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Complete List of Authors:	Christian, Hayley; The University of Western Australia, School of Population Health Maitland, Clover; The University of Western Australia, Health Promotion Evaluation Unit, School of Sport Science, Exercise & Health Enkel, Stephanie; The University of Western Australia, School of Population Health, PLAYCE Research Group Trapp, Gina; The University of Western Australia, Telethon Kids Institute Trost, Stewart; Queensland University of Technology, Institute of Health and Biomedical Innovation, Centre for Children's Health Research Schipperijn, Jasper; University of Southern Denmark Boruff, Bryan; The University of Western Australia, School of Earth and Environment Lester, Leanne; University of Western Australia, Health Promotion Evaluation Unit, School of Sport Science, Exercise & Health Rosenberg, Michael; University of Western Australia, Health Promotion Evaluation Unit, School of Sport Science, Exercise & Health Zubrick, Stephen; The University of Western Australia, Faculty of Education & Telethon Kids Institute
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Influence of the day care, home and neighbourhood environment on young children's physical activity and health: Protocol for the PLAYCE observational study

Hayley Christian, PhD*^{1, 2, 5} (hayley.christian@uwa.edu.au)
Clover Maitland^{1, 3} (clover.maitland@uwa.edu.au)
Stephanie Enkel¹ (stephanie.enkel@uwa.edu.au)
Georgina Trapp, PhD^{1, 2, 5} (gina.trapp@telethonkids.org.au)
Stewart G. Trost, PhD⁴ (s.trost@qut.edu.au)
Jasper Schipperijn, PhD⁶ (jschipperijn@health.sdu.dk)
Bryan Boruff, PhD⁵ (bryan.boruff@uwa.edu.au)
Leanne Lester, PhD³ (leanne.lester@uwa.edu.au)
Michael Rosenberg, PhD³ (michael.rosenberg@uwa.edu.au)
Stephen R Zubrick, PhD^{2, 7} (stephen.zubrick@telethonkids.org.au)

Author affiliations

¹School of Population Health, The University of Western Australia, Perth, Australia

²Telethon Kids Institute, The University of Western Australia, Perth, Australia

³School of Sport Science, Exercise & Health, The University of Western Australia, Perth, Australia

⁴Institute of Health and Biomedical Innovation - Centre for Children's Health Research, Queensland University of Technology, Brisbane, Australia

⁵Centre for the Built Environment and Health and School of Earth and Environment, The University of Western Australia, Perth, Australia

⁶Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

⁷Faculty of Education, The University of Western Australia, Perth, Australia

* Corresponding author:

Asst/Prof Hayley Christian
School of Population Health (M707),
The University of Western Australia,
35 Stirling Highway,
Crawley WA 6009 Australia
Email: hayley.christian@uwa.edu.au
Telephone: 61-8-6488 8501

ABSTRACT

Introduction: The early years are a critical period in a child's health and development, yet most pre-school children fail to meet physical activity guidelines. Outside of the home and neighbourhood, children spend a large proportion of time within early childhood education and care (ECEC) services such as long day care. Research is required to determine how the design of day care outdoor (and indoor) spaces provides opportunities or constraints for physical activity. A significant evidence gap surrounds what objectively measured attributes of the home and neighbourhood environment influence pre-schoolers physical activity. The PLAY Spaces & Environments for Children's Physical Activity (PLAYCE) study will empirically investigate the relative and cumulative influence of the day care, home and neighbourhood environment on pre-schooler physical activity.

Methods and analysis: The PLAYCE study is a cross-sectional observational study (April 2015- April 2018) of 2,400 children 2-5 years attending long day care in metropolitan Perth, Western Australia. Accelerometers will measure physical activity with indoor physical activity measured using Radio Frequency Identification (RFID). Global Positioning Systems (GPS) will be used to determine outdoor location of physical activity around the home and neighbourhood for a sub-sample (n=310). The day care environment will be objectively measured using a validated audit tool. Other potential individual, social and physical environmental influences on pre-schoolers physical activity will be collected by Geographic Information Systems (GIS) measures, parent and day care educator surveys.

Ethics and Dissemination: Ethical approval has been granted by The University of Western Australia Human Ethics Research Committee, approval number RA/4/1/7417. Findings will be published in international peer-reviewed journals and presented at international

conferences. Key findings will be disseminated to stakeholders, collaborators, policy-makers and practitioners working in the ECEC sector. Day care centre directors and parents will be given a summary report of the key findings.

Keywords: Pre-school; Physical Activity; Environment; Childcare; Home; Neighbourhood; Design; Study protocol

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Strengths and limitations of this study

- The PLAYCE study will provide a greater understanding of the combined and relative influence of the home, neighbourhood and day care environments on pre-schooler activity levels.
- This study uses a large random sample with multiple modes of data collection which will allow for a comprehensive measurement of physical activity, its geographical location and the environmental factors that influence it.
- There is a large evidence gap in regard to the optimal design features of indoor and outdoor play settings that promote pre-schoolers' physical activity at day care and this study will inform where best to intervene.
- The PLAYCE study is limited by its cross-sectional observational design however findings will provide information to inform future interventions to increase pre-schooler physical activity levels across a variety of behaviour settings including early education and care policy and practice.
- Recruitment of children via day care centres will limit the generalisability of the findings however, 85% of children (in Australia) attend a preschool or a preschool program in long day care.

INTRODUCTION

Daily physical activity is critical during the early years of life.¹ Physical activity and sedentary behaviours have been shown to track from early childhood into adolescence and adulthood,^{2,3} influencing health throughout the life course. Regular physical activity provides children with a number of health and developmental benefits, including healthy weight, improved bone health, cardiovascular fitness, and enhanced cognitive, emotional and psychosocial development.⁴ A large proportion of young children do not attain sufficient physical activity for their overall health and development⁵ and approximately 20% of children aged 2-4 are overweight or obese.⁵⁻⁸ Current levels of obesity can in part be attributed to declining levels of physical activity in childhood, highlighting the importance of physical activity as a critical strategy for combating rising levels of obesity.^{9,10} International public health guidelines emphasise the benefits of physical activity from a young age with countries such as Australia,^{11,12} the United Kingdom¹³ and Canada¹⁴ recommending young children accumulate at least three hours of light, moderate or vigorous intensity physical activity each day.

Pre-schooler physical activity levels are highly varied, even when objectively measured by accelerometers. A recent review determined that pre-schoolers spend from 2%–41% of their day in moderate to vigorous intensity physical activity, 4%–33% in light intensity physical activity, and 34%–94% being sedentary.¹⁵ Overall, there is a general consensus that many pre-school children do not meet physical activity recommendations.^{16,17} The striking variation in the reported range of pre-schooler physical activity levels¹⁵ reflects a need for context-specific research of pre-schooler physical activity behaviour in order to contribute towards greater stability in, and relevance in international comparisons. There is an urgent need for quality evidence concerning the physical activity behaviour of pre-schoolers and the role of

the environment as a barrier or facilitator of physical activity. This paper describes the study design, sample, measures and significance of the PLAY Spaces & Environments for Children's Physical Activity (PLAYCE) study.

Influence of the environment on early physical activity behaviour

The ecological model of health considers that aspects of an individual's societal and community context can inhibit or enhance physical activity behaviour.^{18 19} The PLAYCE study will apply this framework to better understand the environmental influences on pre-schooler physical activity. Pre-schoolers spend the majority of their time either in the home, neighbourhood or within early childhood education and care (ECEC) services such as long day care, and each of these three settings influence opportunities for physical activity.^{16 20-22}

There is a lack of research using an ecological approach to comprehensively examine the influence of the home, neighbourhood and day care environment on pre-schooler physical activity. The day care setting in particular is where large numbers of young children can be reached to better understand the environmental influences on physical activity.

The day care environment

In 2011, 85% of Australian children aged 3-6 years who were not attending school were attending a pre-school, or a pre-school program in an ECEC service²³. In comparison 93% of children in the United Kingdom are enrolled in formal care²⁴ and 26% of children under the age of six attend centre-based care in the United States.²⁵ ECEC services such as long day care are an important setting for increasing physical activity in the early years, yet international evidence shows that a significant proportion of pre-schoolers fail to meet physical activity recommendations whilst attending day care.^{26 27}

The day care physical environment has the potential to either positively or negatively influence physical activity and the overall health and development of young children in care.^{16 28-30} A 2010 review identified that more space per child and open play areas were correlated with increased physical activity of children attending day care.²⁸ The presence of portable play equipment has also been associated with higher pre-schooler physical activity.^{28 31-35} Further investigation into the relative value of outdoor play designs, as well as the presence and quality of individual physical environment features (e.g., free space, play equipment, vegetation, paths, and shade), is required to identify environmental features that best promote physical activity in the day care setting.³⁵⁻³⁹

Children also accumulate physical activity whilst indoors at day care. Evidence shows that pre-schoolers classified as highly active overall, are more active indoors when compared to pre-schoolers classified with low levels of activity, with no differences observed outdoors.⁴⁰ The indoor environment provides untapped potential for promoting and supporting physical activity³⁰; yet there is a large evidence gap in regards to the optimal design features that promote pre-schoolers' physical activity indoors.

