# Integrating GPS and accelerometry into large scale, population level, data collections: practical utility for measuring participation in outdoor recreation, and concerns and considerations regarding its application in 10-11 year old children.

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# What is GPS?

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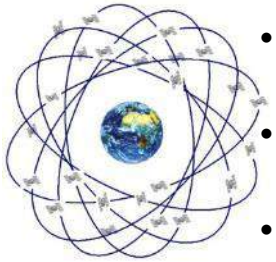
- The Global Positioning System (GPS)
  - U.S owned utility that provides users with positioning, navigation, and timing (PNT) services
  - Launched in 1973



- **Space segment** – 24 operating satellites (network of 31) that transmit one-way signals of position and time.
- **Control segment** – worldwide monitor and control stations that maintain satellites in orbit.
- **User segment** – GPS receiver equipment (the user) to calculate 3D position and time.

- GLONASS (Russia), GALILEO (Europe), BDS (China), IRNSS (India)

- Mobile phones, watches, car navigation systems


# What is an accelerometer?

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- Acceleration is defined as the change in velocity over time (e.g. $m/s^2$).
- Acceleration is proportional to the net external force involved => more directly reflective of energy costs.
- Accelerometers can measure along 1, 2 or 3 sensitive axes.
- Quantifies intensity of activity with respect to time
  - Time function allows frequency and duration to be calculated

- How is acceleration made meaningful?
  - anchored against some biological variable (energy expenditure or heart rate)
  - physical activity pattern recognition (e.g. Stationary, ambulatory)

  - **Duration** (units of time)
  - **Frequency** (number of sessions, bouts or days)
  - **Intensity** (energy expenditure above basal rate, vertical acceleration of the body, frequency of the heart beat)
  - **Type** (walking, cycling, football, gardening)?????
  - **Domain** (leisure, work, school, transport)

# What can GPS technology enable us to explore?

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- A record of position (longitude and latitude)
- Timestamp
- Altitude, Speed
- Precision estimates
  - Number of satellites in view/used
  - Ratio of signal to noise

Why is that useful?

- 'Actual' exposure to our environment

- Digitisation of PA with respect to time
- Timestamp

Why is that useful?

- High frequency record of a health behaviour
- Can be used as a health outcome
- Can also be used to quantify physical inactivity and sedentary behaviour

# What can GPS technology enable us to explore?

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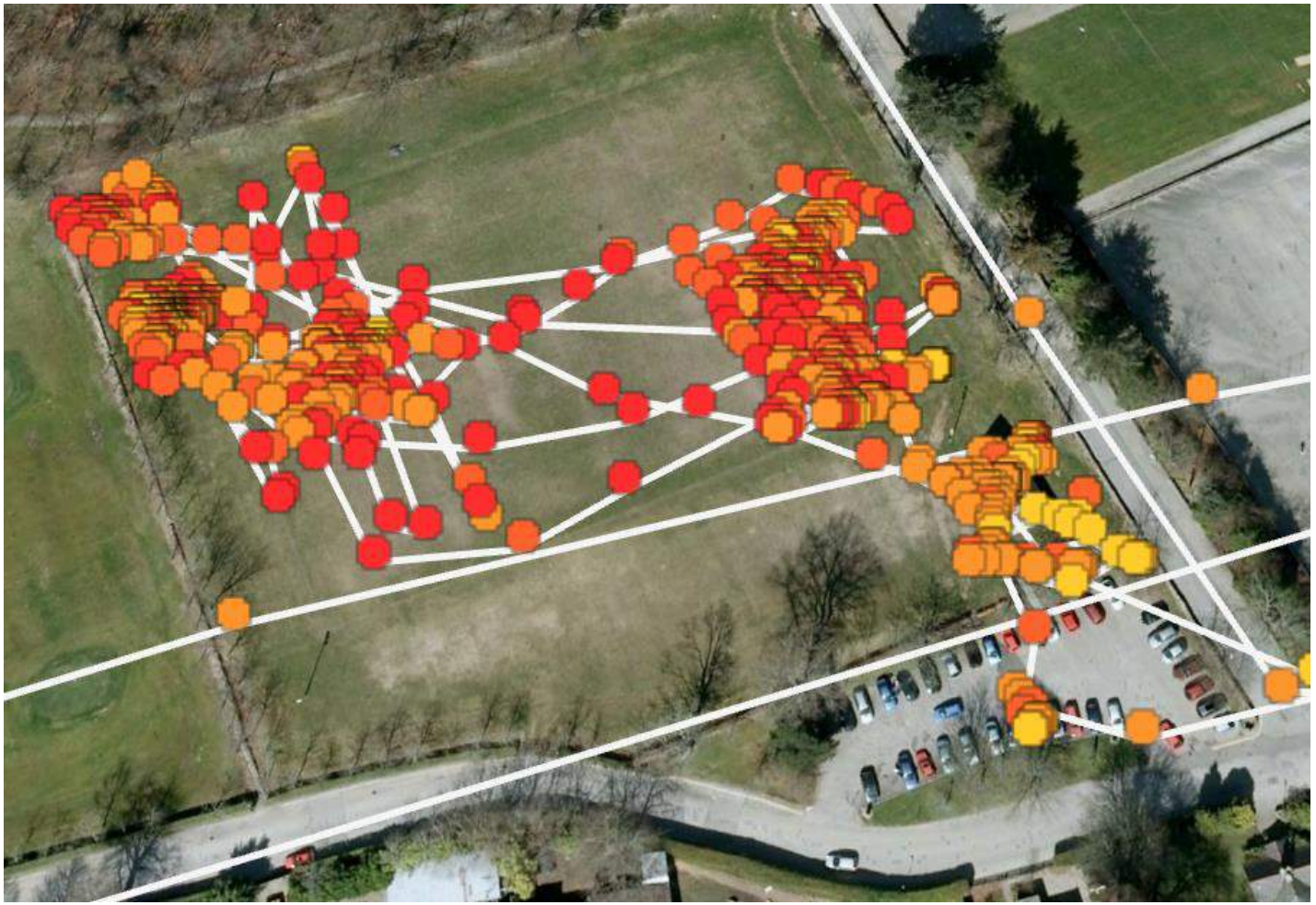

