range (IQR): 680-3,030m).  
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41 *Insert figure 2 here*  
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43 A summary of the changes in the BMI status and time spent in moderate to vigorous physical  
44 activity and sedentary behaviours are listed in Table 3. Over the five year period of this  
45 cohort study, the prevalence of overweight increased from 12.5% to 16.7%, and obesity from  
46 1.7% to 5.1%. Time spent in moderate to vigorous physical activity decreased significantly  
47 from 87 minutes / day to 50 minutes / day. In contrast, time in sedentary behaviours increased  
48 from 512 minutes / day to 600 minutes / day.  
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56 *Insert table 3 here*  
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3 Previous papers based on the cross sectional baseline survey have described overweight and  
4 obesity [3 26], physical inactivity [22], and metabolic syndrome [27] and associated risk  
5 factors. Another paper has used the longitudinal data from the youth cohort to describe  
6 changes in active commuting to school and risk factors for changes in commuting status [28].  
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8 More results will be presented in future papers presenting changes in physical activity,  
9  
10 sedentary behaviour, and overweight/obesity and their associated risks factors.  
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### 19 **Discussion:**

20 We have successfully implemented a 5-year follow-up study in adolescents in Vietnam with a  
21 high retention rate of 77%. Over this period, we found that the prevalence of combined  
22 overweight and obesity increased significantly from 14.2% to 21.8%. Self-reported time  
23 spent on physical activity decreased significantly from 87 minutes / day to 50 minutes / day  
24 and in contrast, sedentary time increased from 512 minutes / day to 600 minutes / day. This is  
25 the first cohort study on adolescent obesity in Vietnam, which provides a comprehensive  
26 assessment of the change in anthropometric growth, dietary intake, physical activity and  
27 environmental factors as well as their associations over the years of follow-up.  
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38 An important strength of the study was maintaining more than 75% of the students in this  
39 cohort which has helped ensure the internal validity of the study. Also, the measurements of  
40 key outcomes and study factors have high reliability and validity from the use of validated  
41 tools (FFQ, V-APARQ, environmental questionnaires) and objective measurements  
42 (accelerometers, GPS devices). The project staff, who took the measurements, was retrained  
43 throughout the study thus helping to ensure standard measurement methods were used across  
44 the cohort. We used a prospective longitudinal design from a representative sample of  
45 adolescents from HCMC and aimed to follow-up the children over five years. Each child has  
46 a health profile including anthropometric and pubertal status data as well as other exposure  
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3 factors each year. The findings will be of relevance to other cities in Vietnam, which are  
4 starting to go through the same environmental and lifestyle changes that have already  
5 occurred in HCMC. The findings will also be relevant to other urban populations in East Asia  
6 and Southeast Asia where rapid economic development is leading to a nutrition transition  
7 similar to that occurring in HCMC.  
8  
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10 The relatively small sample size is one limitation of the study restricting examination of all  
11 potential relationships because of the limited sample in some subgroups. However, the  
12 sample size was adequate to detect changes in BMI over time and changes in key study  
13 factors such as physical activity and screen time which was used as a proxy for sedentary  
14 time. Despite this restriction, this study remains important because it is one of very few  
15 longitudinal studies in Vietnam and South East Asia to explore obesity and changes in  
16 obesity-related risk factors in adolescents.  
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19 Although there was only one non-public school in this study, this reflected the small  
20 proportion of the school population enrolled in this type of school in HCMC. We found no  
21 important differences between public and private schools for the main study factors and  
22 outcomes, such as socioeconomic status. Unlike the situation in many developed countries, in  
23 Vietnam, non-public schools are not popular and students usually enter these schools when  
24 they cannot secure a place in a public school. Thus, we believe the sampling of this study was  
25 not biased and is representative of HCMC adolescents at school.  
26  
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28 In Ho Chi Minh City over the five year period, the prevalence of overweight increased from  
29 12.5% to 16.7% and obesity increased from 1.7% to 5.1%. This increase in overweight and  
30 obesity was consistent with the increases found in 5-year follow up studies from 1999 to  
31 2004 in urban Indonesian children where the prevalence of overweight increased from 4.2%  
32 in children to 8.8% in adolescents, and similarly obesity increased from 1.9% to 3.2% [29].  
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34 Similar findings have been reported from a 5-year follow-up study in Thai school children  
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3 where the prevalence of overweight in boys increased from 12.4% in 1992 to 21.0% in  
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5 1997.[30]

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7 The primary findings of this study are also consistent with the substantial age-related declines  
8  
9 in MVPA among both adolescent boys and girls previously reported in the US [31-32], and  
10  
11 Finland [33]. These results also showed that daily MVPA decreased of 42% over a five year  
12  
13 period when adolescents were aged 12 years to 16 years, which was similar to the 45%  
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15 decline reported for American adolescents in the CATCH study [34]. Furthermore, the  
16  
17 increase in sedentary time with age found in the present study is similar to increases reported  
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19 by longitudinal studies in developed countries [35-36].  
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23 This study can, through the cause-effect relationships examined, provide evidence to guide  
24  
25 the formulation of appropriate and reasonable recommended levels of physical activity to  
26  
27 prevent overweight/obesity in Vietnamese adolescents. The findings will also provide  
28  
29 evidence to help develop recommendations for dietary behaviours or future designs of  
30  
31 schools and neighbourhoods to ensure these environments are health promoting and meet the  
32  
33 needs of Vietnamese adolescents during an age when there is rapid body growth.  
34  
35