The regulatory and operational policy frameworks of the ECEC setting have received little research attention to date. In a U.S. study, day care centres that rated highly in eight physical activity-related policy areas had children that were more active.³³ These findings highlight that day care centre policy can strongly influence the physical activity of attending pre-schoolers.^{28 38} In a recent Australian study of 328 pre-schoolers, higher levels of physical activity whilst at day care was associated with centre's having a written physical activity policy.⁴¹ Further research is required to understand the influence of the day care policy environment. It is important that this research is conducted within existing regulatory

frameworks. For example, in 2012, a new Australian National Quality Framework for Early Childhood Education and Care was implemented to provide minimum standards for day care centres.⁴² The framework requires that physical activity is promoted and embedded in centre programs, but it fails to quantify recommendations and does not specify how to promote physical activity.⁴² Recent data shows that one quarter of centres are not meeting the national standard for 'Health and Safety,' the standard which refers to children's physical activity.⁴² Furthermore, over a third of centres are struggling to meet the benchmark for the 'Physical Environment' national standard. The 'Physical Environment' standard is the newest of the seven quality standards in the Australian National Quality Framework and lacks a clear and objective definition of what it entails and how day care centres should go about meeting it. Research is required to inform day care centres on how best to provide a physical environment that supports children's physical activity, health and development, thus enabling centres to meet high quality standards.

The home environment

Few studies have specifically examined the physical activity of pre-schoolers in the home, despite this being a behaviour setting where they spend a large proportion of time. One U.S. study reported that 41% of pre-schoolers spend between one to two hours outside while at home.⁴³ Thus home-based outdoor play may be an important source of physical activity for many pre-schoolers.⁴⁴⁻⁴⁶ Elements of the outdoor home environment (e.g., presence of yard) have been associated with increased pre-schooler physical activity^{24 47} and the indoor home environment (e.g., electronic media) with less physical activity.^{27 48} Additionally, parent-level factors such as support and encouragement of children's physical activity^{26 49} and participation in physical activity with children⁵⁰ are correlated with increased pre-schooler activity in the home. Further research into aspects of the home indoor (e.g., open plan living

designs) and outdoor physical environment (e.g., size and attributes of the yard) that may inhibit or stimulate pre-schooler physical activity is needed.

The neighbourhood environment

Local neighbourhood factors can also influence pre-schooler physical activity.¹⁹ Evidence suggests that greener neighbourhoods and low levels of traffic positively influence young children’s physical activity.^{19 51} Children who spend more time outdoors in their neighbourhood are also more likely to be physically active,⁹ with the likelihood of outdoor play strengthened by positive parental perceptions of neighbourhood safety.^{19 52 53} Physical activity and child development are also supported by access to child-relevant destinations and services in the neighbourhood^{52 54 55} including local parks, recreation centres and playgrounds.¹⁹ The presence of informal play areas such as sidewalks has also been found to be positively associated with outdoor play amongst pre-schoolers.⁵⁶ Overall, the findings highlight the importance of access to safe places near home for providing young children with opportunities to play outdoors and be physically active.

Many features of the neighbourhood physical environment (e.g., crime and traffic related safety, street connectivity, residential density, access to child-relevant destinations, quality of public open space) have not been objectively measured to determine their influence on pre-schooler activity.¹⁹ A recent review recommended population-level studies examining the role of the single, and cumulative exposures, of neighbourhood environmental features upon young children’s health and development.¹⁹ It is important that studies use objective measures (via Geographic Information Systems (GIS)) of the built environment that are relevant for young children to more accurately capture and quantify the effect of the neighbourhood built environment on pre-schooler physical activity.^{57 58}

Project significance, aims and objectives

Achieving recommended levels of physical activity for health and development is strongly influenced by the environment in which a child spends their time. Among pre-schoolers, time is most frequently spent in the family home, the local neighbourhood and within day care, with each of these locations either positively or negatively influencing physical activity. Further investigation into the influence of these environments is required to determine levels of pre-schooler physical activity in different behavioural settings, while identifying avenues for improvement. Additionally, there is a particular need for objective measurement of pre-schooler physical activity both overall, and in the home, neighbourhood and day care centre context. To overcome limitations of previous research⁵⁹ we have used an ecological approach to comprehensively examine which physical, social and policy-based attributes of the day care, home and neighbourhood environments are associated with physical activity in pre-schoolers aged 2 to 5 years. Specifically, our objectives are to:

1. Determine the physical activity levels of pre-schoolers while attending day care centres, and the contribution it makes towards meeting physical activity guidelines.
2. Identify the features of the outdoor and indoor physical environment, policy environment and educator practices in day care centres that promote or discourage physical activity in pre-schoolers.
3. Measure the proportion of day care centres meeting the Australian National Quality Framework for Early Childhood Education and Care 'Health and Safety' and 'Physical Environment' standards in terms of child physical activity, health and development.
4. Identify the physical activity and sedentary behaviour spatial patterns of pre-schoolers in and around their home, local neighbourhood and at day care.

5. Determine the locations in and around the home, neighbourhood and day care where pre-schoolers are a) physically active and b) physically inactive, and the attributes of these locations.

METHODS

Study design

PLAYCE is a cross-sectional observational study of approximately 2,400 pre-school children, clustered by day care centre (n=120). Pre-school children will be recruited via day care centres so that the relative and cumulative influence of each physical activity behaviour setting (day care, home and neighbourhood) can be examined.

Sampling

Four waves of recruitment of day care centres (and their families) will occur over a two year period (2015-2017) to achieve a sample of 2,400 pre-schoolers from 120 centres (Figure 1). Based upon previous studies, we expect a day care centre response rate of approximately 50%.^{20 60 61} According to the regulating body, the Australian Children’s Education and Care Quality Authority (ACECQA), there are 403 eligible long day care centres located within the Metropolitan Perth and Peel Regions, Western Australia (as of September 2015). Long day care centres provide centre-based childcare by professional staff for large groups of young children. Sampling and recruitment of these centres will be based on the number of approved places (i.e., maximum number of enrolling children permitted) at each centre. This proxy measure of centre size will be used to sample centres to ensure that there is maximum variability in the physical environments between centres to detect a difference in physical activity. Eligible centres will be divided into quartiles by the number of approved places. Centres in each quartile will be segmented into either low, middle or high socioeconomic

status based on the Australian Bureau of Statistics Socio-Economic Index For Areas (SEIFA)⁶² (Figure1). Sixty centres consisting of a random sample of 10 centres from each SEIFA tertile within the lowest and highest quartiles of approved places will be approached during each of the four recruitment waves (total sample=240 centres). Once there are insufficient centres remaining to sample from the highest and lowest quartiles of approved places we will sample centres from the middle quartiles choosing centres with the highest and lowest number of approved places. This sampling approach will maximise variation in size (indoor and outdoor space per child) and socio-economic status of centres. Our sampling method is based on the assumption that larger centres have more space and this is associated with higher levels of physical activity.³⁷

Insert Figure 1: PLAYCE sampling and recruitment

Day care centre recruitment

The PLAYCE study will utilise a tiered consent method, first requiring the agreement of day care centres to take part, before parents are approached. Centres will be sent an information pack about the study and the study team will follow up with a phone call to the centre director a week later. For those centres that are part of a franchise, the consent of the managing director will be obtained before individual centres are approached. Centres that have consented to take part in the study will be briefed by the study team at a centre staff meeting. The briefing will explain the purpose of the study, the required involvement of the centre and methods to recruit parents and children.

Parent recruitment

Recruitment of children will occur in consultation with the director of each day care centre. Parents of all children aged 2 to 5 years will be invited to participate, of which we expect 30-50% participation amongst eligible children.⁶³ The number of participating pre-schoolers per day care centre is expected to range from 10-45⁶⁴. Children with a recognised disability (physical, emotional/behavioural or intellectual) that would affect participation in physical activity and those attending full-time formal schooling (preventing whole days spent in day care) will be ineligible for the study. Centre staff will provide eligible families with a recruitment pack containing information about the study, a consent form and a participant contact details form. Posters, banners, flyers, emails and newsletter templates will also be provided.

Sample size estimates

We aim to recruit 60 day care centres from each of the largest and smallest quartile of centre size to detect a clinically significant difference in the amount of moderate to vigorous physical activity (MVPA) pre-schoolers engage in during a typical day care day. A sample of 1200 children in each of the two groups of centre size (large and small) will provide at least 80% power to detect at least a 8 minute difference in MVPA/day between small (mean=53 minutes; standard deviation (SD)=27 minutes) and large centres (mean=61 minutes; SD=31 minutes). The sample size has been inflated to account for children clustered within day care centres (Clustering design effect inflation factor= $1+(m-1)*ICC$; where m=the average number of children attending each day care centre (n=20) and the intraclass correlation (ICC)=0.1).

Data collection

Data collection will occur continuously over a two-year period accounting for seasonal variation in weather and physical activity. Data on participating children will be collected over seven days, and include measures of the day care centre, as well as the home and neighbourhood environment. The data collection methods used across the home, neighbourhood and day care physical activity behaviour settings are outlined in Figure 2 and described in detail below.

Insert Figure 2: PLAYCE study data collection methods across pre-schooler physical activity behaviour settings

Objective measurement of pre-schooler physical activity

ActiGraph GT3X+ accelerometers will be used to assess the frequency, duration and intensity of physical activity. The devices will be worn on an elastic belt placed at the right side of the hip⁶⁵. Children will be fitted with an accelerometer on the day the research team visit a day care centre or the next day that the child attends the centre. Accelerometers will be worn during waking hours for seven days. Day care staff and parents will be asked to record if the accelerometer (and GPS for the sub-study) is removed for any reason in a diary. The devices have moderate to strong evidence of validity for measuring daily time spent in sedentary (SED), light (LPA), moderate (MPA), and vigorous (VPA) intensity physical activity in young children.⁶⁵ Sampling intervals (epochs) will be set to 15 seconds to accommodate for the typical nature of pre-schoolers' physical activity.⁶⁵ We will use cut-points developed by Pate and colleagues to distinguish between SED, LPA and MVPA, respectively.⁶⁶⁻⁶⁸ Data validation will be based on at least three week days (including at least one day at daycare with 75% wear time) and one weekend day with a minimum 8 hours wear time/day.^{15 63 69}

Accelerometer data will be processed for the amount and intensity of physical activity pre-schoolers undertake at day care and overall.

