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ORIGINAL RESEARCH

Advancing Science and Policy Through a Coordinated International Study of Physical Activity and Built Environments: IPEN Adult Methods

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***Background*:** National and international strategies to increase physical activity emphasize environmental and policy changes that can have widespread and long-lasting impact. Evidence from multiple countries using comparable methods is required to strengthen the evidence base for such initiatives. Because some environment and policy changes could have generalizable effects and others may depend on each country's context, only international studies using comparable methods can identify the relevant differences. ***Methods*:** Currently 12 countries are participating in the International Physical Activity and the Environment Network (IPEN) study. The IPEN Adult study design involves recruiting adult participants from neighborhoods with wide variations in environmental walkability attributes and socioeconomic status (SES). ***Results*:** Eleven of twelve countries are providing accelerometer data and 11 are providing GIS data. Current projections indicate that 14,119 participants will provide survey data on built environments and physical activity and 7145 are likely to provide objective data on both the independent and dependent variables. Though studies are highly comparable, some adaptations are required based on the local context. ***Conclusions*:** This study was designed to inform evidence-based international and country-specific physical activity policies and interventions to help prevent obesity and other chronic diseases that are high in developed countries and growing rapidly in developing countries.

***Keywords*:** walking, walkability, pooled analyses, global, urban

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Physical inactivity is estimated to be the fourth leading cause of death in the USA[1] and worldwide.[2] International[3] and national strategies[4] to increase physical activity emphasize environment and policy changes that can have widespread and long-lasting impact. Intervention strategy recommendations are generally based on ecological models that take into account multiple levels of influence (eg, individual and social as well as environmental and policy) on different domains of physical activity (eg, leisure, transport) in different settings (eg, home, work, neighborhood).[5] Environment and policy interventions need to be guided by evidence. Good quality evidence to guide international action is lacking, because studies have only assessed a limited range of environments within countries and little international data has been collected.

Studies in developed countries have identified consistent environmental correlates of physical activity, especially when the environment is measured objectively using Geographic Information Systems (GIS).[6] As documented in numerous reviews, neighborhood walkability (a construct that includes intersection density, mixed land use, and residential density) and access to recreation resources (such as parks, recreation centers and programs) have been related to overall physical activity and to walking for transportation and recreation.[7–14] Perceptions of environments measured by surveys also have been associated with physical activity, in some cases providing explanatory power additional to that of objective measures.[15,16] Neighborhood aesthetics, perceived safety from crime, and fewer traffic hazards have been less consistently associated with more overall physical activity and walking.[7,8] In some countries, access to activity-supportive environments varied significantly by neighborhood disadvantage.[17–19]

Most studies of built environments have been conducted in the USA, Australia and Western Europe, with recent studies extending findings to Japan,[20] Colombia,[21] and Brazil.[22–24] Though the results have been mostly consistent, common methods were not employed, self-report measures of physical activity and environmental attributes dominated, and the limited variability in environmental exposures and physical activity within countries may have underestimated the strength of association. The 11-country International Prevalence Study that included common methods and a wide range of environments[25] found stronger associations with physical activity, compared with single-country studies that have limited variability.[9,10] Despite the strengths of the 11-country study, it was limited by not having objective measurement, the brevity of its self-report measures of physical activity and environmental factors, and by a design that did not maximize environmental variability within and across countries.

Methodological and technical advances now make it possible to conduct significantly improved international studies that allow comparisons across countries. Objective GIS measures of environments and accelerometer-based measures of physical activity are feasible for large-scale application in many countries.[26–28] Objective measures that are not limited by predetermined response scales are particularly important in an international study where social norms could reduce variation or increase bias in self-reports. For example, perceptions of safety are reported in the context of expected norms. Because of the specificity of associations between environmental attributes and domains of physical activity and the emerging sedentary-behavior domain,[22] it is important to apply more detailed self-report measures of physical activity in multiple domains in international studies. By 2004, the use of a common protocol, with state-of-the-science measures and methods to maximize variability in environments was shown to be feasible in the USA,[29] Australia,[30] and Belgium.[31] These methodological advances set the stage for a coordinated international study with high quality measures.

International evidence about the built environment and physical activity could inform international and national policies and guide the implementation of international strategies, such as those from the World Health Organization.[3,32] An international study design which maximizes variance within countries allows countries to present robust evidence at the national level that could inform local policies. Because some environment and policy associations could generalize across countries and others may depend on each country's context, only international studies using comparable methods can identify the relevant differences. Such findings could inform evidence-based international and country-specific interventions to increase physical activity that could help prevent obesity and other chronic diseases that are high in developed countries and growing rapidly in developing countries.[33]

The purpose of the present article was to describe the methods of the IPEN (International Physical activity and the Environment Network) Adult study, which aims to use common methods to collect physical activity and built environment data in environmentally- and culturally-diverse countries and to maximize the variance in the built environment within and across countries. This study will not only improve estimates of the strength of relationships of built environment attributes with domain-specific physical activities, sedentary behaviors, and obesity, it will improve our understanding of the nature of such relationships across a broad continuum of environmental attributes related to community walkability, access to recreation facilities, and social contexts. We describe the research design, common measures, and strategies used to establish quality control and data comparability for the IPEN study, including plans for pooled analyses.

The IPEN Adult Study: Development, Aims, Design, and Methods

Development

Preliminary Studies. Preliminary study findings supported the feasibility and value of a comprehensive international study. In the 11-country study, people with the most favorable built environments were twice as likely to meet physical activity guidelines as those living in the least-favorable neighborhoods.[25] The USA study found objectively measured total physical activity, as well as reported walking for transportation and leisure, were significantly related to neighborhood walkability.[29] The built environment was related to total physical activity and walking for transportation even after adjusting for demographics and psychosocial variables.[34] The Australian study[30] found that adults living in high-walkable neighborhoods did more walking for transport compared with those living in low-walkable neighborhoods, but there were no such differences for walking to recreation. Results of the Belgian study showed that high-walkable neighborhood residents reported more transport-related walking and cycling, more recreational walking, and less motorized transport than low-walkable neighborhood inhabitants. Also accelerometer-assessed moderate-to-vigorous physical activity was higher in high-walkable neighborhoods[30]. In further analyses examining associations of environmental perceptions with physical activity and sedentary time across these 3 countries using pooled analyses, some generalizable associations were revealed. However, several country-specific associations also appeared, confirming the need for international studies, including a broad range of environmentally- and culturally-diverse countries, to fully understand the complex associations between the built environment and health behaviors.[35,36] These findings demonstrated that methods could be comparably applied across countries and that associations varied in their strength and relationship to different outcomes. Studies from several other countries have been published, demonstrating the international relevance of built environments to physical activity but revealing somewhat-discrepant results that can only be resolved through international studies with comparable methods.[22,24,37]