# What can GPS technology enable us to explore?

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SPACES

Studying Physical Activity in Children's Environments across Scotland

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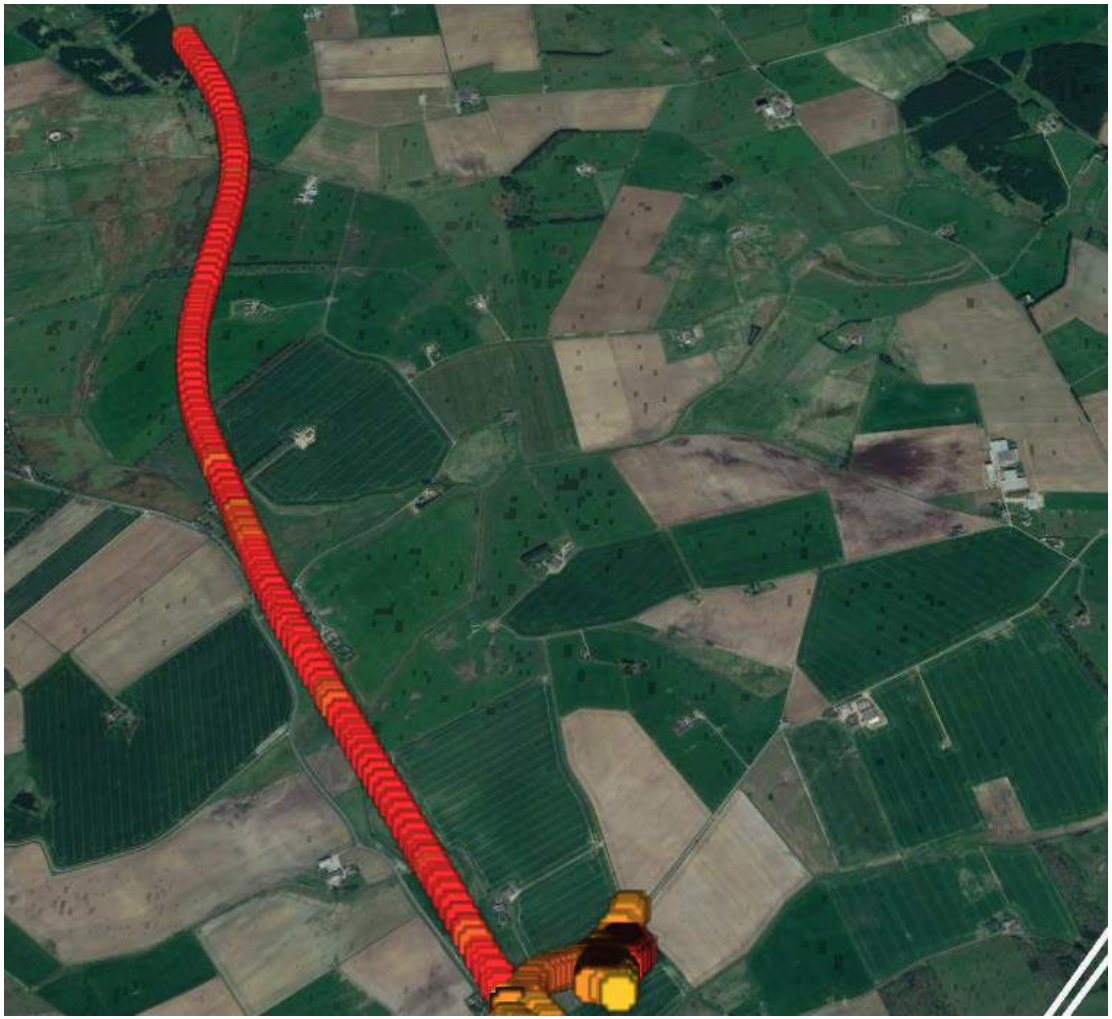

# What can GPS technology enable us to explore?

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So what?