### 36 **Conclusion**

37  
38 The rapidly increasing prevalence of obesity as well as the significant decrease in time on  
39  
40 moderate to vigorous activity and increase in sedentary time in adolescents in Ho Chi Minh  
41  
42 City suggesting that this population is at increased future risk of non-communicable diseases.  
43  
44 There is an urgent need to develop interventions to target this population to promote physical  
45  
46 activity and decrease sedentary behaviour in order to prevent overweight/obesity. The  
47  
48 complete data analysis of this cohort study will allow a full exploration of the role of  
49  
50 environmental and lifestyle behaviours on adolescent overweight and obesity, and also  
51  
52 identify the factors most strongly associated with excess weight gain and the appearance of  
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54 overweight and obesity in different age groups of adolescents from this large city in Vietnam.  
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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.

For peer review only

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11 [4c63-b25a-35d8ade4298a&groupId=41249.](http://www.hids.hochiminhcity.gov.vn/c/document_library/get_file?uuid=2d9fc8bd-2eb4-4c63-b25a-35d8ade4298a&groupId=41249)  
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4 and management of the study and all revised this manuscript critically. All authors gave final  
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22  
23 **Data sharing statement:** Access to the dataset is available from the corresponding author  
24 ([nguyenhoang\\_doantrang@yahoo.com](mailto:nguyenhoang_doantrang@yahoo.com)) or the principle investigator ([hongutc@yahoo.com](mailto:hongutc@yahoo.com))  
25 in STATA format for academic researchers interested in undertaking a formally agreed  
26 collaborative research project.  
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**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 (n=364)	SD	Mean (n=395)	SD	Mean (n=759)	SD	P*
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 (1 <sup>st</sup> tertile)	33.6	28.7, 38.5	33.1	28.4, 37.7	33.4	30.0, 36.7	
2 <sup>nd</sup> tertile	31.4	26.6, 36.2	35.9	31.2, 40.7	33.8	30.4, 37.1	
Richest (3 <sup>rd</sup> tertile)	35.0	30.1, 39.9	30.9	26.3, 35.5	32.8	29.5, 36.2	

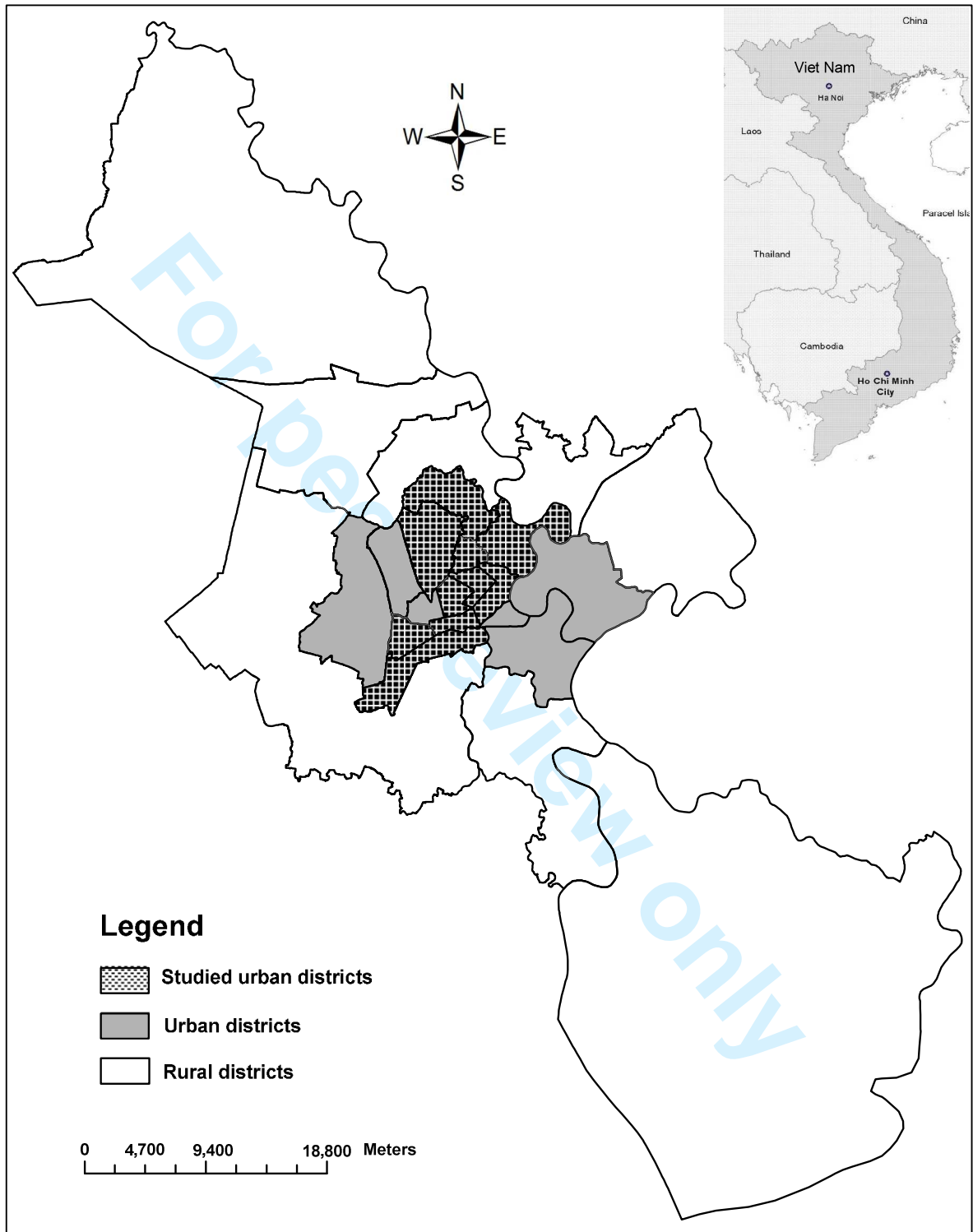
\*test compared characteristics between boys and girls