Establishing an International Network. Before proposing an international study, we first developed an international network to assess interest and build capacity for conducting a comparable study across countries. The first 3 studies in the USA, Australia, and Belgium which had successfully implemented a common study design and measures were the basis for the network and demonstrated that common methods were feasible in an international context. The IPEN network was established in 2004 to support investigators in applying for funding in their own country to translate and adapt common measures. A website was created to share materials and methods, and several hundred investigators from over 50 countries joined the network. There was widespread agreement among network members to participate in the collection of physical activity and built environment data using common methods in countries with a wide range of physical activity and environmental attributes, to coordinate data collection and implement quality control procedures to ensure comparability of measures, and to pool the data for analyses. It was clear that the countries involved would be able to provide dramatic variability in physical activity levels and domains (particularly variation in walking and cycling for transportation) and variability in built environments.

Developing the International Study Framework. A study design that ensured high environmental variability within countries would yield 2 important benefits: 1) improved ability of the contributing countries to find associations within their own country and inform national policy, and 2) a continuum of walkability overlapping across countries so that a country "dummy variable" would not explain the differences. Although several investigators were interested in studying children and older adults, it was decided to focus initially on adults only, as the methods and studies in this population were most established. The investigators based in the USA took the lead on a grant application and in 2009 received funding from the National Institutes of Health, National Cancer Institute to coordinate the IPEN study.

In the time that it took to secure this funding, investigators in several countries had translated the IPEN study materials and were testing them in pilot studies. Other investigators had received full or partial funding from within-country sources to conduct an IPEN study. Some studies, therefore, were commenced or completed without the oversight of the IPEN coordinating center. Thus, the present paper outlines deviations from protocols that may threaten the quality of the data, deviations that naturally occur with cultural adaptation, and methods used to ensure that only comparable and quality data are entered into analyses.

IPEN Study Aims

The primary aim of the IPEN study was to estimate strengths of association between detailed measures of the neighborhood built environment with leisure physical activity, walking/cycling for transportation, and BMI in all participants, based on self-report survey data collected according to a common protocol. The secondary aims of the IPEN study examined the same questions as the primary aims, but used objective measures in a smaller sample of participants:

1. To estimate strengths of association between detailed self-report measures of the built environment, based on standardized surveys, with total physical activity, based on objective monitoring with accelerometers.
2. To estimate strengths of association between detailed individual-level objective measures of the built environment around each participant's home address, using 1000m and 500m network buffers created in GIS, with self-reported overall leisure physical activity and walking (and cycling) for transportation.
3. To estimate strengths of association between detailed measures of the built environment using GIS, with BMI and total physical activity, measured objectively with accelerometers
4. To create indices of self-reported measures of mixed land use, neighborhood walkability, access to recreation facilities and public transportation, aesthetics, traffic safety, and crime safety, that optimize explanation of physical activity and BMI in pooled analyses, so these indices can be recommended as international standards of measurement.

Participating IPEN Countries

The 3 main criteria for countries to be contributors to the IPEN primary pooled analyses were as follows:

1. Data were collected from adults (20–65 years of age) residing in neighborhoods selected systematically to vary in walkability and, if possible, in income. (Not all countries had access to census data that included neighborhood level income information). Neighborhoods (clusters of contiguous administrative units) were first identified to maximize variability in walkability; then, participants were selected from within those neighborhood areas. The areas were comprised of smaller administrative units, like census collection districts or census block groups, so that walkability could be assessed to truly reflect the proximal area around the home. A minimum of 12 neighborhoods was required, half representing low walkability, half representing high walkability
2. At least 500 participants completed core built environment and physical activity surveys
3. At least 250 participants wore accelerometers for a 7-day period.

Investigators were selected for the IPEN study based on their ability to collect the data (which included investigator experience, funding availability, completed pilot work and having translated IPEN materials) and diversity of their geographic location. Participating countries are from North America, Europe, the Antipodes, South America, and Asia: Australia (AUS), Belgium (BEL), Brazil (BRZ), Colombia (COL), the Czech Republic (CZ), Denmark (DEN), Hong Kong (HK), Mexico (MEX), New Zealand (NZ), Spain (SP), the United Kingdom (UK), and the United States of America (USA). Table 1 outlines the variation in environments and key economic and health indicators in each participating country. Obesity rates ranged from 8%–48%, population density ranged from 2.8 to 6349 residents per square km, GDP per capita ranged from US$9,200 to US$46,400, and activity levels ranged from 25%–70% of adults classified as high active. Not only did the countries provide a range in neighborhood density and income but they also provided examples of environmental attributes not available in other countries; for example pedestrian-only centers in Europe, cul-de-sacs in USA, and "ciclovias" and Bus Rapid Transit systems in Latin America.[38] This first stage of IPEN funding had to focus on mostly developed countries where investigator experience and GIS data were strong. Additional countries with body mass index (BMI) data only may be included in future analyses, and we are trying to support investigators in Nigeria, Malaysia, and Bangladesh to adapt environment measures to their countries.

IPEN Study Design

Overview. The IPEN study is an observational, epidemiologic, multicountry, cross-sectional study. Participants were selected from neighborhoods chosen to maximize variance in neighborhood walkability and SES (in most countries). The goal of the study design was to have equal numbers of neighborhoods stratified as follows: high walkable/higher SES, high walkable/lower SES, low walkable/higher SES, and low walkable/lower SES. For selection of study neighborhoods, most countries used a neighborhood walkability index that was measured objectively with GIS data at the smallest administrative unit available. A neighborhood walkability index for the whole area of study was first developed.[6] Then, neighborhoods with lower and higher index scores were selected (see Neighborhood Selection section). Adults living in the selected neighborhoods were contacted and invited to complete surveys on their physical activity and perceptions of the environment. In most studies, participants were recruited over time equally from all neighborhood types to control for seasonal variability (see Recruitment section). Subgroups of participants wore accelerometers for 7 days to objectively measure physical activity, and individual-level walkability index scores and access to recreation facilities were created in GIS, based on a 500-m and 1000-m network area buffers around participants' individual residential addresses (see Measures section below). The neighborhood index was designed to provide variability at the neighborhood selection and recruitment stage, and the individual index more accurately reflected the neighborhood around each participant.