Objective measurement of pre-schoolers spatial movement patterns at day care

An RF Code Radio Frequency Identification (RFID) system will track the location of RFID tags (worn on the wrist) in real time throughout the day care day, providing indoor room level location information. The RFID system compliments more established Global Positioning Systems (GPS) that are unable to detect signals indoors and provides spatial location inside buildings. The RFID equipment used in this study has EC (European Conformity) and FCC (Federal Communications Commission USA) wireless regulatory certification and is designed to be worn by children or adults for personnel tracking.⁷⁰ Participating children will wear an RFCode M163-i wristband tag while at day care during the study week. RFID location data will be analysed to ascertain the amount of time children spend in indoor rooms while at day care. Using the timestamp from the accelerometer and RFID tag, data will be linked so that physical activity level is matched with day care centre indoor positioning.

Objective measurement of pre-schoolers spatial movement patterns at home and in the neighbourhood (GPS sub-study)

Qstarz Q-1000XT Global Positioning System (GPS) devices will be used with a sub-sample of children (n=310) to log X, Y location coordinates, distance, speed, elevation, and time for seven days. The Q-1000XT has a median dynamic accuracy of 2.9 meters under different environmental conditions.⁷¹ The Qstarz GPS is a small device that is worn on the left hip on the same belt as the accelerometer. We aim to collect location data from the GPS unit for the majority of waking hours on at least three weekdays and one weekend day during the seven-

day period.⁷¹ Outdoor location and physical activity data will be processed for analysis using the Personal Activity Location Measurement System (PALMS) software.⁷¹

Measurement of the day care centre physical and policy environment

We have adapted the Environment Assessment and Policy Observation (EPAO) instrument⁷² 'Physical Environment' sub-scale for the Australian context and expanded it to gather detailed information on the indoor and outdoor physical environment of day care centres. The EPAO instrument was developed to assess the quality of day care centres physical activity and eating behaviours in the U.S.^{72 73} and has been validated.^{33 74} Physical environment and physical activity policy components of the EPAO assess fixed play equipment, portable play equipment, outdoor running space, indoor play space, and whether the centre has a written policy and documented curriculum on physical activity.^{72 75} The presence and quality of other features of the outdoor day care physical environment including vegetation,⁷⁶⁻⁷⁸ paths,⁷⁹ surface material,³⁶ slope/gradient,⁸⁰ natural features⁸⁰ and play settings⁷² will also be collected. Revised audit items have undergone intra- and inter-rater reliability testing and have been found to have acceptable reliability (i.e., kappa or intraclass correlation coefficient [ICC] > 0.60).⁸¹ Greenness will be determined by viewing satellite imagery⁸² and shade above play structures examined through fisheye photography.⁷⁷ The actual 'useable' outdoor and indoor space will be measured using a laser measure.

Day care educator survey

Information on educator and centre-level physical activity-related practices will be collected. Survey items are based upon the Nutrition and Physical Activity Self-Assessment for Child Care⁷⁹ and have been adapted for the Australian context. Time provided for physical activity, types of physical activities, equipment available for children to use, educator physical activity

related practices and professional development and the application of relevant physical activity-related policies in the centre will be measured. Items have very good to excellent test re-test reliability (i.e., kappa or ICC > 0.60).⁸¹ Two educators per centre (centre director and one other) will complete the survey.

Parent survey

The parent survey will collect socio-demographic information about the child (e.g., age, gender, siblings) and parents (e.g., age, gender, socio-economic status). Additional individual factors will include child sleep,⁸³ temperament,⁸⁴ preference for physical activity,⁸⁵ and physical competence.⁸⁶ The social environment will be measured by parents perceived importance of and support for child physical activity^{87 88} and rules and limits around children's physical activity.^{63 85} Additional contextual measures of child physical activity behaviour will include the amount of structured and unstructured physical activity,⁸⁹ outdoor play^{44 90} and electronic media use.⁶³ Parent perceptions of the neighbourhood environment (neighbourhood safety, crime-related safety, access to services, streets in the neighbourhood, places for walking, neighbourhood surroundings and neighbourhood preferences) will be measured using the Neighbourhood Environment Walkability Scale for Youth (NEWS-Y).⁹¹ Finally, information about home yard space⁹² and dog ownership⁹³ will be collected.

Objective measurement of day care centre and home neighbourhood built environment

Geographic Information Systems (GIS) data will objectively measure aspects of each day care centre, home and neighbourhood environment. Neighbourhood-level GIS measures for each centre and participant's homes will be calculated using a specified buffer area (800m) from the centre/home. GIS derived measures for day care centres and the home include outdoor space, greenness, availability and quality of public open space and traffic exposure

(Table 1). Home-based GIS measures also include walkability (index comprised of three sub-components: street connectivity, land use mix and residential density)⁹⁴ and access to local amenities (e.g. access to schools, public transport and shops and services).

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Table 1: PLAYCE study day care centre, home and neighbourhood environment GIS derived measures

Measure	Description
Day Care Centre Neighbourhood Environment:	
Outdoor space	Area of block that are not covered by day care centre building (outdoor space)
Green Space	Access (distance) to parks, types and sizes of parks and quality (e.g., playgrounds) of parks
	Access to nature areas
	Access to school grounds
	Neighbourhood greenness
Traffic exposure	Percentage of total length of roads within a service area that are NOT main roads
Home and Neighbourhood Environment:	
Home yard area	Area of residential blocks that are not covered by building (yard size)
Green Space	Access to parks, types and sizes of parks and quality (e.g., playgrounds) of parks
	Access to nature areas
	Access to school grounds
	Neighbourhood greenness
Child-Relevant Destinations	Access to kindergartens, child-centre-based-care, child health clinics, family support services, play group venues
Street connectivity	Number of 3-way or greater intersections/service area
Land use mix	Access to utilitarian and recreational destinations. Evenness of spread of different land uses within a service area
Residential density	Number of residential dwellings/residential land area in service area
Low traffic exposure	Percentage of total length of roads within a service area that are NOT main roads
Public transport stops	Number of public transport stops (bus and rail) within a service area

Data analysis plan

Objective 1: Determine the physical activity levels of pre-schoolers while attending day care centres, and the contribution it makes towards meeting physical activity guidelines.

In addition to descriptive statistics, a mixed model regression approach will be used to determine the amount of physical activity (LMVPA and MVPA) children accumulate whilst at day care and the contribution it makes to meeting the recommended three hours of physical activity per day. Analyses will adjust for clustering of children within day care centres as well as individual child and parent socio-demographic factors (e.g., child age and gender, time spent at day care, parent socio-economic status).

Objective 2: Identify the features of the outdoor and indoor physical environments, policy environment and educator practices in day care centres that promote or discourage physical activity in pre-schoolers.

A mixed model regression approach will be used to compare the amount of physical activity (LMVPA and MVPA) children accumulate whilst indoors and outdoors at large compared with small sized day care centres. Analyses will also examine the influence of different combinations of indoor and outdoor space per child (e.g., high amount of outdoor and indoor space/child vs. low amount of outdoor and indoor space/child) as well as features of the outdoor and indoor physical environments, policy environment and educator practices in day care centres associated with pre-schooler physical activity (and sedentary time). Analyses will adjust for the same variables as Objective 1 analyses. A moderation and mediation analysis will be performed using the physical environment quality rating for day care centres.

Objective 3: Measure the proportion of day care centres meeting the Australian National Quality Framework for Early Childhood Education and Care 'Health and Safety' and

‘Physical Environment’ standards in terms of child physical activity, health and development.

We will determine the proportion of centres who are meeting and not meeting the ‘Health and Safety’ national standard in terms of achieving the recommended three hours of physical activity per day. We will also determine the proportion of centres who are meeting and not meeting the ‘Physical Environment’ national standard in terms of the presence and quality of attributes within the day care physical environment. Findings from Objective 2 analyses will inform what key ‘Physical Environment’ attributes will be included. All analyses will adjust for child and centre level confounders.

Objective 4: Identify the physical activity and sedentary behaviour spatial patterns of pre-schoolers in and around their home, local neighbourhood and at day care; Objective 5: Determine the locations in and around the home, neighbourhood and day care where pre-schoolers are a) physically active and b) physically inactive, and the attributes of these locations.

We will use GPS and accelerometer derived variables to determine where, when and for how long pre-schoolers are active (or inactive) around their home and neighbourhood. Separate multilevel models will be used to determine the influence of specific features of the home and neighbourhood environment (e.g., size of backyard, access to green space, traffic exposure, neighbourhood walkability) on pre-schooler physical activity (and sedentary behaviour). Significant predictors of the home and neighbourhood environments will be placed in the one model to determine the relative significance of these environments on children’s physical activity. The relative contribution of the home, neighbourhood and day care environments to achieving recommended levels of physical activity will be examined through multi-level regression models. Data will be analysed using combinations of SPSS, STATA and SAS analytical software packages.

