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Built environment and physical activity in New Zealand adolescents: a protocol for a cross-sectional study

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ABSTRACT

Introduction: Built-environment interventions have the potential to provide population-wide effects and the means for a sustained effect on behaviour change. Population-wide effects for adult physical activity have been shown with selected built environment attributes; however, the association between the built environment and adolescent health behaviours is less clear. This New Zealand study is part of an international project across 10 countries (International Physical Activity and the Environment Network–adolescents) that aims to characterise the links between built environment and adolescent health outcomes.

Methods and analyses: An observational, cross-sectional study of the associations between measures of the built environment with physical activity, sedentary behaviour, body size and social connectedness in 1600 New Zealand adolescents aged 12–18 years will be conducted in 2013–2014. Walkability and neighbourhood destination accessibility indices will be objectively measured using Geographic Information Systems (GIS). Physical activity and sedentary behaviours will be objectively measured using accelerometers over seven consecutive days. Body mass index will be calculated as weight divided by squared height. Demographics, socioeconomic status, active commuting behaviours and perceived neighbourhood walkability will be assessed using the Neighbourhood Environment Walkability Scale for Youth and psychosocial indicators. A web-based computer-assisted personal interview tool Visualisation and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces (VERITAS) and Global Positioning System (GPS) receivers will be used in a subsample of 300 participants. A qualitative research component will explore barriers and facilitators for physical activity in adolescents with respect to the built and social environment in a subsample of 80 participants.

Ethics and dissemination: The study received ethical approval from the Auckland University of Technology Ethics Committee (12/161). Data will be entered and stored into a secure (password protected) database. Only the named researchers will have access to the data. Data will be stored for 10 years and permanently destroyed thereafter. The results papers will be submitted for publication in peer-reviewed journals.

Strengths and limitations of this study

- Limited data exist on detailed and multilevel relationships of interaction between the social and physical environments specific to the New Zealand (NZ) adolescents.
- The use of Global Positioning System/Visualisation and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces (GPS/VERITAS) will define the adolescents' geographical context and will provide accurate estimates of location in which physical activity takes place.
- The study forms the NZ arm of the international IPEN-Adolescents collaboration, whereby adolescents' physical activity and sedentary behavior data are collected using a common methodology across multiple countries.
- Parents may self-select neighbourhoods; therefore, associations between built environment and walkability may in part be a reflection of neighbourhood self-selection bias. Parents' neighbourhood preference and self-selection will be accounted for in the analysis.
- When conducting spatial analyses on aggregated data, errors affecting the validity of results may be introduced. Geocoded data and other techniques will assist in gaining a more accurate understanding of neighbourhood boundaries for adolescents.

INTRODUCTION

The benefits of physical activity in youth are well documented.[1–5] Regular moderate-to-vigorous physical activity (MVPA) is positively associated with musculoskeletal health, cardiovascular well-being (eg, healthy blood pressure, lipid and lipoprotein levels, cardiovascular autonomic tone), metabolic health, maintenance of a healthy weight, psychological well-being (eg, improved self-concept, reduced anxiety and depression) and reduced risk of type 2 diabetes.[6 7] The accumulation of at least 60 min of MVPA per day is recommended for youth; however, accumulating physical activity below this threshold is still beneficial, especially for those whose health is at risk (eg, overweight or obese youth).[6] Despite awareness of the well-established benefits of physical activity, rapid changes in technology and the habitual environment over the past 50 years may have caused an increase in sitting, passive travel and subsequently a reduction in incidental physical activity.[8] Furthermore, over the course of adolescence, physical activity typically decreases by 60–70%,[9] while sedentary behaviour remains high at 7–14 h/day.[10–12] The latter trend is a matter of particular concern given that emerging evidence suggests that sedentary behaviour has negative effects on health that are independent of the beneficial effects of physical activity.[13–15] In addition, levels of activity during school age years significantly predict activity levels[16] and health outcomes[17] into adulthood.