Neighborhood Definitions and Selection. The smallest administrative unit that represented a neighborhood-level geographic scale was selected for the development of the walkability measures for neighborhood selection. In Table 2, the unit for neighborhood selection is

Table 1 Study Details and Summary Statistics for 12 IPEN Study Countries to Demonstrate Range of Across-Country Variability

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
Principal investigator	Owen	De Bourdeaudhuij	Reis	Sarmiento	Frömel & Mitáš	Troelsen	MacFarlane & Cerin	Pratt	Schofield	Guillen-Grima	Davey	Sallis
Funding sources in addition to NCI IPEN grant	National Health and Medical Research Council of Australia; Queensland Health	Ghent University research grant	Ponticia Universidade Catolica do Parana	Universidad de los Andes; Colciencias grant 519-2010	Research grant from Ministry of Education, Youth & Sports of the Czech Republic	Municipality of Aarhus	2 grants from Research Grants Council of Hong Kong	CDC Foundation	Health Research Council of New Zealand	Navarra Dept of Health	Medical Research Council	National Heart, Lung, & Blood Institute
Study name	PLACE	BEPAS	E.S.P.A.C.O.S.	Ambientes Físicos Construidos, Actividad Física y Calidad de Vida en adultos de Bogotá	Research of physical activity, lifestyle, obesity and environment	DEPAS	NA	Mexican Physical Activity and Built Environment Study	URBAN	IPEN Spain; Influence of environment on human behavior	Socio-Ecological Mapping of Physical Activity Behaviors & Health Outcomes in Deprived Inner-City Communities	NQLS
Study specific publications	[16,39,79–88]	[31,89–91]	[23]	[21,41,92]	[42]	NA	[55,93,94]	NA	[61]	NA	[95–98]	[6,29]
GDP per capita in US dollars[99]	38,800	36,600	10,200	9,200	25,100	36,000	42,700	13,500	27,300	33,700	35,200	46,400
Obesity rates % BMI 30+[100]	Males: 19.3; Fem: 22.2	Males: 14.8; Fem: 10.7	Males: 12.4; Fem: 24.5	Males: 19.6; Fem: 26.1	Males: 20.2; Fem: 22.1	Males: 12.0; Fem: 8.3	Males: 31.0; Fem: 15.4 (BMI 25+)	Males: 30.1; Fem: 41.0	Males: 28.9; Fem: 39.9	Males: 17.3; Fem: 17.3	Males: 23.7; Fem: 26.3	Males: 44.2; Fem: 48.3
IPS data (% high active)[25,101–103]	58.6	29.6	24.6	52.7	62.9	70.4	34.1	66.4	63.1	39.6	66.4	62.0
Population per sqkm[104]	2.8	344.2	23.8	39.9	132.1	130.0	6348.6	57.9	15.9	81.3	253.3	33.9
Car ownership per 1000 population[105]	619	486	156	67	399	408	128	209	560	479	458	842

Table 2 Neighborhood (NH) Selection Criteria for 12 IPEN Countries

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
Cities/ regions	Adelaide	Ghent	Curitiba	Bogotá	Olomouc & Hradec Králové	Aarhus	Hong Kong	Cuernavaca	North Shore, Waitakere, Wellington, & Christ-church	Pamplona	Stoke on Trent	Baltimore, Maryland Seattle, Washington
# neighbor-hoods/areas/ census units	32 NH / 156 districts	24 NHs	32 census tracts	30 NHs	62 NHs	16 districts	32 tertiary planning units	32 Census tracts	48 NHs & 261 Meshblocks	Over sampling in different build dates	16 Lower Super Output Areas	32 NHs & 219 block groups
Walkability administra-tive unit	Census Collection Districts	Statistical sectors	Block group	Block group	Urban districts	Smallest statistical sectors	Tertiary Planning Units (TPUs)	Census Tracts	Meshblocks	NA	Output Areas	Block group
Walkability index details	GIS: 5 land uses, intersec-tion density (unweighted), net residen-tial density, net retail area	GIS: Intersection density, residential density Observations: land uses; No retail FAR	GIS: 5 land uses, intersec-tions density (unweighted), residential density; No retail FAR	GIS: 18 land uses, intersec-tion density (unweighted), residential density, retail FAR	GIS: 7 land uses, intersec-tion density (weighted), residential density, retail FAR	GIS: 5 land uses, intersec-tion density, residential density, retail FAR	GIS: Inter-section density (unweighted), residential density; No land Use or retail FAR	GIS: 5 land uses, intersec-tion density (weighted), residential density, retail density	GIS: 5 land uses, intersec-tion density (unweighted), net residen-tial density, retail FAR	Observa-tions: Pedes-trian only old town, modern high density down town, sub-urbs	GIS: 5 land uses, intersec-tion density (unweighted), residential density; No Retail FAR	GIS: 5 land uses, intersec-tion density (weighted), net residen-tial density, retail FAR
Walkability criteria	Possible score 4–40 (1–10 for each component); 1st quartile = low, 4th quartile = high	1st, 2nd, 3rd, 4th (low), 7th, 8th, 9th, 10th (high) deciles	2nd-3rd (low) and 8th-9th (high)	GIS derived walkability index; Median split	1st, 2nd, 3rd, 4th (low) 7th, 8th, 9th, 10th (high) deciles	GIS derived walkability index; Median split	GIS derived walkability index; High = 6.0–0.8 with mean = 3.0; range for Low = –1.9 to –1.5 with mean = –1.8)	GIS derived walkability index; Median split	GIS derived walkabil-ity index; Partitioned into tertiles. Middle walk-ablity tertile excluded.	Build date & pedestrian only areas	16 neigh-borhoods based on GIS derived walk-ability index; All quintiles represented	first, 2nd, 3rd, 4th (low), 7th, 8th, 9th, 10th (high) deciles of WI (–1.29 to –8.28 in Seattle ; –1.57to –8.17 in Baltimore)

(continued)