ETHICS AND DISSEMINATION

Ethical approval has been granted by The University of Western Australia Human Ethics Research Committee, approval number RA/4/1/7417. Directors of day care centres will provide informed written consent to participate and parents will provide informed written for themselves and their child's participation in the study. All equipment to be used in the study has been approved for use with children. Furthermore, all individuals working directly with children will have a Working with Children Check⁹⁵ as per Western Australian legislative requirements.

All participants' responses and data will be strictly confidential. No names or addresses will appear on any typed reports including publications. Only aggregated data will be used to describe research findings. All data will be retained at completion of the study for at least 7 years and kept as per The University of Western Australia requirements for data retention and disposal.

Findings will be published in international peer-reviewed journals. The Final Report and a copy of published papers will be forwarded to key stakeholders, collaborators, policy-makers and practitioners working in the ECEC sector. The research team will work closely with Day Care Directors, Educators, and the regulating body (ACECQA) to inform the Australian National Quality Framework for Early Childhood Education and Care⁴² and the Australian Early Years Learning Framework⁴². Findings will also be disseminated via a number of local, national and international conference presentations and invited talks. The Director of each participating day care centre will receive a group summary report and individual child physical activity reports will be given to parents.

DISCUSSION AND CONCLUSION

Early physical activity behaviour has a significant effect on health across the life course. Findings from the PLAYCE study will provide important evidence for reducing the long-term effects of physical inactivity and chronic disease. The PLAYCE study will determine how much physical activity pre-schoolers accumulate in different behaviour settings (home, neighbourhood and day care), and the contribution each of these makes towards achieving the recommended level of physical activity for health and development. This study will investigate a range of features, including indoor and outdoor space, play equipment, the natural environment, traffic exposure, access to local amenities, day care educator practices and day care centre policies to determine their level of influence on children’s physical activity across different behaviour settings. Findings will strengthen the evidence base to inform which features of the day care, home and neighbourhood physical environment are most important for influencing young children’s physical activity. This information can be used by: i) early childhood educators and regulating bodies to provide day care environments that support and encourage more physical activity in pre-schoolers; ii) urban planners and policy makers to develop more child and family friendly neighbourhoods; and iii) practitioners to develop interventions to support parents in providing opportunities for their children to play outdoors.

The findings will contribute to the evidence base required to inform policies that can positively impact pre-schooler physical activity levels across three key settings: home, day care and the neighbourhood. In seeking to influence policy and practice relating to the health and development of young children, this project will actively engage with key stakeholders, collaborators, policy-makers and practitioners from the study’s inception through to the

dissemination and translation of findings. For example, by identifying features of the day care physical environment that promote physical activity and active play, we will assist Childhood Educators identify if their day care centre is meeting the 'Physical Environment' and 'Health and Safety' quality standards and how they can improve the physical environment to support children's physical activity, health and development. This in turn will inform practices to help centres achieve and exceed national quality standards relating to the day care environment and children's physical activity and health. Furthermore, findings from this study will be used as baseline measures for developing 'natural experiments' of the day care physical (and policy) environment to establish the causal impact of the day care environment on children's physical activity and development. Considering a large proportion of pre-school age children attend day care, optimising the day care environment to facilitate young children's physical activity has the potential to increase population levels of physical activity in this age group.

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Competing interests

The authors declare that they have no competing interests.

Authors’ contributions

HC conceived and designed the study. CM, GT, SGT, JS, BB, LL, MR and SRZ had input to the study design. HC, CM and SE drafted the manuscript revising it critically at each stage. All authors contributed to the drafting of the manuscript, and read and approved the final manuscript.

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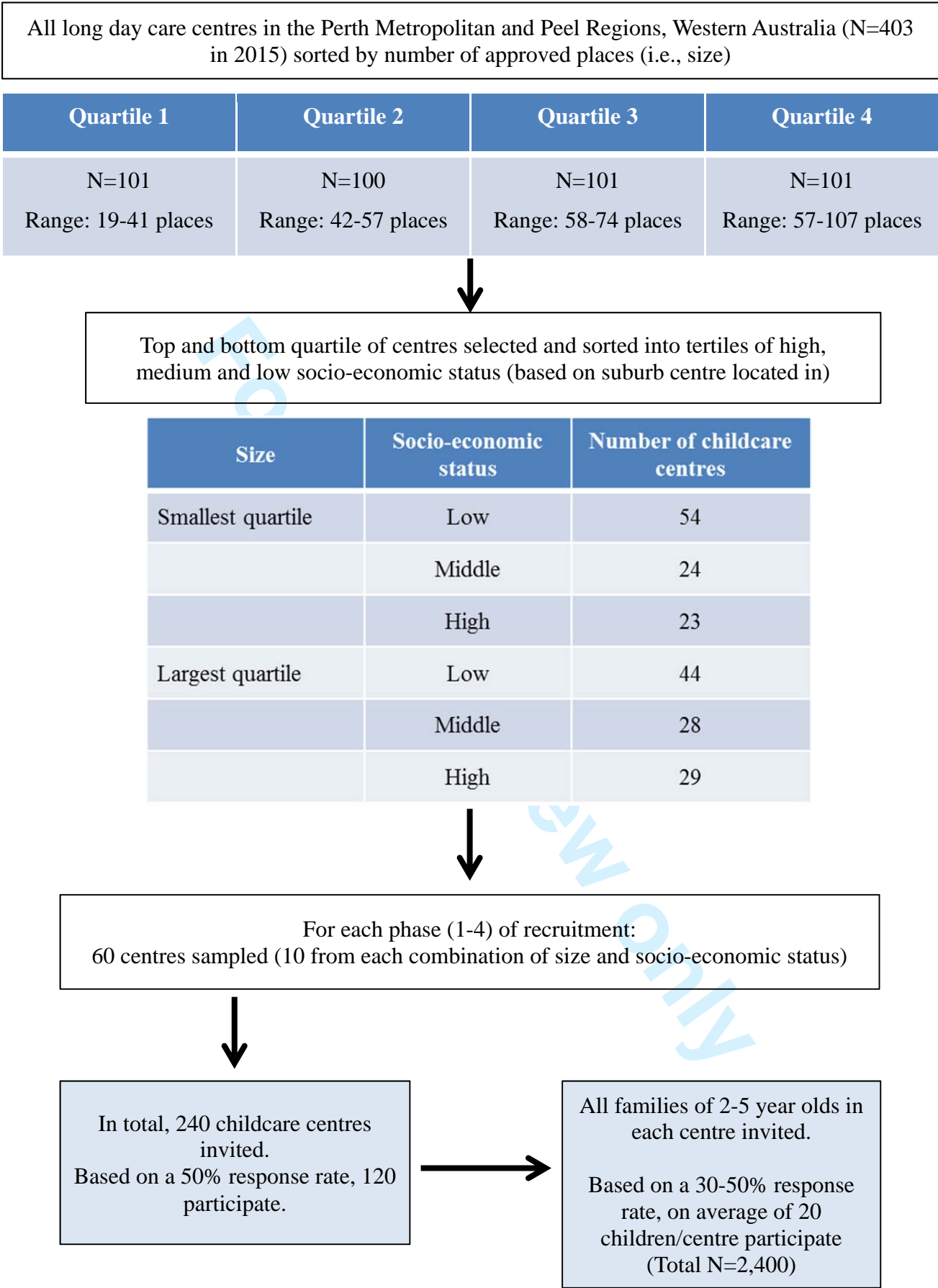