Behavioural modification programmes have only achieved limited and mostly short-term physical activity improvements.[18–20] For sustainable changes that optimise positive behaviours, it is important to understand that physical activity and sedentary behaviours occur within a broader ecological framework.[21] It is recognised that in order to be effective, complex integrated interventions are required that include supportive policies and social and physical environments.[22 23] Manipulating social and physical environments to be more health promoting will most likely have sustainable and far-reaching impacts on population health behaviours and outcomes. We have previously examined the relationship of objective built environment measures (ie, destination access, street connectivity, dwelling density, land use mix) with accelerometer-derived and self-reported physical activity in adults.[24] The work was part of a larger international study (IPEN-International Physical activity and Environment Network) with 12 participating countries. The potential of walkable neighbourhoods for supporting health-enhancing increases in physical activity, at least for adults, was high.[24] A 1 SD increase in neighbourhood walkability variables yielded a 7–13% increase in physical activity. This effect is likely to be much higher than effects achieved through behavioural intervention alone.[25 26]

While the evidence base for associations between the built environment and physical activity in adults has been steadily accumulating,[24 27 28] our understanding of this relationship in adolescents is at its infancy,[29–38] and at times non-intuitive.[33 39] Adolescents were consistently identified in our adult focus groups in our previous study as a subgroup whose changing needs for independent mobility and age and culturally appropriate forms of physical activity are less likely to be met, particularly in more suburban built environment forms.[40] In a recent review, land-use mix and residential density were the most highly correlated built environment variables with overall physical activity in youth.[41] However, the review did not find any environmental variables that consistently correlated with physical activity in adolescents. Nonetheless, latest research indicates that adolescents' physical activity tends to occur close to their homes,[35 42] and that strong associations exist between inactivity with lower neighbourhood walkability, amount of public open space and neighbourhood safety,[43] as well as higher densities of cul-de-sac networks.[36] MVPA is significantly lower for rural adolescents compared with those living in urban environments; however, these differences between neighbourhood type are not seen for body mass index (BMI).[44] Geospatial data indicate that adolescent girls engage in higher intensity physical activity in places with parks, schools and higher population density, and that they accumulate lower levels of physical activity in places with more roads and food outlets.[32] Low-income adolescents were physically active at fields/courts, indoor recreation facilities, small and large parks and swimming pools,[42] but reduced accessibility of physical activity facilities and food outlets was associated with being overweight.[34]

In the Built Environment and Adolescent New Zealanders (BEANZ) study, we seek to understand the relationship of physical activity, sedentary behaviour and body size with neighbourhood-level built environment features in New Zealand (NZ) adolescents. We hypothesise that neighbourhood walkability and neighbourhood destination accessibility indices will be positively associated with minutes of MVPA, and inversely associated with minutes of sedentary time and BMI. We will also investigate associations between the built environment and social connectedness to the community,[45] the moderating effects of ethnicity and mediating effects of active commuting, neighbourhood mobility, and perceived neighbourhood walkability. A novel aspect of this study is the use of Portable Global Positioning System (GPS) receivers together with web-based interactive mapping and geocoding software to examine adolescents' mobility and access to regular destinations. These ancillary data will enable the shape and scale of environmental exposure to be defined in considerable detail.

Our study forms part of the IPEN-adolescent collaboration, using comparable data collection, management and protocol sharing across 10 countries. By comparing diverse countries, built environmental heterogeneity can be captured (and therefore generate robust estimates of the real effects) while facilitating intracountry and intercountry comparisons. The goal is to generate credible evidence to guide long-term town planning, policy change and redesign of existing urban environments to maximise physical activity and community connectedness and minimise sedentary behaviour and body size, all key determinants of human health.