Table 2 *(continued)*

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
SES criteria	Median HH income	Median HH (excluding outliers of <€11600 and >€116000); lowest 4 deciles & highest 4 deciles	Mean HH income	SES index including HH income/ month, car ownership, education; low (strata 1–2), medium-high (strata 3–5);	SES index including: income, level of education, ownership of housing, car, computer, telephone, employment status; High = 30+ points; Low £ 30 points	Median HH; median split	Median household income (below HK$10,000/ month = low; above HK$25,000/ month = high) High SES: >50% High & <15% Low HHs; Low SES: <30% High and >25% Low HHs.	Low: 1–4, high 6–10; out of 12 SES govern- ment defined levels by Census Tracts (levels 11 and 12 were excluded due to inaccessi- bility to such neighbor- hoods)	% Maori population partitioned into tertiles. Middle tertile excluded.	NA	16 NHs based on Index of Multiple Deprivation: (all high deprivation NHs, deciles 1–6)	2nd, 3rd, 4th (low) 7th, 8th, 9th (high) deciles of HH income for region ($33,107– $88,705 in Seattle & $26,337– $94,796 in Baltimore)
Additional criteria	NA	NA	NA	Slope, public transit, parks; average slope (£ 10% and > 10%); proximity to TransMilenio bus system (£ 500 meters and > 500 meters); public-park provisions (< 6% of total land devoted to parks; > 6% of total land devoted to parks).	Prefabricated block of flats, historical city centers, newly built apartments, & outskirts of city	NA	Only TPUs that have more than 50% Chinese speaking households were included	Blocks immediately proximal to a different census tract with another Walkabil- ity and/or SES were excluded	NA	NA	NA	NA

(continued)

Table 2 *(continued)*

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
# participants per NH (actual or expected)	Low walk/ low SES = 535; Low walk/high SES = 634; High walk/ low SES = 481; High walk/high SES = 544	Low walk/ low SES: 288; Low walk/high SES: 295; High walk/ low SES: 290; High walk/high SES: 293	22 per census tract; 176 in each SES x Walkability cluster	Low walk/ low SES 300; Low walk/ high SES: 139; High walk/low SES: 261; High walk/ high SES: 300	Low walk/ low SES: 115; Low walk/high SES: 207; High walk/ low SES: 176; High walk/high SES: 270	Low walk/low SES 121; Low walk/high SES: 178; High walk/ low SES: 161; High walk/ high SES: 182	15	32 census tracts, 7 blocks per census tract, 3 households per block, 1 participant per household; 168 in each SES x Walkability cluster	42 HH per NH; 1 adult, 1 child per HH; 12 NH (3 per city) in each walkability by Maori quadrant	Low walk/ low SES: 293; Low walk/high SES: 365; High walk/ low SES: 101; High walk/high SES: 145	N = 761 by deprivation (588 20-65 yrs); N = 372 by walkability (255 20-65 yrs)	Range per NH is 45-104; Low walk/low SES =533; Low walk/ high SES =566; High walk/Low SES = 527; High walk/ high SES =573

Abbreviations: HH, household; GIS, geographic information system; WI, walkability index; SES, social economic status; NA, not applicable; TPU, tertiary planning unit; NH, neighborhood; LSOA, Lower Super Output Areas; ACC, accelerometer; IPAQ, International Physical Activity Questionnaire; QOL, quality of life; WHO, World Health Organization; abbrev, abbreviated; PA, physical activity.

identified for each country. For every administrative unit across the study cities or regions, a walkability index was derived as a function of at least 2 variables: a) net residential density (ratio of residential units to the land area devoted to residential use); b) land use mix (diversity of land use types per block; normalized scores ranged from 0–1, with 0 being single use and 1 indicating an even distribution of area across several types of uses—eg, residential, retail, entertainment, office, institutional); and c) intersection density (connectivity of street network measured as the ratio of number of intersections with 3 or more legs to land area of the administrative unit). In 5 countries, retail floor area ratio (FAR) was also employed as a proxy for pedestrian-oriented design. The walkability index is described in more detail elsewhere.[6,39]

For neighborhood selection, standardized scores for each measure were calculated separately for each city in each country, so that residential areas could be selected to maximize the variability within countries. In the USA, the walkability index used for block group selection was a weighted sum of z-scores of the 4 normalized urban form measures as stated in the following expression (some countries did not double-weight intersection density):

$$\text{Walkability} = [(2 \times \text{z-intersection density}) + (\text{z-net residential density}) + (\text{z-retail floor area ratio}) + (\text{z-land use mix})].$$

Administrative units were ranked and divided into deciles or quartiles based on the normalized walkability index for each city and household-level income data from the census. Four groups of residential areas were determined: high walkability–high income; high walkability–low income; low walkability–high income; low walkability–low income. Administrative units in the bottom 4 and top 4 deciles represented "low-" and "high-walkable" categories, respectively. In the USA, the second, third, and fourth deciles constituted the "low income" category and the seventh, eighth, and ninth deciles made up the "high income" category. The fifth and sixth deciles were omitted to create separation between the categories.

Table 2 outlines the neighborhood-selection techniques employed in each country. The main deviations in the walkability index were 1) countries were not able to obtain retail floor area data, 2) some countries did not double-weight intersection density, 3) numbers of land use categories varied, 4) some countries were unable to obtain neighborhood-level income data, and 5) some countries selected neighborhoods based on variation across quartiles rather than deciles. One country, Spain, did not use GIS-based data to select neighborhoods, but based their selection on construction date, which has also been associated with walkability.[40]

Additional adjustments were made to neighborhood selection criteria to reflect specific conditions in some countries. For example, in Bogotá, Colombia, access to transit and slope are strong correlates of walking for transport[41] so these were considered as stratifying variables in their neighborhood selection process. In the Czech Republic, types of residential buildings were included in the selection process, as these varied across walkability but were also strongly independently related to walking.[42]

Participant Recruitment. Table 3 outlines the participant recruitment techniques and response rates across countries. The required recruitment strategy was systematic selection of participants with addresses in the chosen neighborhoods. About half the countries recruited and conducted data collection by phone and mail, and half the studies contacted households in person. Databases of resident addresses from commercial and government sources were used for the phone and mail recruitment. For the in-person recruitment, standard procedures for identifying households and participants within a household were employed (eg, every *n*th house was selected and residents with the most recent birthday were recruited).[43] In Hong Kong, intercept interviews were conducted in residential areas where individual addresses were not available, for example in large apartment buildings. Some countries used monetary incentives, and some provided nonmonetary incentives including feedback on physical activity.[44]

The IPEN requirement was a minimum of 500 participants with survey data in each country while maximizing the number of neighborhoods. Larger studies provided more than 2000 participants. Sample size variations and neighborhood clustering of participants will be accounted for in the statistical models (see Analysis section below).