Figure 1: PLAYCE sampling and recruitment

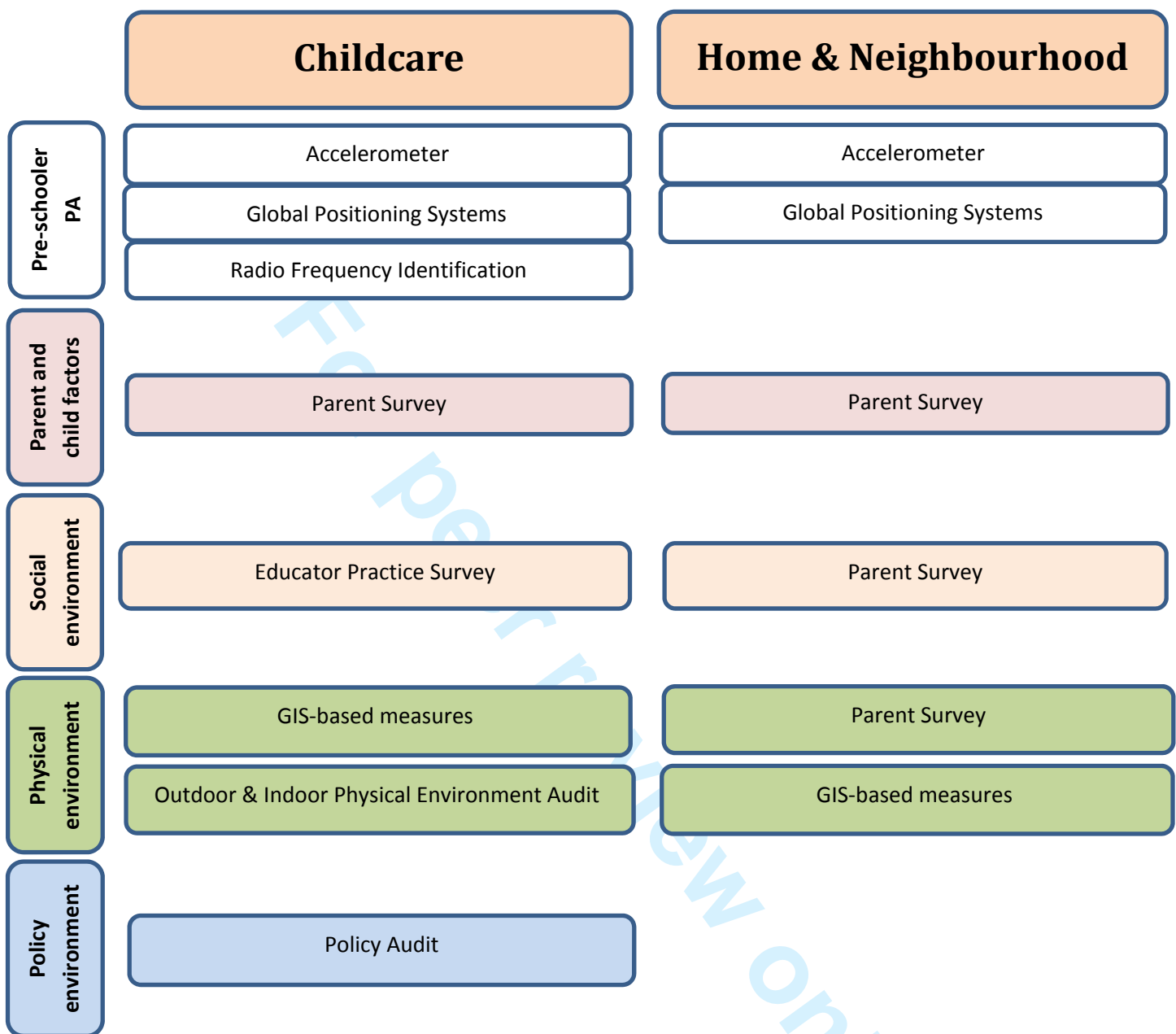


Figure 2: PLAYCE study data collection methods across pre-schooler physical activity behaviour settings

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Influence of the day care, home and neighbourhood environment on young children's physical activity and health: Protocol for the PLAYCE observational study

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SCHOLARONE™
Manuscripts

Influence of the day care, home and neighbourhood environment on young children’s physical activity and health: Protocol for the PLAYCE observational study

Hayley Christian, PhD*^{1, 2, 5} (hayley.christian@uwa.edu.au)
Clover Maitland^{1, 3} (clover.maitland@uwa.edu.au)
Stephanie Enkel¹ (stephanie.enkel@uwa.edu.au)
Georgina Trapp, PhD^{1,2,5} (gina.trapp@telethonkids.org.au)
Stewart G. Trost, PhD⁴ (s.trost@qut.edu.au)
Jasper Schipperijn, PhD⁶ (jschipperijn@health.sdu.dk)
Bryan Boruff, PhD⁵ (bryan.boruff@uwa.edu.au)
Leanne Lester, PhD³ (leanne.lester@uwa.edu.au)
Michael Rosenberg, PhD³ (michael.rosenberg@uwa.edu.au)
Stephen R Zubrick, PhD^{2,7} (stephen.zubrick@telethonkids.org.au)

Author affiliations

- ¹School of Population Health, The University of Western Australia, Perth, Australia
- ²Telethon Kids Institute, The University of Western Australia, Perth, Australia
- ³School of Sport Science, Exercise & Health, The University of Western Australia, Perth, Australia
- ⁴Institute of Health and Biomedical Innovation - Centre for Children’s Health Research, Queensland University of Technology, Brisbane, Australia
- ⁵Centre for the Built Environment and Health and School of Earth and Environment, The University of Western Australia, Perth, Australia
- ⁶Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark
- ⁷Faculty of Education, The University of Western Australia, Perth, Australia

* Corresponding author:
Asst/Prof Hayley Christian
School of Population Health (M707),
The University of Western Australia,
35 Stirling Highway,
Crawley WA 6009 Australia
Email: hayley.christian@uwa.edu.au
Telephone: 61-8-6488 8501

ABSTRACT

Introduction: The early years are a critical period in a child's health and development, yet most pre-school children fail to meet physical activity guidelines. Outside of the home and neighbourhood, children spend a large proportion of time within early childhood education and care (ECEC) services such as long day care. Research is required to determine how the design of day care outdoor (and indoor) spaces provides opportunities or constraints for physical activity. A significant evidence gap surrounds what objectively measured attributes of the home and neighbourhood environment influence pre-schoolers physical activity. The PLAY Spaces & Environments for Children's Physical Activity (PLAYCE) study will empirically investigate the relative and cumulative influence of the day care, home and neighbourhood environment on pre-schooler physical activity.

Methods and analysis: The PLAYCE study is a cross-sectional observational study (April 2015- April 2018) of 2,400 children 2-5 years attending long day care in metropolitan Perth, Western Australia. Accelerometers will measure physical activity with indoor physical activity measured using Radio Frequency Identification (RFID). Global Positioning Systems (GPS) will be used to determine outdoor location of physical activity around the home and neighbourhood for a sub-sample (n=310). The day care environment will be objectively measured using a validated audit tool. Other potential individual, social and physical environmental influences on pre-schoolers physical activity will be collected by Geographic Information Systems (GIS) measures, parent and day care educator surveys.

Ethics and Dissemination: Ethical approval has been granted by The University of Western Australia Human Ethics Research Committee, approval number RA/4/1/7417. Findings will be published in international peer-reviewed journals and presented at international

conferences. Key findings will be disseminated to stakeholders, collaborators, policy-makers and practitioners working in the ECEC sector. Day care centre directors and parents will be given a summary report of the key findings.

Keywords: Pre-school; Physical Activity; Environment; Childcare; Home; Neighbourhood; Design; Study protocol

Strengths and limitations of this study

- The PLAYCE study will provide a greater understanding of the combined and relative influence of the home, neighbourhood and day care environments on pre-schooler activity levels.
- This study uses a large random sample with multiple modes of data collection which will allow for a comprehensive measurement of physical activity, its geographical location and the environmental factors that influence it.
- There is a large evidence gap in regard to the optimal design features of indoor and outdoor play settings that promote pre-schoolers' physical activity at day care and this study will inform where best to intervene.
- The PLAYCE study is limited by its cross-sectional observational design however findings will provide information to inform future interventions to increase pre-schooler physical activity levels across a variety of behaviour settings including early education and care policy and practice.
- Recruitment of children via day care centres will limit the generalisability of some of the findings however, over half of all pre-schoolers (in Australia) usually attend formal child care such as long day care.

INTRODUCTION

Daily physical activity is critical during the early years of life.[1] Physical activity and sedentary behaviours have been shown to track from early childhood into adolescence and adulthood,[2 3] influencing health throughout the life course. Regular physical activity provides children with a number of health and developmental benefits, including healthy weight, improved bone health, cardiovascular fitness, and enhanced cognitive, emotional and psychosocial development.[4] A large proportion of young children do not attain sufficient physical activity for their overall health and development[5] and approximately 20% of children aged 2-4 are overweight or obese.[5-8] There is an urgent need for quality evidence concerning the physical activity behaviour of pre-schoolers and the role of the environment as a barrier or facilitator of physical activity. This paper describes the study design, sample, measures and significance of the PLAY Spaces & Environments for Children’s Physical Activity (PLAYCE) study.

Influence of the environment on early physical activity behaviour

The ecological model of health considers that aspects of an individual’s societal and community context can inhibit or enhance physical activity behaviour.[9 10] The PLAYCE study will apply this framework to better understand the environmental influences on pre-schooler physical activity. Pre-schoolers spend the majority of their time either in the home, neighbourhood or within early childhood education and care (ECEC) services such as long day care, and each of these three settings influence opportunities for physical activity.[11-14] There is a lack of research using an ecological approach to comprehensively examine the influence of the home, neighbourhood and day care environment on pre-schooler physical activity. The day care setting in particular is where large numbers of young children can be reached to better understand the environmental influences on physical activity.

The day care environment

In 2011, 83% of Australian children 4-5 years who did not attend school were attending a pre-school, or a pre-school program in an ECEC service and 54% of 2-3 year olds usually attended formal childcare such as long day care[15]. In comparison 93% of children in the United Kingdom are enrolled in formal care[16] and 26% of children under the age of six attend centre-based care in the United States.[17] ECEC services such as long day care are an important setting for increasing physical activity in the early years, yet international evidence shows that a significant proportion of pre-schoolers fail to meet physical activity recommendations whilst attending day care.[18 19]

The day care physical environment has the potential to either positively or negatively influence physical activity and the overall health and development of young children in care.[14 20-22] A 2010 review identified that more space per child and open play areas were correlated with increased physical activity of children attending day care.[20] The presence of portable play equipment has also been associated with higher pre-schooler physical activity.[20 23-27] Further investigation into the relative value of outdoor play designs, as well as the presence and quality of individual physical environment features (e.g., free space, play equipment, vegetation, paths, and shade), is required to identify environmental features that best promote physical activity in the day care setting.[27-31]

Children also accumulate physical activity whilst indoors at day care. Evidence shows that pre-schoolers classified as highly active overall, are more active indoors when compared to pre-schoolers classified with low levels of activity, with no differences observed outdoors.[32] The indoor environment provides untapped potential for promoting and

supporting physical activity[22]; yet there is a large evidence gap in regards to the optimal design features that promote pre-schoolers’ physical activity indoors.