METHOD AND ANALYSIS

The standardised checklist for the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations was used to ensure that all the elements recommended were addressed within this section.[46]

Design

BEANZ will be based on an observational, cross-sectional design that examines the associations of objective and subjective measures of the built environment with physical activity, sedentary behaviour, body size and social connectedness in 1600 NZ adolescents aged 12–18 years from eight secondary schools (approximately 200 participants per school). Moreover, differences between non-Māori and Māori population groups will be explored. Demographics, socioeconomic status (SES), active commuting, psychosocial indicators and perceptions of the built environment will be measured in the full sample. Data will be collected in the 2013–2014 academic school years for the southern hemisphere. A GPS and interactive mapping substudy of approximately 300 participants will assess neighbourhood mobility by geolocating participants' destinations, modes of travel, activity locations, walking/cycling areas and perceived neighbourhood boundaries. Focus groups will explore barriers and facilitators to physical activity with respect to neighbourhood built and social environment in a subsample of approximately 80 participants. Data will be collected from two major cities in New Zealand: Auckland and Wellington. Auckland is the largest city in New Zealand with a population of approximately 1.4 million residents (one-third of the country's population),[47] with a population density comparable to Los Angeles and Helsinki.[48] Wellington, the capital city of New Zealand, is located on the southern part of the North Island and has a population density comparable to Vancouver and Honolulu.[48]

Neighbourhood, school and participant selection

Associations between exposure and outcome variables are estimated based on data collected using a multistage sampling strategy. This strategy maximises heterogeneity in the exposure variables (built environment) while allowing comparisons to be made between those of low and high SES. In the first instance, Geographic Information Systems (GIS) will be used to calculate three built environment measures—street connectivity, residential density and land use mix—for each meshblock (smallest census tract units available in New Zealand).[40] Street connectivity will be calculated by dividing the number of 3-or-more-way intersections by the area in square kilometres. To avoid edge effects associated with meshblocks delineated by street centrelines, street connectivity will be calculated for 20 m meshblock buffers. Intersections will be extracted from 2013 street network datasets provided by territorial authorities. Residential density will be calculated by dividing the number of dwellings by the residential land area. The number of dwellings will be obtained from the 2006 census data provided at the meshblock level. Residential land area will be derived from 2013 zoning datasets provided by territorial authorities. Land use mix will be calculated using the area of five land use categories (residential, commercial, industrial, open space, other) in an entropy equation.[49] Land uses will be determined using 2013 zoning datasets provided by territorial authorities. The raw scores for these three built environment measures will be normalised (converted to deciles) and summed to create a basic walkability index. This basic meshblock level walkability index will only be used in school and participant selection. The GIS-based built environment indices that will be created for each participant and used in analyses are described in a later section.

The raw scores for these built environment measures will be normalised and summed to create a basic walkability index. Next, the basic walkability index and pre-existing deprivation data (NZ Dep 2006) will be used to classify all Auckland and Wellington urban meshblocks into one of four strata: (1) higher walkable, higher SES; (2) higher walkable, lower SES; (3) lower walkable, higher SES and (4) lower walkable, lower SES. Meshblocks with the top four walkability/SES deciles are classified as higher walkable/SES, and meshblocks with the bottom four walkability/SES deciles are classified as lower walkable/SES. Meshblocks with walkability or SES in deciles 5 and 6 are excluded.

School selection will be based on convenience and proximity to large numbers of meshblocks in each of the four strata. Within each school, all potential participants will be sampled, regardless of the quadrant they reside in, and for each participant walkability will be calculated: all students will be assigned to the strata of the meshblock they primarily reside in. This procedure will take place prior to the consent process. Adolescents living in one of the four meshblock strata will be invited to participate in the study. Participation in the study will require written, informed consent from a parent or caregiver and written assent from the adolescent. At the time of consent, parents will be asked to rate the importance of a variety of reasons for choosing to live in their neighbourhood. Subsequent schools will be selected on the basis of the quadrants that need to be balanced. In addition to this approach, care will be taken to balance student numbers across the four strata within and across schools. A similar sampling strategy was used in our previous study of the environmental correlates of physical activity in adults; the heterogeneity generated by this technique permitted several meaningful associations to be detected.[40] A subsample of approximately 40 participants will be randomly selected from each school for the GPS and interactive mapping measurements.