Measures

The required core measures were the International Physical Activity Questionnaire (IPAQ) long form and the Neighborhood Environment Walkability Scale, Full or Abbreviated (NEWS-A). Other measures were recommended and were only collected in some countries. For these, subsample analyses will be performed. Accelerometer data collection was considered a secondary aim because a) it does not provide the specificity of physical activity domains central to achieving the study aims, b) it is more challenging and costly to collect than surveys, and c) it was not expected that every country would have the ability to collect these data. We acknowledged that individual-level environment data based on a GIS buffer around each participant's home address (more detailed than the aggregate neighborhood selection procedures) was also more challenging, so this was also not required. Encouragingly, only one country did not collect accelerometer data and another was not able to access GIS data. A few countries collected observation or audit data on neighborhood attributes. Measures used in each country are summarized in Table 4.

Physical Activity Measures

Self-Reported Activities (Required). The 31-item IPAQ long form is a comprehensive assessment of physical activity in four domains: work, household,

Table 3 Recruitment Methods Across 12 IPEN Countries

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
Dates	2003–2004	2007–2008	2010	2010–2011	2009–2011	2011	2007; 2011	2011	2007–2010	2010	2007; 2009	2002–2003; 2003–2005
Season	Equal across N all seasons; Equal across NHs	All seasons; Not equal across NHs	Spring	No seasons; Not equal across NHs	All seasons; Equal across NHs	Spring	All seasons; Equal across NHs	Spring/ Summer/ Fall (Equal across NHs)	All seasons; Not equal across NHs	Winter, Spring, Summer; Equal across NHs	Summer	All seasons; Equal across NHs
Participant identification	Australian Bureau of Statistics (ABS) Census data & GIS databases	Public Service of Ghent selected random sample within NHs	Address registry	Participants from NHs in previous study	GIS data from address points database	Through municipality records & personal identification numbers	Randomly selected buildings within NHs. Residents of selected buildings were invited to enroll via mail or recruited by RAs	Randomly selected buildings within NHs from database of the National Institute of Geography and Statistics.	GIS points & routes	Through health centers	Random selection of HHs within 16 LSOAs using post code address file	Telephone #s from commercial company
Participant selection by Household (HH)	Random sample of HHs	Random sample of HHs (300 per NH)	Random sample of HHs; random selection within HH.	Random sample of HHs; Oversampling of men	Random sample of HHs, person with nearest birthday	Random sample of persons.	Convenience	Random sample of HHs; random selection within HH.	Random sample of HHs	Random sample of HHs	Random sample of HHs; random selection within HH.	Random sample of HHs, many NH used all available records

(continued)

Table 3 *(continued)*

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
Contact mode: In person/mail/ phone	Mail	In person/mail	In person	In person	In person	Mail/phone	Advertise- ments, & targeted mailing	In person	In person	Mail	In person/mail	Mail/phone
N participants [total & acceler- ometer (ACC)]	2650	1200; 1166 ACC	704; 327 ACC	1000 (expected); 254 ACC	820; 600 ACC	600 (expected); 250 ACC	500; 301 ACC	672; 350 ACC (expected)	2031; 1233	900; 349 ACC	843; 194 ACC	2199; 2121 ACC
Incentives	$1 lottery ticket for enrolling; $1 lottery ticket for completion & entered to win one of 5 $300 grocery vouchers	Feedback to participants on accelerometer results	None	Feedback to par- ticipants and umbrella or bag ($5 value)	Feedback to participants & pedom- eters www. INDARES. com	Feedback to par- ticipants on accelerom- eter results; $100 lottery plus $200 lottery after ACC mea- surement	Lottery for $300HK, and after ACC mea- surement, $200HK super- market voucher, plus some activity feedback	$8 dis- count coupon or gift card	None	None	$20 for mail survey	$20 & $30
Age range	20–65	20–65	20–65	20–70	20–65	20–65	18–65	20–65	20–65 & 3–12	20–65	16–94	20–65

Abbreviations: HH, household; GIS, geographic information system; WI, walkability index; SES, social economic status; NA, not applicable; TPU, tertiary planning unit; NH, neighborhood; LSOA, Lower Super Output Areas; ACC, accelerometer; IPAQ, International Physical Activity Questionnaire; QOL, quality of life; WHO, World Health Organization; abbrev, abbreviated; PA, physical activity.

Table 4 Survey Methods and Content Across 12 IPEN Countries

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
Administration mode	Mail	In person	In person	In person	In person	Online	Mail	In person	In person	Mail	In person/ mail	Mail/Online
IPAQ long mode	Self report	Interview	Interview: only transport PA, leisure PA & sedentary behaviors	Interview: only transport PA, leisure PA & sedentary behaviors	Self report	Self report	Self report	Interview: only transport PA, leisure PA & sedentary behaviors	Interview	Self report	Interview/ self report	Self report
Sedentary activities (eg, TV watching, commuting)	Yes		Yes	Yes	Yes	Yes	Yes	Yes		Yes		Yes
NEWS (full or abbreviated), administration mode	Full, self report	Full, self report	Abbrev, interview	Abbrev, interview	Abbrev, self report	Abbrev, self report	Abbrev, interview & self report	Abbrev, interview	Abbrev, interview	Full, self report	Abbrev, self report & interview	Full, self report
QoL	SF12	SF12	WHOQOL-8	WHOQOL-8	SF12	SF12	SF12 (in subsample)	Yes	NA	SF12	SF12v2	SF 12
Psychosocial	Self efficacy, Barriers, Benefits, Social support, Enjoyment	Benefits, Social support, Attitude, Modeling, Social norm	Self efficacy, Social support, Enjoyment, PA Intention	Social support, Enjoyment	NA	Barriers, Benefits, Social support & Attitude/ motivation for PA.	Self efficacy, Barriers, Social support	Social support, Enjoyment	Barriers, Social support	Self efficacy, Barriers, Social support	Stages of change	Self efficacy, Barriers, Benefits, Social support, Enjoyment
BMI (measurement mode)	Self report	Self-report	In person & self report	Self-report	Self-report	Self-report	In person & self-report	In person	In person	Self report	In person & self report	Self report

(continued)