The regulatory and operational policy frameworks of the ECEC setting have received little research attention to date. In a U.S. study, day care centres that rated highly in eight physical activity-related policy areas had children that were more active.[25] These findings highlight that day care centre policy can strongly influence the physical activity of attending pre-schoolers.[20 30] In a recent Australian study of 328 pre-schoolers, higher levels of physical activity whilst at day care was associated with centre’s having a written physical activity policy.[33] Further research is required to understand the influence of the day care policy environment.

It is important that such research is conducted within existing regulatory frameworks. For example, in 2012, a new Australian National Quality Framework for Early Childhood Education and Care was implemented to provide minimum standards for day care centres which in Australia are mostly privately owned (requiring enrolment and a daily fee for service).[34] The framework requires that physical activity is promoted and embedded in centre programs, but it fails to quantify recommendations and does not specify how to promote physical activity.[34] Recent data shows that one quarter of centres are not meeting the national standard for ‘Health and safety,’ the standard which refers to children’s physical activity (Standard 2.2 : Healthy eating and physical activity are embedded in the program for children, Element 2.2.2: Physical activity is promoted through planned and spontaneous experiences and is appropriate for each child).[34] Furthermore, over a third of centres are struggling to meet the benchmark for the ‘Physical Environment’ national standard (Standard 3.1: The design and location of the premises is appropriate for the operation of a service;

Standard 3.2: The environment is inclusive, promotes competence, independent exploration and learning through play; Standard 3.3: The service takes an active role in caring for its environment and contributes to a sustainable future).[34] The 'Physical Environment' standard is the newest of the seven quality standards in the Australian National Quality Framework and lacks a clear and objective definition of what it entails and how day care centres should go about meeting it. Research is required to inform day care centres on how best to provide a physical environment that supports children's physical activity, health and development, thus enabling centres to meet high quality standards.

The home environment

Few studies have specifically examined the physical activity of pre-schoolers in the home, despite this being a behaviour setting where they spend a large proportion of time. One U.S. study reported that 41% of pre-schoolers spend between one to two hours outside while at home.[35] Thus home-based outdoor play may be an important source of physical activity for many pre-schoolers.[36-38] Elements of the outdoor home environment (e.g., presence of yard) have been associated with increased pre-schooler physical activity[16 39] and the indoor home environment (e.g., electronic media) with less physical activity.[19 40] Additionally, parent-level factors such as support and encouragement of children's physical activity[18 41] and participation in physical activity with children[42] are correlated with increased pre-schooler activity in the home. Further research into aspects of the home indoor (e.g., open plan living designs) and outdoor physical environment (e.g., size and attributes of the yard) that may inhibit or stimulate pre-schooler physical activity is needed.

The neighbourhood environment

Local neighbourhood factors can also influence pre-schooler physical activity.[10] Evidence suggests that greener neighbourhoods and low levels of traffic positively influence young children’s physical activity.[10 43] Children who spend more time outdoors in their neighbourhood are also more likely to be physically active,[44] with the likelihood of outdoor play strengthened by positive parental perceptions of neighbourhood safety.[10 45 46] Physical activity and child development are also supported by access to child-relevant destinations and services in the neighbourhood[45 47 48] including local parks, recreation centres and playgrounds.[10] The presence of informal play areas such as sidewalks has also been found to be positively associated with outdoor play amongst pre-schoolers.[49] Overall, the findings highlight the importance of access to safe places near home for providing young children with opportunities to play outdoors and be physically active.

Many features of the neighbourhood physical environment (e.g., crime and traffic related safety, street connectivity, residential density, access to child-relevant destinations, quality of public open space) have not been objectively measured to determine their influence on pre-schooler activity.[10] A recent review recommended population-level studies examining the role of the single, and cumulative exposures, of neighbourhood environmental features upon young children’s health and development.[10] It is important that studies use objective measures (via Geographic Information Systems (GIS)) of the built environment that are relevant for young children to more accurately capture and quantify the effect of the neighbourhood built environment on pre-schooler physical activity.[50 51]

Project significance, aims and objectives

Achieving recommended levels of physical activity for health and development is strongly influenced by the environment in which a child spends their time. Among pre-schoolers, time is most frequently spent in the family home, the local neighbourhood and within day care, with each of these locations either positively or negatively influencing physical activity. Further investigation into the influence of these environments is required to determine levels of pre-schooler physical activity in different behavioural settings, while identifying avenues for improvement. Additionally, there is a particular need for objective measurement of pre-schooler physical activity both overall, and in the home, neighbourhood and day care centre context. To overcome limitations of previous research[52] we have used an ecological approach to comprehensively examine which physical, social and policy-based attributes of the day care, home and neighbourhood environments are associated with physical activity in pre-schoolers aged 2 to 5 years. Specifically, our objectives are to:

1. Determine the physical activity levels of pre-schoolers while attending day care centres, and the contribution it makes towards meeting physical activity guidelines.
2. Identify the features of the outdoor and indoor physical environment, policy environment and educator practices in day care centres that promote or discourage physical activity in pre-schoolers.
3. Measure the proportion of day care centres meeting the Australian National Quality Framework for Early Childhood Education and Care 'Health and Safety' and 'Physical Environment' standards in terms of child physical activity, health and development.
4. Identify the physical activity and sedentary behaviour spatial patterns of pre-schoolers in and around their home, local neighbourhood and at day care.

5. Determine the locations in and around the home, neighbourhood and day care where pre-schoolers are a) physically active and b) physically inactive, and the attributes of these locations.

METHODS

Study design

PLAYCE is a cross-sectional observational study of approximately 2,400 pre-school children, clustered by day care centre (n=120). Pre-school children will be recruited via day care centres so that the relative and cumulative influence of each physical activity behaviour setting (day care, home and neighbourhood) can be examined.

Sampling

Four waves of recruitment of day care centres (and their families) will occur over a two year period (2015-2017) to achieve a sample of 2,400 pre-schoolers from 120 centres (Figure 1). Based upon previous studies, we expect a day care centre response rate of approximately 50%. [11 53 54] According to the regulating body, the Australian Children’s Education and Care Quality Authority (ACECQA), there are 403 eligible long day care centres located within the Metropolitan Perth and Peel Regions, Western Australia (as of September 2015). Each six months we will review the number of long day care centres registered by ACECQA and add new centres to our list of centres we can sample from.

Long day care centres provide centre-based childcare by professional staff for large groups of young children. Sampling and recruitment of these centres will be based on the number of approved places (i.e., maximum number of enrolling children permitted) at each centre. This proxy measure of centre size will be used to sample centres to ensure that there is maximum

variability in the physical environments between centres to detect a difference in physical activity. Eligible centres will be divided into quartiles by the number of approved places. Centres in each quartile will be segmented into either low, middle or high socioeconomic status based on the Australian Bureau of Statistics Socio-Economic Index For Areas (SEIFA)[55] (Figure1). Sixty centres consisting of a random sample of 10 centres from each SEIFA tertile within the lowest and highest quartiles of approved places will be approached during each of the four recruitment waves (total sample=240 centres). Once there are insufficient centres remaining to sample from the highest and lowest quartiles of approved places we will sample centres from the middle quartiles choosing centres with the highest and lowest number of approved places. This sampling approach will maximise variation in size (indoor and outdoor space per child) and socio-economic status of centres. Our sampling method is based on the assumption that larger centres have more space and this is associated with higher levels of physical activity.[29]

Insert Figure 1: PLAYCE sampling and recruitment

Day care centre recruitment

The PLAYCE study will utilise a tiered consent method, first requiring the agreement of day care centres to take part, before parents are approached. Centres will be sent an information pack about the study and the study team will follow up with a phone call to the centre director a week later. For those centres that are part of a franchise, the consent of the managing director will be obtained before individual centres are approached. Centres that have consented to take part in the study will be briefed by the study team at a centre staff meeting. The purpose of the staff briefing will be to engage staff in the study, explain the purpose, the

required involvement and methods to recruit parents and children. Centres will receive a summary report of their findings.

Parent recruitment

Recruitment of children will occur in consultation with the director of each day care centre. Parents of all children aged 2 to 5 years will be invited to participate, of which we expect 30-50% participation amongst eligible children.[56] The number of participating pre-schoolers per day care centre is expected to range from 10-45[57]. Children with a recognised disability (physical, emotional/behavioural or intellectual) that would affect participation in physical activity and those attending full-time formal schooling (preventing whole days spent in day care) will be ineligible for the study. Centre staff will give eligible families with a recruitment pack containing information about the study, a consent form and a participant contact details form. Centres will be provided with multiple methods to let families know about the study and encourage their participation (email and newsletter templates, banners, sign up posters, flyers etc). At the end of the study parents will be provided with an individualised report of their child’s results and children will receive a thank you gift (Frisbee).

Sample size estimates

We aim to recruit 60 day care centres from each of the largest and smallest quartile of centre size to detect a clinically significant difference in the amount of moderate to vigorous physical activity (MVPA) pre-schoolers engage in during a typical day care day. A sample of 1200 children in each of the two groups of centre size (large and small) will provide at least 80% power to detect at least a 8 minute difference in MVPA/day between small (mean=53 minutes; standard deviation (SD)=27 minutes) and large centres (mean=61 minutes; SD=31 minutes). The sample size has been inflated to account for children clustered within day care

centres (Clustering design effect inflation factor= $1+(m-1)*ICC$; where m =the average number of children attending each day care centre ($n=20$) and the intraclass correlation ($ICC=0.1$).