Sample size

In adjusted multilevel models, it has been estimated that a sample of 1600 adolescents recruited from two schools within each stratum (eight in total) would allow the detection of a small effect size (ie, 1.4% of explained outcome variance found in similar studies conducted elsewhere[50]) with 80% power. The calculated sample size assumes a two-tailed probability level of 5%, a conservative clustering effect equivalent to an intraclass correlation coefficient of 0.10, and a regression model with 25 background covariates explaining 25% of the outcome variance (comparable to what might be expected from the selected variables). With an anticipated sample size of 320 Māori adolescents (our smallest subgroup comparison), the corresponding detectable effect size will be 7% of the explained outcome variance (medium effect size).

Exposure, outcomes and covariates

Exposures

GIS data provide multiple spatially-referenced layers that can be used to create meaningful and objective exposure measures of the built environment. They are used to objectively characterise the built environment surrounding the primary home address of each participant and can be applied across a range of road network buffers (eg, 500, 800, 1000 and 1600 m) in order to evaluate differences between various limits of exposure. Road network buffers can be created to define areas that can be reached on the street network system, but exclude areas that are not accessible due to major barriers (motorway, river and lake). Two main indices, each a composite function of 2–8 other variables, are used to assess physical environmental features: walkability index[51] and neighbourhood destination accessibility index (NDAI).[52] These are described in more detail below. All exposure measures (table 1) follow the common protocols established for the international IPEN-adolescents collaboration.

Detailed walkability

The detailed walkability index is a summary score of five distinct variables calculated within GIS: net residential density, land use mix, retail density, street connectivity and street discontinuity. This protocol was created for the US-based Neighborhood Quality of Life Study project[51] and has subsequently been implemented in the US-based TEAN study,[53] the Australian PLACE study[49] and all IPEN adult country study sites.[54]

Neighbourhood destination accessibility

Pedestrian access to destinations will be calculated using the NDAI.[52] The NDAI is an objective measure of

Table 1 Summary of study exposure, outcomes and covariates

Exposure	Covariates
Detailed walkability index	Demographics
Net residential density	Age
Land use mix	Sex
Retail density	Ethnicity
Street connectivity	School
Street discontinuity	Socioeconomic status
Neighbourhood destination accessibility index	Parent education
Education destinations	Parent occupation
Transport destinations	Family car ownership
Recreation destinations	Household crowding
Social and cultural destinations	Active commuting
Food retail destinations	Frequency of active commuting
Financial destinations	Duration of active commuting
Health destinations	Neighbourhood mobility
Other retail	Frequency and location of regular destinations
Outcomes	Frequency and location of activity
Physical activity behaviour	Total walking area
Minutes of MVPA	Total cycling area
Minutes of light activity	Perceived neighbourhood boundary
Sedentary behaviour	Perceived neighbourhood walkability
Minutes of overall sedentary activity	Perceived residential density
Minutes of television watching	Perceived land use mix
Body size	Perceived traffic/crime safety
Body mass index	Perceived aesthetics
Waist circumference	Psychosocial indicators
	Self-efficacy
	Cons/barriers
	Family support
	Peer support
	Weather
	Total rainfall
	Mean temperature
	Hours of daylight

MVPA, moderate-to-vigorous physical activity.

pedestrian access to neighbourhood destinations; it characterises the distribution of urban infrastructure within an 800 m street network distance from the residence. The NDAI has an advantage over most previous area-level measures of the urban environment in that it captures the range and intensity of everyday destinations such as schools, supermarkets and cafes, which may encourage active travel and enhance recreational physical activity at the population level. Also, the NDAI has been specifically designed for the New Zealand environment. The eight domains captured in the NDAI are education, transport, recreation and play, social and cultural, food retail, financial, health and other retail.