**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 <sup>§</sup> )	512 362, 632	554 412, 658	596 436, 699	607 443, 707	600 424, 682	0.001

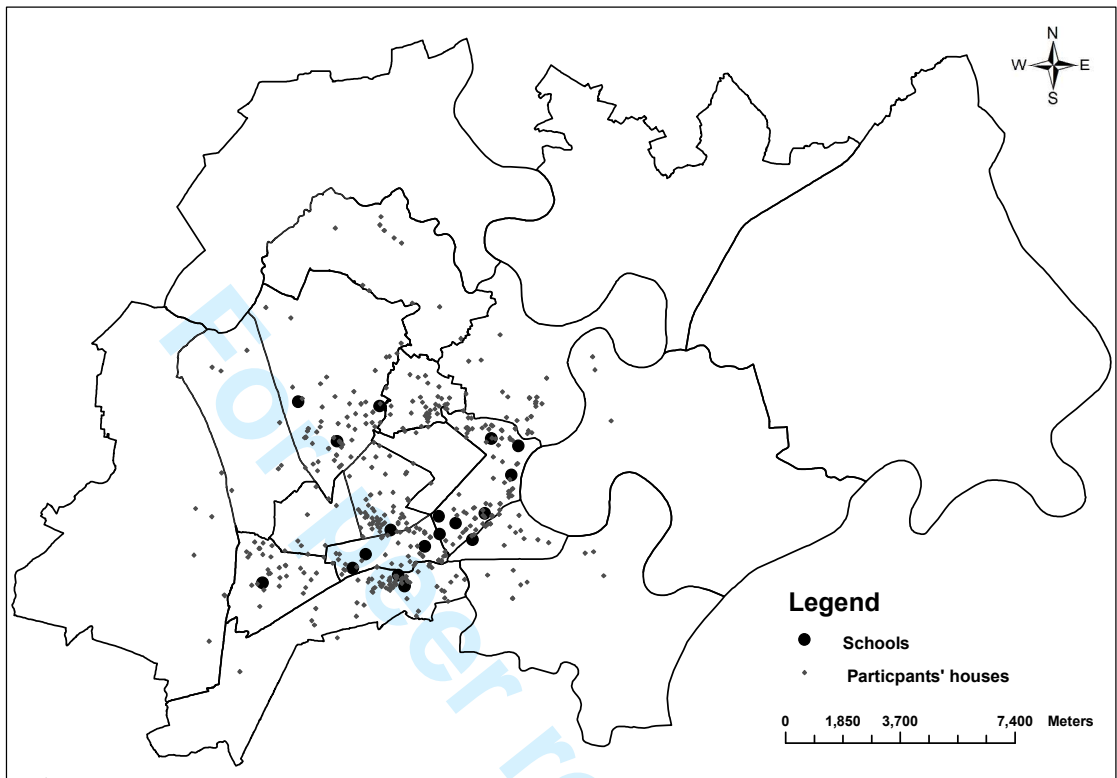
\*MVPA: moderate to vigorous physical activity; \*\* V-APARQ: Vietnamese- Adolescent Physical Activity Recall Questionnaire; <sup>§</sup>ASAQ: Adolescent Sedentary Activity Questionnaire  
<sup>+</sup> test for changes

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



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**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
<b>Introduction</b>			
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
<b>Methods</b>			
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	
<b>Results</b>			

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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	12
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 (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	13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	13,14
<b>Limitations</b>			
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
<b>Other information</b>			
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](http://www.strobe-statement.org).