Data collection

Data collection will occur continuously over a two-year period accounting for seasonal variation in weather and physical activity. Data on participating children will be collected over seven days, and include measures of the day care centre, as well as the home and neighbourhood environment. The data collection methods used across the home, neighbourhood and day care physical activity behaviour settings are outlined in Figure 2 and described in detail below.

Insert Figure 2: PLAYCE study data collection methods across pre-schooler physical activity behaviour settings

Objective measurement of pre-schooler physical activity

ActiGraph GT3X+ accelerometers will be used to assess the frequency, duration and intensity of physical activity. The devices will be worn on an elastic belt placed at the right side of the hip[58]. Children will be fitted with an accelerometer on the day the research team visit a day care centre or the next day that the child attends the centre. Accelerometers will be worn during waking hours for seven days. Day care staff and parents will be asked to record if the accelerometer (and GPS for the sub-study) is removed for any reason in a diary. The devices have moderate to strong evidence of validity for measuring daily time spent in sedentary (SED), light (LPA), moderate (MPA), and vigorous (VPA) intensity physical activity in young children.[58] Sampling intervals (epochs) will be set to 15 seconds to accommodate

for the typical nature of pre-schoolers’ physical activity. [58] We will use cut-points developed by Pate and colleagues to distinguish between SED, LPA and MVPA, respectively.[59-61] Data validation will be based on at least three week days (including at least one day at daycare with 75% wear time) and one weekend day with a minimum 8 hours wear time/day.[56 62 63] Accelerometer data will be processed for the amount and intensity of physical activity pre-schoolers undertake at day care and overall. Children’s height and weight will be measured.

Objective measurement of pre-schoolers spatial movement patterns at day care

An RF Code Radio Frequency Identification (RFID) system will track the location of RFID tags (worn on the wrist) in real time throughout the day care day, providing indoor room level location information. The RFID system compliments more established Global Positioning Systems (GPS) that are unable to detect signals indoors and provides spatial location inside buildings. The RFID equipment used in this study has EC (European Conformity) and FCC (Federal Communications Commission USA) wireless regulatory certification and is designed to be worn by children or adults for personnel tracking.[64] Participating children will wear an RFCode M163-i wristband tag while at day care during the study week. RFID location data will be analysed to ascertain the amount of time children spend in indoor rooms while at day care. Using the timestamp from the accelerometer and RFID tag, data will be linked so that physical activity level is matched with day care centre indoor positioning.

Objective measurement of pre-schoolers spatial movement patterns at home and in the neighbourhood (GPS sub-study)

Qstarz Q-1000XT Global Positioning System (GPS) devices will be used with a randomly selected (based on day care centre attended) sub-sample of children taking part in the

PLAYCE study (n=310) to log X, Y location coordinates, distance, speed, elevation, and time for seven days. This sample size will provide 80% power to detect a meaningful difference in MVPA between two groups for an attribute of the neighbourhood environment (e.g., living in high vs. low walkable neighbourhood). The Q-1000XT has a median dynamic accuracy of 2.9 meters under different environmental conditions.[65] The Qstarz GPS is a small device that is worn on the left hip on the same belt as the accelerometer. We aim to collect location data from the GPS unit (and corresponding accelerometer) for the majority of waking hours on at least three weekdays and one weekend day during the seven-day period.[65] Outdoor location and physical activity data will be processed for analysis using the Personal Activity Location Measurement System (PALMS) software.[65]

Measurement of the day care centre physical and policy environment

We have adapted the Environment Assessment and Policy Observation (EPAO) instrument[66] 'Physical Environment' sub-scale for the Australian context and expanded it to gather detailed information on the indoor and outdoor physical environment of day care centres. The EPAO instrument was developed to assess the quality of day care centres physical activity and eating behaviours in the U.S.[66 67] and has been validated.[25 68] Physical environment and physical activity policy components of the EPAO assess fixed play equipment, portable play equipment, outdoor running space, indoor play space, and whether the centre has a written policy and documented curriculum on physical activity.[66 69] The presence and quality of other features of the outdoor day care physical environment including vegetation,[70-72] paths,[73] surface material,[28] slope/gradient,[74] natural features[74] and play settings[66] will also be collected. Revised audit items have undergone intra- and inter-rater reliability testing and have been found to have acceptable reliability (i.e., kappa or intraclass correlation coefficient [ICC] > 0.60).[75] Greenness will be determined by viewing

satellite imagery[76] and shade above play structures examined through fisheye photography.[71] The actual ‘useable’ outdoor and indoor space will be measured using a laser measure.

Day care educator survey

Information on educator and centre-level physical activity-related practices will be collected. Survey items are based upon the Nutrition and Physical Activity Self-Assessment for Child Care[73] and have been adapted for the Australian context. Time provided for physical activity, types of physical activities, equipment available for children to use, educator physical activity related practices and professional development and the application of relevant physical activity-related policies in the centre will be measured. Items have very good to excellent test re-test reliability (i.e., kappa or ICC > 0.60).[75] Two educators per centre (centre director and one other) will complete the survey.

Parent survey

The parent survey will collect socio-demographic information about the child (e.g., age, gender, siblings) and parents (e.g., age, gender, socio-economic status). Additional individual factors will include child sleep,[77] temperament,[78] preference for physical activity,[79] and physical competence.[80] The social environment will be measured by parents perceived importance of and support for child physical activity[81 82] and rules and limits around children’s physical activity.[56 79] Additional contextual measures of child physical activity behaviour will include the amount of structured and unstructured physical activity,[83] outdoor play[36 84]and electronic media use.[56] Parent perceptions of the neighbourhood environment (neighbourhood safety, crime-related safety, access to services, streets in the neighbourhood, places for walking, neighbourhood surroundings and neighbourhood

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3 preferences) will be measured using the Neighbourhood Environment Walkability Scale for
4 Youth (NEWS-Y).[85] Finally, information about home yard space[86] and dog
5 ownership[87] will be collected.
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11 *Objective measurement of day care centre and home neighbourhood built environment*

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14 Geographic Information Systems (GIS) data will objectively measure aspects of each day
15 care centre, home and neighbourhood environment. Neighbourhood-level GIS measures for
16 each centre and participant's homes will be calculated using a specified buffer area (800m)
17 from the centre/home. GIS derived measures for day care centres and the home include
18 outdoor space, greenness, availability and quality of public open space and traffic exposure
19 (Table 1). Home-based GIS measures also include walkability (index comprised of three sub-
20 components: street connectivity, land use mix and residential density)[88] and access to local
21 amenities (e.g. access to schools, public transport and shops and services).
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Table 1: PLAYCE study day care centre, home and neighbourhood environment GIS derived measures

Measure	Description
Day Care Centre Neighbourhood Environment:	
Outdoor space	Area of block that are not covered by day care centre building (outdoor space)
Green Space	Access (distance) to parks, types and sizes of parks and quality (e.g., playgrounds) of parks
	Access to nature areas
	Access to school grounds
	Neighbourhood greenness
Traffic exposure	Percentage of total length of roads within a service area that are NOT main roads
Home and Neighbourhood Environment:	
Home yard area	Area of residential blocks that are not covered by building (yard size)
Green Space	Access to parks, types and sizes of parks and quality (e.g., playgrounds) of parks
	Access to nature areas
	Access to school grounds
	Neighbourhood greenness
Child-Relevant Destinations	Access to kindergartens, child-centre-based-care, child health clinics, family support services, play group venues
Street connectivity	Number of 3-way or greater intersections/service area
Land use mix	Access to utilitarian and recreational destinations. Evenness of spread of different land uses within a service area
Residential density	Number of residential dwellings/residential land area in service area
Low traffic exposure	Percentage of total length of roads within a service area that are NOT main roads
Public transport stops	Number of public transport stops (bus and rail) within a service area

Data analysis plan

In addition to descriptive statistics, a mixed model regression approach will be used to determine the amount of physical activity (LMVPA and MVPA) children accumulate whilst a) at day care and the contribution it makes to meeting the recommended three hours of physical activity per day; and b) whilst indoors and outdoors at large compared with small sized day care centres. Analyses will also examine the influence of different combinations of indoor and outdoor space per child (e.g., high amount of outdoor and indoor space/child vs. low amount of outdoor and indoor space/child) as well as features of the outdoor and indoor physical environments, policy environment and educator practices in day care centres associated with pre-schooler physical activity (and sedentary time). A moderation and mediation analysis will be performed using the physical environment quality rating for day care centres. Analyses will adjust for clustering of children within day care centres as well as individual child and parent socio-demographic factors (e.g., child age and gender, time spent at day care, parent socio-economic status).

We will determine the proportion of centres who are meeting and not meeting the 'Health and Safety' national standard in terms of achieving the recommended three hours of physical activity per day and the proportion of centres who are meeting and not meeting the 'Physical Environment' national standard in terms of the presence and quality of attributes within the day care physical environment. Findings from Objective 2 analyses will inform what key 'Physical Environment' attributes will be included. All analyses will adjust for child and centre level confounders.

Finally, we will use GPS and accelerometer derived variables to determine where, when and for how long pre-schoolers are active (or inactive) around their home and neighbourhood.

Separate multilevel models will be used to determine the influence of specific features of the home and neighbourhood environment (e.g., size of backyard, access to green space, traffic exposure, neighbourhood walkability) on pre-schooler physical activity (and sedentary behaviour). Significant predictors of the home and neighbourhood environments will be placed in the one model to determine the relative significance of these environments on children’s physical activity. The relative contribution of the home, neighbourhood and day care environments to achieving recommended levels of physical activity will be examined through multi-level regression models.