Outcomes

Physical activity

Minutes of MVPA will be objectively measured using the hip-mounted triaxial accelerometers (Actigraph GT3X+) over seven consecutive days. The GT3X+ is a small, durable and water-resistant device worn on an elastic belt that records the frequency, duration and intensity of physical activity with a high level of accuracy and precision.[55] Participants are asked to wear the Actigraph during all waking hours (except when bathing or swimming) for 7 days; however, at least five complete days (including at least one weekend day) will be required for analysis to ensure reliable estimates of MVPA.[56] Consistent with previous research, a valid day will be defined as at least 10 h of data for weekdays and 8 h for weekend days; non-wear time will be defined as 60 min of consecutive zero counts.[57 58] In addition, each participant will be given a 7-day compliance log to complete daily, which assists with identifying non-wear periods. On collection of the accelerometer, data are downloaded and screened for completeness and possible malfunction using the MeterPlus software (http://www.meterplussoftware.com). Accelerometer count data will be classified into minutes of light, moderate and vigorous activity using thresholds developed by Evenson *et al*[59]; these have performed well in a recent comparison of accelerometer count thresholds for youth.[60]

Sedentary behaviour

Minutes of sedentary activity will be objectively assessed using the GT3X+ accelerometer over the 7-day measurement period. The aforementioned cut-points established by Evenson *et al*[59] will be used to define sedentary time (<100 counts/minute).

Body size

Height, weight and waist circumference of each participant will be measured by trained field researchers using a stadiometer, calibrated scales and a tape measure. These procedures occur immediately before the researchers distribute the accelerometers; participants wear light clothing and shoes are removed. BMI will be calculated as weight divided by squared height. Participants are classified into weight status categories using age-specific and sex-specific BMI thresholds.[61]

Covariates

Demographics and SES

Age, sex, ethnicity and SES will be collected from the participants. Consistent with the IPEN-adolescents protocol, household income will be the preferred SES indicator, but the highest level of parental education will be used when income is unavailable.

Active commuting

The frequency, distance, duration and mode of all active commuting trips to or from the home address in the previous 6 months will be assessed with the computer-assisted personal interview (CAPI). The recall of each trip will be aided by a basic travel log (time, location and mode of transport only) to be completed nightly with the accelerometer compliance log. Participants will be asked to bring this information with them to the subsequent CAPI.

Neighbourhood mobility

The majority of studies investigating the built environment and health have focused exclusively on residential neighbourhoods as a predictor of exposure[62 63] and overlooked the prospect that a large proportion of activity choices may be influenced by additional environments that are experienced during daily routines. This may reduce the accuracy of environmental exposure assessment[64] and introduce errors that may confound research results. It has been suggested that investigating aspects of daily mobility (regular destinations and the movement between them) will be important to enhance the assessment of exposure[65] and resolve the Uncertain Geographic Context Problem.[66] Using GPS and interactive activity destination questionnaires, we aim to accurately capture the full extent of daily mobility and its mediating built environment effect on health.

The Visualization and Evaluation of Route Itineraries, Travel Destinations, and Activity Spaces (VERITAS) is a web-based CAPI tool integrating interactive mapping capacities (based on Google Maps) and has the potential to explore destinations inside and outside the residential neighbourhood. VERITAS was initially developed and tested for the RECORD Cohort Study, a major longitudinal study of over 7200 French adults.[67–70] The applicability and feasibility of this method to an adolescent population is detailed elsewhere (manuscript under review but available on request). While we will be using GIS to provide an objective assessment of the surrounding environment (ie, exposure measures), VERITAS will allow the research team to search and geolocate participants' regular destinations (visited within the previous 6 months), activity locations, walking/cycling areas, routes and modes of travel between locations, travel companions, and perceived or experienced neighbourhood boundaries (ie, neighbourhood mobility). The VERITAS programme will run through an internet browser on a laptop computer, and will be designed to automatically upload all participant responses to our secure database when connected to a wireless network. Spatiotemporal data will be collected using the Qstarz BT-Q1000XT GPS receiver (Qstarz International, Taipei, Taiwan), which has been deemed to be one of the more accurate portable GPS receivers on the market.[71] The GPS will be worn in a pouch alongside the accelerometer. GPS data will be cleaned, filtered and merged with accelerometer data using the Personal Activity Location Measurement System (PALMS, refer to: https://ucsd-palms-project.wikispaces.com).[72] The merged data streams retrieved from PALMS will be disaggregated into discrete trips and imported into ArcGIS for further analysis. Data obtained from GPS and VERITAS differ both temporally (previous 1 week and 6 months, respectively) and spatially (a continuous sequential polyline compared with point data). Although VERITAS will be able to obtain data for extended periods, it lacks the temporal sequence of events available from GPS tracking. However, as short periods of GPS monitoring may not truly represent destinations visited over extended periods, the combination of both has been recommended to create complementary and more robust measures of environmental exposure.[69]