Table 4 *(continued)*

	Australia	Belgium	Brazil	Colombia	Czech Republic	Denmark	Hong Kong	Mexico	New Zealand	Spain	United Kingdom	United States
Other environment measures	Home Environment, Convenient facilities, Self selection, Dog ownership, Places for PA, NH satisfaction, Social Capital, NH preference	Cycling facilities, Home environment-, Convenient facilities, NH Satisfaction	Cycling facilities, Home environment, NH Satisfaction	Cycling facilities, Home environment	Home environment, type of NH, organized PA, Dog Ownership	Home environment, Self selection, Dog ownership, Social Capital	Self selection	Common places for Pa, Convenient facilities, Access to parks	NH preference	Home environment, Convenient facilities, Self selection, Dog ownership, Places for PA,	Social capital	Home Environment, Convenient facilities, Self selection, Dog ownership, Places for PA, NH satisfaction, Social Capital, NH preference, Social Cohesion
Individual demographics (basic = education, marital status,, age, gender, car ownership)	Basic, + # in HH, Children in HH, Ages of children, Type of residence, Home ownership, Length at residence, Drivers license, Income, Born in country, Employment, Years in country	Basic, + Type of residence,, Drivers license, Employment situation	Basic + # in HH, Children in HH, Length in neighborhood, Employment, Years in country, & city	Basic + Length at residence, Income, Employment	Basic + # in HH, Children in HH, Ages of children, Type of residence, Home ownership, Length at residence, Drivers license, Income, Employment	Basic + Race, # in HH, Children in HH, Ages of children, Type of residence, Home ownership, Length at residence, Drivers license, Income, Employment	Basic +Income, Employment	Basic + Time in neighborhood, motorcycle ownership, # in HH, Children in HH, Drivers license, Type of residence, Home ownership	Basic + Race, # in HH, Children in HH, Ages/ genders of children, Type of residence, Home ownership, Length at residence, Drivers license, Income, Employment, Years in country	Basic + Race, # in HH, Children in HH, Ages of children, Type of residence, Home ownership, Length at residence, Drivers license, Income	Basic + Race, Type of residence, Home ownership, Length at residence, Drivers license, Income, Born in Country, Employment, Years in country	Basic,+ Race, # in HH, Children in HH, Ages of children, Type of residence, Home ownership, Length at residence, Drivers license, Income, Born in country, Employment, Years in country
Timing of survey & accelerometer (ACC)	Survey only	Complete survey, then wear ACC for 7 days	Complete survey after wearing ACC for 7 days	Complete survey after wearing ACC for 7 days	Complete survey, then wear ACC for 7 days	Complete survey, then wear ACC for 7 days	Con-current	Complete survey after wearing ACC for 7 days	Complete survey after wearing ACC for 7 days	Complete survey, then wear ACC for 7 days	Complete survey, then wear ACC for 7 days	Complete survey after wearing ACC for 7 days

Abbreviations: HH, household; GIS, geographic information system; WI, walkability index; SES, social economic status; NA, not applicable; TPU, tertiary planning unit; NH, neighborhood; LSOA, Lower Super Output Areas; ACC, accelerometer; IPAQ, International Physical Activity Questionnaire; QOL, quality of life; WHO, World Health Organization; abbrev, abbreviated; PA, physical activity.

transportation, and leisure. A reference period of the 'last 7 days' was used to assess frequency and duration of moderate- and vigorous-intensity activities. Reliability and validity testing was conducted with 2700 adults at 14 data collection sites in 12 countries.[45] Eight-day test-retest reliability for total physical activity was very good with a median intraclass correlation (ICC) of about .80. Criterion validity using ActiGraph accelerometers was acceptable with a median rho of .33. Though there is evidence that IPAQ overestimates physical activity,[46] it was the most appropriate measure for the current study because it provided estimates for all 4 domains.

Objectively-Assessed Activity (Preferred). Accelerometers worn on the hip were used to measure physical activity over 7 days. All countries employed the ActiGraph (Pensacola, FL) accelerometer, except one (New Zealand used the Actical; MiniMitter/Respironics, Bend, OR). Depending on the data collection dates, the ActiGraph models varied. Two countries employed the 7164 and 71256 models, six countries used the GT1M model, and five countries used the GT3X. One country employed the ActiGraph 'ActiTrainer' accelerometer, which is comparable to the GT1M but also measures heart rate. Though different accelerometer models have demonstrated comparability in trials for moderate and vigorous physical activity counts,[47] there appear to be differences at lower intensity levels that have implications for sedentary behavior measures.[48,49] To inform analyses, the accelerometer models are being compared in small studies, and correction algorithms to adjust for accelerometer model as well as for the difference between the ActiGraph and Actical, are being developed. All countries employed a 60-second epoch for storing data. Countries varied in their definition of wearing time, which may impact physical activity outcomes.[50–52] The Coordinating Center processed and conducted reliability checks on the raw accelerometer data to ensure all data were processed using the same scoring parameters. Data were processed using MeterPlus v4.3 (Santech, Inc., www.meterplus-software.com). Scoring criteria included 1) identifying nonwear time as 60 or more minutes of consecutive zero counts, and 2) requiring 10 or more valid hours of wearing time to define a valid day. Differences across countries in required number of valid days will be addressed through statistical adjustment (see analysis section below). A detailed accelerometer protocol guiding the procedures used is available on the IPEN website.[53]

Built Environment Measures

Perceived Neighborhood Environment (Required). Many studies have established the importance of resident perceptions of the neighborhood environment,[8] including the ability to assess concepts not included in common GIS databases, such as aesthetics and safety. Studies also demonstrated that objective GIS measures were not always correlated with residents' perceptions.[15,44] The Neighborhood Environment Walkability Scale (NEWS) and an empirically derived abbreviated version[54] (NEWS-A) assess perceived residential density, land use mix (diversity and access), street connectivity, walking/biking infrastructure, aesthetics, traffic safety, and crime safety. Proximity to both public and private recreation facilities is also measured by the NEWS. Reliability and validity have been documented in several countries.[55–59] Most scales had test-retest reliability ICCs > .75. Each country was encouraged to administer at least the NEWS-A and develop additional items to assess environmental features specific to their country such as pedestrian-only zones. In Belgium, Denmark, Colombia, Mexico, and Brazil, more sophisticated cycling facility items were developed, in part based on the ALPHA European survey.[60] Though additional items cannot be used in the primary pooled analyses, they can be used in analyses with subsets of countries. Other country-specific adaptations included more measures of public transit and different destinations listed in the land use questions to reflect local conditions.