ETHICS AND DISSEMINATION

Ethical approval has been granted by The University of Western Australia Human Ethics Research Committee, approval number RA/4/1/7417. Directors of day care centres will provide informed written consent to participate and parents will provide informed written for themselves and their child’s participation in the study. At the day care centre data collection visit research staff will provide each child with a brief and simple description of the devices (accelerometers and RFID/GPS), will answer any questions the child may have and confirm they are willing to wear the device/s. All equipment to be used in the study has been approved for use with children. Furthermore, all individuals working directly with children will have a Working with Children Check⁹⁵ as per Western Australian legislative requirements.

All participants’ responses and data will be strictly confidential. No names or addresses will appear on any typed reports including publications. Only aggregated data will be used to describe research findings. All data will be retained at completion of the study for at least 7

years and kept as per The University of Western Australia requirements for data retention and disposal.

Findings will be published in international peer-reviewed journals. The Final Report and a copy of published papers will be forwarded to key stakeholders, collaborators, policy-makers and practitioners working in the ECEC sector. The research team will work closely with Day Care Directors, Educators, and the regulating body (ACECQA) to inform the Australian National Quality Framework for Early Childhood Education and Care[34] and the Australian Early Years Learning Framework[34]. Findings will also be disseminated via a number of local, national and international conference presentations and invited talks. The Director of each participating day care centre will receive a group summary report and individual child physical activity reports will be given to parents.

DISCUSSION AND CONCLUSION

Early physical activity behaviour has a significant effect on health across the life course. Findings from the PLAYCE study will provide important evidence for reducing the long-term effects of physical inactivity and chronic disease. The PLAYCE study will determine how much physical activity pre-schoolers accumulate in different behaviour settings (home, neighbourhood and day care), and the contribution each of these makes towards achieving the recommended level of physical activity for health and development. This study will investigate a range of features, including indoor and outdoor space, play equipment, the natural environment, traffic exposure, access to local amenities, day care educator practices and day care centre policies to determine their level of influence on children's physical activity across different behaviour settings. Findings will strengthen the evidence base to inform which features of the day care, home and neighbourhood physical environment are

most important for influencing young children’s physical activity. This information can be used by: i) early childhood educators and regulating bodies to provide day care environments that support and encourage more physical activity in pre-schoolers; ii) urban planners and policy makers to develop more child and family friendly neighbourhoods; and iii) practitioners to develop interventions to support parents in providing opportunities for their children to play outdoors.

The findings will contribute to the evidence base required to inform policies that can positively impact pre-schooler physical activity levels across three key settings: home, day care and the neighbourhood. In seeking to influence policy and practice relating to the health and development of young children, this project will actively engage with key stakeholders, collaborators, policy-makers and practitioners from the study’s inception through to the dissemination and translation of findings. For example, by identifying features of the day care physical environment that promote physical activity and active play, we will assist Childhood Educators identify if their day care centre is meeting the ‘Physical Environment’ and ‘Health and Safety’ quality standards and how they can improve the physical environment to support children’s physical activity, health and development. This in turn will inform practices to help centres achieve and exceed national quality standards relating to the day care environment and children’s physical activity and health. Furthermore, findings from this study will be used as baseline measures for developing interventions for the day care physical (and policy) environment to establish the causal impact of the day care environment on children’s physical activity and development. Considering a large proportion of pre-school age children attend day care, optimising the day care environment to facilitate young children’s physical activity has the potential to increase population levels of physical activity in this age group.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

HC conceived and designed the study. CM, GT, SGT, JS, BB, LL, MR and SRZ had input to the study design. HC, CM and SE drafted the manuscript revising it critically at each stage. All authors contributed to the drafting of the manuscript, and read and approved the final manuscript.

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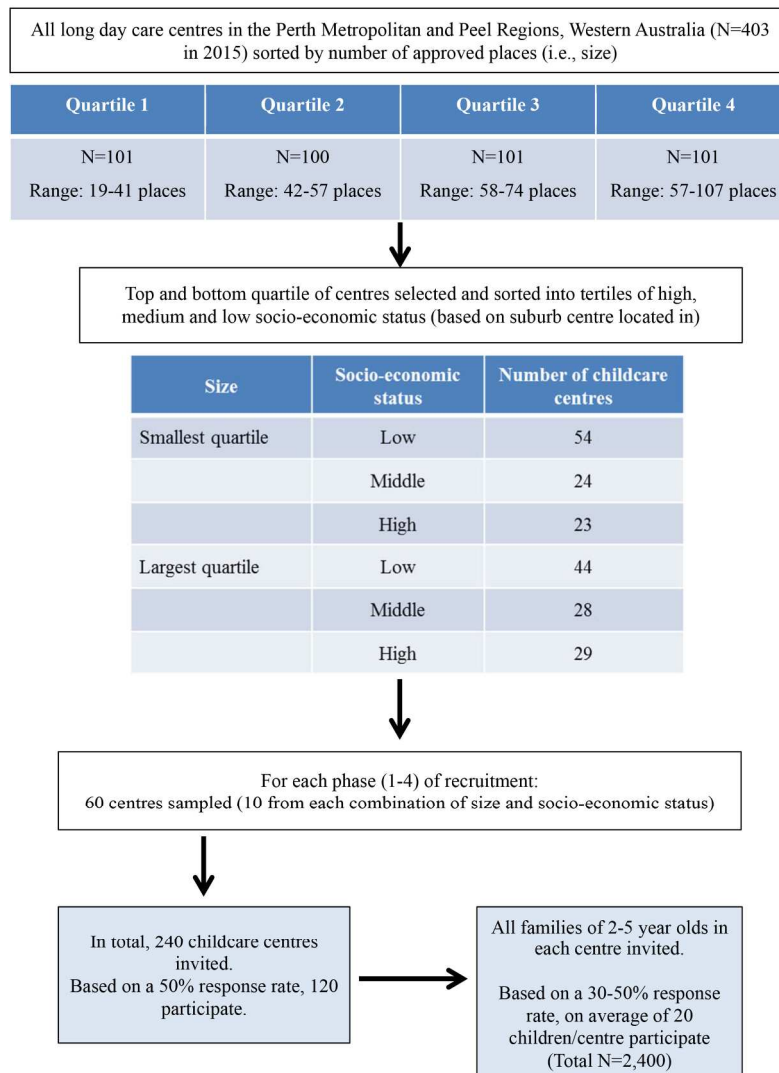


Figure 1: PLAYCE sampling and recruitment

233x357mm (300 x 300 DPI)

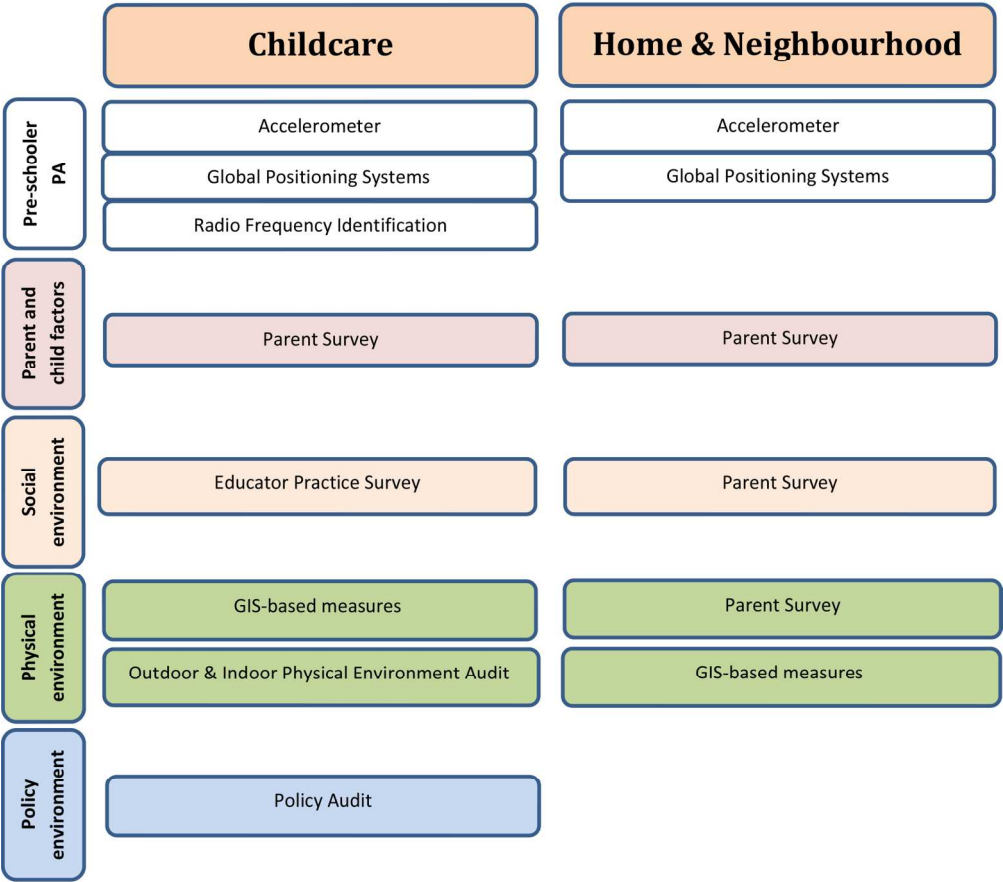


Figure 2: PLAYCE study data collection methods across pre-schooler physical activity behaviour settings

196x221mm (300 x 300 DPI)