The neighbourhood mobility data will allow the demarcation of the territorial range by active travel modes. A spatial 'polygon' will be created, consisting of a multisided geometric shape surrounding the home address that connects the various locations to which participants claim to have walked or cycled. The area (m^2) within these polygons will be calculated and used to define separate shapes based on the travel modes. In situations where participants walk or cycle to only one location (eg, school), the polygon area will be the distance between the location and home addresses multiplied by 1 m. As with the active commuting assessment, the recall of visited locations and trips will be aided by the travel log that will be completed daily. Finally, using VERITAS, each participant will be able to map their perceived neighbourhood boundary, allowing us to isolate the effects of their self-defined neighbourhood environment on the outcome measures.

Perceived neighbourhood walkability

In order to understand the mediating effect of individual perceptions of the neighbourhood on the relationship between the objectively-measured built environment and physical activity behaviour, the Neighbourhood Environment Walkability Scale for Youth (NEWS-Y) will be administered as a self-completion hard copy survey. NEWS-Y is based on the NEWS, which has demonstrated good reliability and validity.[73–76] In addition to the GIS-based walkability index variables (residential density, land use mix and street connectivity), NEWS-Y assesses pedestrian/cycle facilities, aesthetics, traffic safety and crime safety. The ten NEWS-Y subscales have acceptable test-retest reliability (ICC 0.56–0.87) and specific subscales were correlated significantly with physical activity for adolescents.[77]

Psychosocial indicators

A small number of psychosocial variables associated with adolescent physical activity will be measured in the study. These include: self-efficacy; perceived barriers to being physically active; family support; and peer support.[77] These variables have shown the most consistent psychosocial correlations with adolescent physical activity in the literature.[78] Further, by including such items, we are able to examine our findings within a multilevel framework, thereby accounting for and separating the various layers of influence (ie, individual, social and physical environments).[79]

Self-reported physical activity, sedentary behaviour and commuting to school

In addition to perceived neighbourhood walkability and psychosocial indicators, participants will be asked to report on commuting (to and from school, walking and biking, barriers to walking and cycling),[80–82] physical activity (at and outside school, places for, barriers in the neighbourhood, decisions about, confidence about, enjoyment of, social support, workout equipment, activity rules and athletic ability)[83–85] and sedentary behaviour (during school and weekend days, things in the bedroom and personal electronics).[86] The scales have been shown to be reliable and valid in the adolescent population.[80–82 86]

Weather

We have previously demonstrated the significant impact of inclement weather conditions on physical activity in New Zealand children.[87] To monitor these potential confounding effects, we will obtain hourly rainfall, mean temperature and hours of daylight statistics from the New Zealand Met Service for each data collection day and use these as covariates in the models.

Procedures

Data will be collected from participants within the school setting during school hours. During the measurement session, the NEWS-Y[77] questionnaire will be administered, anthropometric measures will be taken and accelerometers and compliance logs will be distributed. Text messages will be sent to adolescents/parents before the data collection session as a reminder to attend. A random subsample of 40 adolescents per school will be allocated a GPS receiver to wear in conjunction with the accelerometer, and will complete the VERITAS interview. All participants will be instructed on the correct use, wear-time and care of the equipment. Participants will be issued with a $20 shopping voucher on completion of data collection and return of the monitors and compliance logs.