GIS Variables Based on Individual Buffers (Preferred). Environmental variables are being computed in GIS around each individual's home address within street network buffers defined by 500 and 1000 m. Two buffer sizes are being examined because the optimal buffer is not clearly established and may differ by country. In contrast to the neighborhood selection measures that standardized the walkability indices by city to maximize within-country variance, for the individual-level measures a "world standardized" walkability index will be created with scores that are standardized against the full range of scores available from all countries. Analyses will explore whether the relationship between walkability and physical activity remains linear when a full range of environmental variability is available. In addition, the influence of the individual components of the walkability index will be examined separately with raw data, as it is not clear whether all components will continue to operate in the expected direction at all levels of walkability or income. Eleven of twelve countries have GIS data to characterize built environments. Individual countries have previously published detailed methodologies of their approaches.[61] Some countries have additional GIS data on park size and availability, private recreation facilities, public transit access, traffic volume, and pedestrian/cycling facilities. The quality and comparability of GIS measures across countries is being systematically assessed, and available GIS variables and methods to enhance comparability will be reported in a separate methodological paper. Only comparable constructs will be entered into pooled analyses.

Other (Recommended) Survey Measures

Body Mass Index (BMI). In all 12 countries, participants reported their height and weight or had them measured to calculate BMI [kg/m^2].

Psychosocial Measures. For countries that measured them, inclusion of psychosocial variables allows analyses of multiple levels of correlates with outcomes, consistent with ecological models of behavior.[5] Three psychosocial variables were included as optional measures to allow exploration of potential cultural differences related to physical activity that may have independent associations with outcomes or may interact with built environment variables. Self-efficacy, barriers, and social support may reflect cultural differences in beliefs and social behaviors.[62–66] Nine countries collected psychosocial measures.

Quality of Life (QoL). QoL was measured as an exploratory outcome with most countries employing standard items from the SF12[67] or WHO Quality of Life scale.[68] Most often the QoL measures were 1) How would you describe your general health? and 2) How satisfied are you with your life as a whole? Ten countries collected QoL data.

Demographic Variables. Demographic items taken from national surveys were used to assess age, gender, years of education, annual household income, number of people in the household, race/ethnicity, marital status, automobile ownership, and number of years living at this address. The format of demographic variables was often country-dependent and based on legislative requirements or established local standard formats (eg, census race groupings). Some countries did not collect individual income data as this is not considered an appropriate question. 'Years of education' is most commonly used in international studies as a proxy for SES and was required as a minimum for the demographic variables in the IPEN study.

Quality Control And Comparability Methods

All investigators completed the San Diego State University Institutional Review Board training, the NIH Fogarty International Center ethical requirements, and their own country's ethics requirements. All participants provided informed consent for participation in their country-level study. Participant confidentiality for pooled data were maintained by using numeric identification codes rather than names. Address-based GIS variable creation was conducted in each country and no address information was transmitted to the coordinating center. All data transfer used a secure file sharing system.

Quality control procedures were based on written protocols. Manuals, protocols, trainings and consultation were provided to countries on accelerometer data collection, management, and scoring to facilitate common methods for increasing wear-time compliance and standardizing data screening procedures.[53,69] Surveys and back translations (if required) were provided by each country for comparison. Multiple methods were employed to ensure quality and comparability of survey data collected across countries: 1) independent assessment of content comparability of all survey items by at least 2 expert reviewers, 2) examination of data for outliers and invalid responses, 3) documentation and standardization of item-level response coding, and 4) renaming of country-specific variables to a common naming convention for use in IPEN pooled analyses.

A similar process was used to assess the GIS variables. Initially each country completed a formative survey to precisely describe the availability of and access to GIS data in their country and the possibility for specific built environment measures and methodologies. This information was reviewed by expert reviewers at the coordinating center who created a set of GIS variable templates for the purpose of producing comparable variables across countries.[70] The IPEN GIS Templates defined and operationalized a common set of built environment constructs (eg, residential density), variables, procedures, and standardized variable names (templates available at http://www.ipenproject.org/documents/methods_docs/IPEN_GIS_TEMPLATES.pdf). Upon completion of GIS work, countries submit their GIS datasets to the coordinating center along with documentation of the definitions and procedures used. Two experts review variables from each country, judge deviations from the IPEN templates, and only accept comparable GIS measures for the pooled analyses. For measures with acceptable protocol variations across countries, analytical techniques are employed to adjust for potential differences.

Analysis Plans

Due to the multistage sampling strategies used, the IPEN dataset has a hierarchical structure which, in the most complex case, consists of person-level observations nested within administrative (eg, census) units, administrative units nested within neighborhoods, and neighborhoods nested within cities (Table 2). This type of data organization requires the use of statistical methods that can account for the dependency of data collected within specific geographical areas (cities, neighborhoods, and/or administrative units).[71,72] Of the available statistical approaches used to model data with more than two levels of variation, Multilevel Generalized Linear Models with random intercepts and slopes were selected.[72] This modeling approach has several advantages. First, it can estimate between-city and between-neighborhood variability in outcomes and associations (eg, how much does the effect of access to recreational facilities on physical activity vary across neighborhoods and cities?), and identify factors contributing to such differences (eg, what explains neighborhood- and city-level differences in effects of access to recreational facilities on physical activity?). Second, it can model different types of data (eg, continuous, binary or multinomial outcomes) with normal and nonnormal distributional assumptions.[73] Third, unlike other methods for clustered, hierarchically organized data, this approach performs relatively well even when the number of observations across geographical area is highly unbalanced,[74] which is particularly relevant to this project as the participant numbers across cities and neighborhoods, and neighborhood numbers across cities vary substantially.

In principle, the models will be set up so that administrative units, neighborhoods, and cities represent first-, second-, and third-level clusters, respectively. Cities rather than countries will be the highest level of clusters since most countries have available data from a single city (Table 1). The models will provide estimates of area-specific effects. This means that the point estimate of a regression coefficient will represent the association of a variable with the outcome in the 'average' city or neighborhood, while estimation of between-city or between-neighborhood variability in the regression coefficient will subsequently permit the computation of city- or neighborhood-specific associations. Associations will be simultaneously estimated at the within- and between-area levels, as their magnitude may differ.[72] This type of approach will minimize potential problems associated with pooled analyses of studies with different sample sizes. Given the relatively small number of cities included in the study (approximately 19), the linear models will be estimated using Restricted Maximum Likelihood or Bayesian Markov Chain Monte Carlo methods with noninformative priors.[75] The latter approach provides the most robust estimates of regression coefficients and their variability when the outcome is binary (eg, overweight/obese vs. normal weight; sufficiently vs. insufficiently active)[75,76] or nonnormally distributed.[73]

All models will be adjusted for quantifiable differences in between-study methods contributing to confounding effects. These may include neighborhood size, walkability components used for neighborhood selection, whether socioeconomic status was used as a neighborhood selection criterion, survey-administration method, participation incentive (yes vs. no), accelerometer wear time, and seasonality.