Quantitative analyses

The proposed dataset will have a hierarchical independent variable structure which consists of person-level observations nested within neighbourhoods and schools. The main aim of the study is to examine confounder-adjusted associations of environmental variables with physical activity and body size outcomes. For this purpose, cross-classified (by neighbourhoods and schools) generalised linear mixed models (MGLM) with random intercepts will be used. These can account for multiple sources of dependency (schools and neighbourhoods) and different types of data (eg, continuous or binary) following a normal distribution or other types of distributions (eg, negative binomial, Poisson).[88] MGLMs perform well when the number of observations across areas is highly unbalanced,[89] which will be relevant to this project as the number of participants may vary substantially across schools and neighbourhoods. Given the relatively small number of strata included in the study, MGLMs will be estimated using Restricted Maximum Likelihood (REML) or Bayesian Markov chain Monte Carlo (MCMC) methods with non-informative priors,[90] the latter being appropriate for binary (eg, overweight/obese vs normal weight)[90 91] or non-normally distributed outcomes.[88] The non-linear relationship will be examined using restricted cubic splines.[92] A probability level of 0.05 will be adopted.

Qualitative methodology

A total of 16 focus groups, with approximately 5–8 participants, will be conducted at eight participating schools. One researcher (VI) will conduct all the focus groups and at least one of the co-researchers will assist. Variability in walkability will be sought by recruiting two schools in Auckland (representing relatively low walkability) and Wellington (relatively high walkability). However, students within focus groups will be selected to represent a range of neighbourhood settings to facilitate discussion on differing experiences of the built environment. Participants will also take part in the quantitative component and complete all data collection. To aid open discussion and allow meaningful comparisons, separate focus groups will be conducted by age, with younger students (approximately 12–14 years) further stratified by sex, and older students (approximately 15–18 years) in mixed sex groups.[42] Focus groups will be conducted using 40 min school periods to accommodate school timetables in a semistructured interview. The focus groups are designed to examine the enablers and barriers to being physically active, particularly with regard to active transport, engagement in formal and informal physical activity, safety and social drivers. Researchers will specifically seek discussion on activity within participants' residential neighbourhood and school environments as well as alternative activity spaces in their everyday lives, including those outside of their geographical suburbs. Maps of local environments to prompt discussion on where youth are active (and where they avoid), types of activity and travel routes will be used. Interviews will be digitally recorded and transcribed by group, with all individual identifying information removed.

Qualitative analyses

Initially, two of the researchers will independently read the transcripts, code and extract themes. The themes will be presented to the team. Disagreement will be resolved through discussion and themes will be confirmed. A coding framework will be developed using NVivo software to organise data generated by the project research questions (deductive) and emergent topics (inductive).[93] Analyses will be conducted across and within groups to examine commonalities and differences by built environment settings and individual factors (ie, sex, age and culture). Concurrent analyses of qualitative and quantitative data will allow insightful integration and triangulation of findings across the study components, allowing us to draw inferences about how youth interact with and manage their lived environments, and what that means for their physical activity and well-being.[94 95]

ETHICS AND DISSEMINATION

All adolescents will be required to provide assent to participate in the study. An information sheet will be designed specifically for adolescents in a manner that will be easy to understand. In addition, all parents of the assenting adolescents will be required to provide parental consent. Parents will also receive a detailed information sheet outlining the study and its requirements.

Data will be entered and stored into a secure (password protected) database. Only the named researchers will have access to the data. Data will be stored for 10 years and permanently destroyed thereafter.

It is unlikely that participants will experience discomfort or embarrassment during data collection. However, as body measures of weight and height will be assessed objectively, there is the potential of concern around body weight and size. The institution's counselling services will be accessed if a situation arises. All body measurements will be taken behind a portable screen with gender appropriate research officers. All data will be kept private and confidential.

At the completion of the study, results will be provided to key stakeholders and organisations (eg, high schools, adolescents and parents). Results will be disseminated by means of a written report to schools that have participated in the study. Adolescents and/or their parents/legal guardians will receive a report detailing the individual results collected. Government organisations, health boards and councils will be able to access key findings and recommendations resulting from the project through seminar presentations and report distribution. Research findings will also be circulated to the scientific community in the form of publications in refereed journals.

DISCUSSION

We have described the methods for the BEANZ study which seeks to estimate strengths of association between objective measures of the local environment with accelerometer-derived and self-reported physical activity and sedentary behaviour in youth. A novel aspect of this study is the exploration of detailed and multilevel relationships of interaction between the social and physical environments specific to the NZ adolescents. This will be achieved through additional measures (eg, GPS, VERITAS, focus groups, NDAI) which collectively serve to advance knowledge in this important area of health research, policy advocacy and ultimately youth health outcomes. In particular, the use of GPS/VERITAS to identify the locations that adolescents visit on a daily basis, defining their geographical context, will provide us with accurate estimates of location in which physical activity takes place.

International evidence shows that the most consistent environmental attributes positively associated with reported physical activity in youth were land use mix and residential density, but inconsistent findings have been observed for parks, recreation facilities and street connectivity.[41] Others found that proximity to parks, recreation facilities and proximity to school[32 42 96 97] along with transport infrastructure were positively associated with physical activity in adolescents.[97] Traffic hazards (number of roads to cross, traffic speed) and local conditions (crime, area deprivation) were negatively associated with physical activity.[43 97] Obesogenic environmental attributes of homes, neighbourhoods and schools are believed to promote sedentary behaviour among youth,[98] and there is growing evidence that being socially connected with others contributes to adolescent wellbeing.[45] While some evidence exists to show the importance of the built environment for adolescent physical activity and wellbeing, the use of different methods and limited physical variability within any given environment may serve to consistently underestimate the associations observed. In this study, variance is maximised in two ways. Two major cities in New Zealand are sampled, and these data are subsequently combined with nine other countries through the IPEN-adolescent study. The larger study will improve our understanding of the nature of the relationships that exist between adolescent physical activity, sedentary behaviour and body weight with specific features of the built environment related to walkability, commuting and access to facilities for recreation.

Individuals (or at least parents) may self-select neighbourhoods; therefore, associations between built environment and walkability may in part be a reflection of neighbourhood self-selection bias. Mixed results have been found when investigating neighbourhood self-selection and walkability.[99–103] The relationship is a complex one and prospective studies are needed to study the effects of neighbourhood self-selection on neighbourhood walkability. When reviewing 38 empirical studies that used different approaches to explore the influence of self-selection, Cao *et al*[104] established that all studies reviewed found a statistically significant influence of the built environment after accounting for self-selection. While exploring this particular relationship is not the focus of the present study, parents' neighbourhood preference and self-selection will be accounted for in the analysis. As aforementioned earlier, parents will be asked to rank the importance of a variety of reasons for choosing to reside in the particular neighbourhood. The reasons (that address self-selection) could be: easy access to services, walkable environment and/or access to recreational and sporting facilities. This information will be used in the analysis.

When conducting spatial analyses on aggregated data, errors affecting the validity of results may be introduced.[105] The problem has been referred to as the Modifiable Areal Unit Problem defined as the 'geographic manifestation of the ecological fallacy in which conclusions based on data aggregated to a particular set of districts may change if one aggregates the same underlying data to a different set of districts'.[106] In other words, the way spatial data are aggregated may result in different findings. There has been disagreement in the literature on the best solution for this problem; however, it has been suggested that the only appropriate resolution is to use individual-level data that are geocoded based on residential location.[107] Indeed, our selection strategy uses geocoded data and we are employing techniques (GPS and VERITAS) to gain a more accurate understanding of neighbourhood boundaries for youth. This will substantially advance our knowledge in this field.

This study will contribute to national and international scientific knowledge by forming the NZ arm of the international IPEN-adolescents collaboration, whereby adolescents' physical activity and sedentary behaviour data are collected using a common methodology across multiple countries (Australia, Belgium, Brazil, China, Denmark, Malaysia, New Zealand, Portugal and the USA). Furthermore, the larger study will improve our understanding of the nature of the relationships that exist between adolescent physical activity, sedentary behaviour and body weight with specific features of the built environment related to walkability, commuting and access to facilities for recreation.

Ultimately, by showing the relationships between health outcomes and the neighbourhood built environment, we aim to influence and inform policy and city planning practices. City planners, policy makers and government agencies will be engaged early.[108 109] Results will also be shared with other sustainable transport advocacy, urban planners and public health organisations. Dissemination of findings to NZ secondary schools and students themselves will maximise the potential impact of the findings.

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