DiscussionThe public health significance of studies of built environments, physical activity, and obesity rests on the consensus that lack of consideration of the health effects of decisions in the urban planning, transportation, and park and recreation sectors have contributed to epidemics of physical inactivity, obesity, and chronic diseases.[3,32,77] International[3,32] (Global Advocacy for Physical Activity: www.globalpa.org.uk) and national[4] (Australian Heart Foundation: www.heartfoundation.org.au; Canada Heart and Stroke Foundation: www.heartandstroke.ca; US National Physical Activity Plan: www.physicalactivityplan.org; US Guide to Community Preventive Services: www.thecommunityguide.org/index.html) intervention strategies for physical activity promotion and obesity control recommending environmental change have created the need for evidence to justify and guide major policy changes. A strong evidence base for such policy changes will be required because of the cost, the implications for traditional planning practice, and powerful opposition against actions that reduce the priority of the car for transportation.[78] Before 2000 there were few studies of built environments and physical activity, and the emergence of interdisciplinary collaborations, new measures of environmental attributes, and appropriate designs for built environment studies created an opportunity to coordinate the use of common measures and methods across countries. The need to examine the full range of environmental variation to ensure accurate estimation of effect sizes is a specific rationale for international studies. IPEN was developed to create comparable datasets around the world whose pooled results could inform international policy and country-specific results could inform national policy. Currently, 12 countries are participating in the IPEN study, approximately 14,119 participants will provide self-report survey data on built environments and physical activity, and 7145 participants are likely to have accelerometer data. Additional countries may be able to join the study before analyses. Already, Brazil,[23] Australia,[30] UK,[61] Belgium,[57] and the USA[29] have published findings from their IPEN supported studies and are contributing to scientific advances. In particular, a three country comparison has demonstrated that the relationships between the built environment and physical activity and sedentary behavior vary somewhat across countries.[35,36]

Capacity building over several years was required to lay the foundation for a coordinated international study. As a network, IPEN has provided support to hundreds of investigators from developed and developing countries through posting of methods, sharing of grant proposals, and training in state-of-science measures in a new field of study. IPEN provided capacity building in areas of the world where physical activity and environment research was only starting to be developed. The IPEN website has been well used. Many investigators who are not participating in the coordinated study are using some of the methods and measures promoted by IPEN. Investigators who received direct or indirect support from IPEN are already presenting and publishing their results.[22,24,31]

Limitations

Though it can be considered a success that several investigators received internal funding for their IPEN study before the coordinating center was able to support quality control procedures, this resulted in deviations from the study design and measurement protocols. While neighborhood selection methods varied in components used in the walkability index, neighborhood selection criteria were designed to maximize variability in the built environment, and this primary goal has likely been achieved. There were also variations in incentives, recruitment mode and methods, data sources for addresses, and sample sizes across countries. We will compare recruitment rates across neighborhood types and countries and control for such variations in the analyses, as well as sample size. Survey and GIS variables will be compared by independent raters, and only data from countries with comparable constructs will be included in pooled analyses. This may result in different sample sizes for different research questions. Differences in survey administration mode will be controlled for in the statistical models. The accelerometer data will be standardized with comparable nonwear time criteria and data processing. Variations in participant wear time will be controlled for in the analyses, and differences in models will be dealt with through an adjustment algorithm we are currently developing.

A central challenge is the need to balance comparability and cultural relevance. Comparability is required to allow pooled analyses. Cultural relevance is generally achieved through addition of measures of environments specific to each country or other variables of interest to specific investigators.

Future Aims

Several regions of the world, particularly developing regions, are not represented in the coordinated study, and IPEN directors are seeking opportunities to expand to these areas. Of special interest are countries in Africa, which is the only continent currently not represented. Investigators in Nigeria, Kenya, and South Africa are interested in participating, and current plans are to support these investigators to collaborate in the development and evaluation of the NEWS in these countries as a step toward comparable IPEN studies.

In 2010, IPEN initiated the Council for Environment and Physical Activity (CEPA) as part of the International Society of Physical Activity and Health. The main goals of CEPA are to support and build capacity for built environment research internationally beyond the IPEN study and use the findings in physical activity advocacy (http://www.ispah.org/cepa).

The IPEN coordinating center has developed protocols, materials, communication mechanisms, and a network that could be applied to other international studies on built environments as they relate to physical activity and obesity. Of particular interest to IPEN members are studies of youth and older adults, which are being developed through CEPA. A grant from the National Institutes of Health has been funded to support an IPEN Adolescent study, and an IPEN Senior study is in development.

Policy Implications

An explicit goal of the IPEN study is to use the evidence to inform national and international policy decisions in multiple sectors of society. IPEN investigators will be encouraged and supported to develop relationships with decision makers in their countries who are in positions to apply the results of the studies. IPEN will develop materials that summarize the results and develop relationships with professional and advocacy organizations to communicate the results widely. The objective GIS data and detailed self-reported built and social environment measures should generate rich results with clear relevance to multiple policies. Analyses are planned that examine the shape of the association between raw built environment variables and physical activity that can provide an evidence base for policies such as zoning regulations, street design standards, and park locations likely to support high levels of physical activity. Evaluating generalizability of these associations across countries and the feasibility of international standards could be an important contribution of IPEN to long-term environmental and policy changes.

The information collected through the IPEN study may provide the basis for a global set of community design indicators and the ability to cross-fertilize ideas of what may be working to promote physical activity in different cultural settings. The IPEN built environment and physical activity data will provide a baseline against which follow up data can be compared. Collecting follow-up data would allow evaluation of where changes in activity patterns, sedentary behavior, and BMI are occurring in association with environmental changes.

Understanding, from an international perspective, how built environment attributes may influence behavior has scientific and practical significance. The range of countries contributing data to IPEN Adult should not only provide more accurate estimates of built environment-physical activity associations, but each country may contribute unique results that are of value to internal decision making. For example, in Europe and Asia pedestrian-only main streets and town centers are common, but in North America and Australasia they are not. Before investing in development of pedestrian-only town centers, policy makers in the USA may want evidence that the strategy is effective. Studying bicycle facilities, robust transit systems, and excellent park systems in some countries can identify best practices that could be emulated elsewhere. Conversely, better quantification of the effects of suburban sprawl, poor pedestrian infrastructure, and unfavorable aesthetics can provide cautionary information to decision makers in many countries.

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