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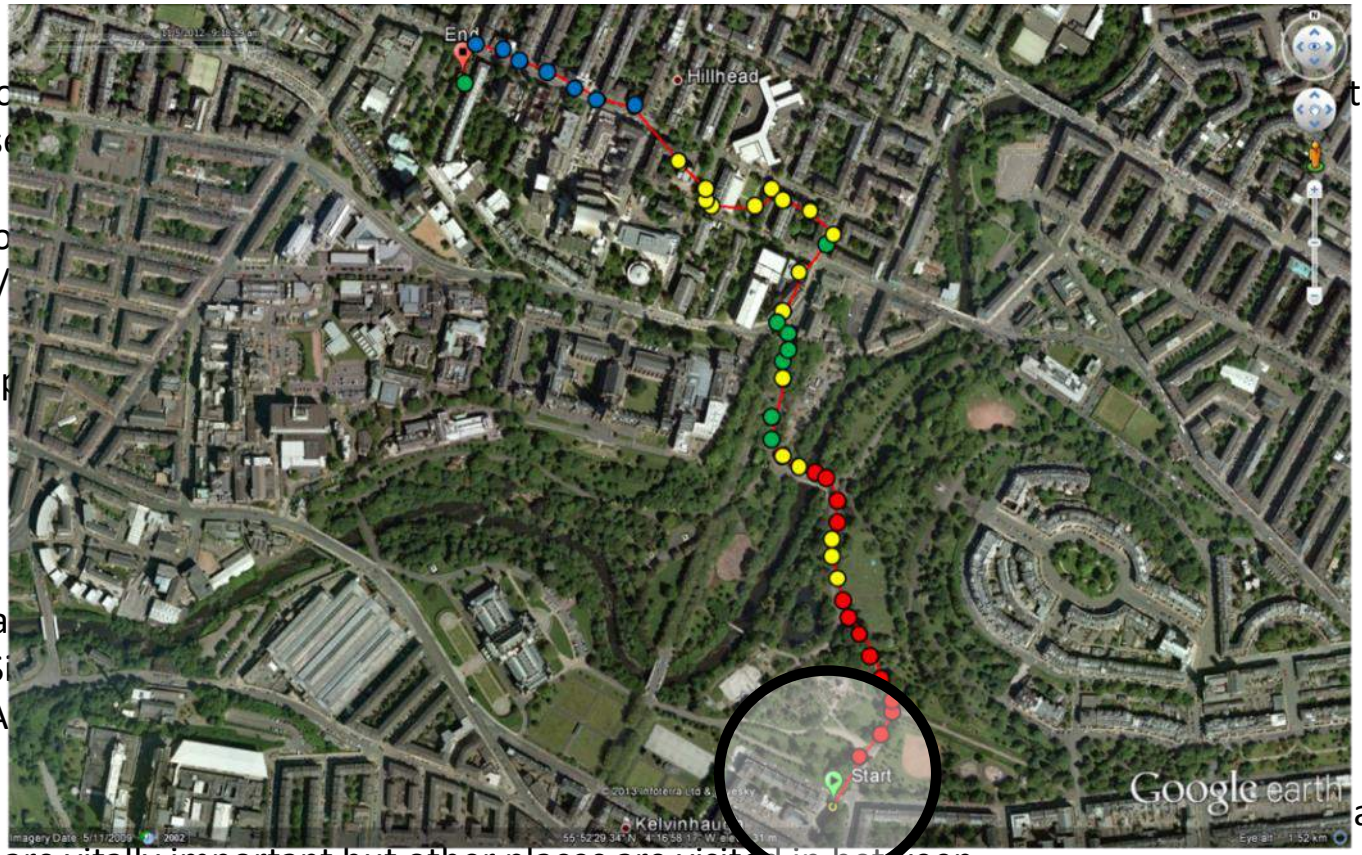


text

and school are vitally important but other places are visited in between.

*Example mapping of physical activity data (spatial and intensity) within Google earth: green = sedentary, yellow = light, red = moderate, blue = vigorous*

# What can GPS technology enable us to explore?


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Transport

- What percentage of transport is active and passive?
- What distance do people travel by bike, or on foot?
- Does traffic volume determine transportation mode to school?
- Does cycling/walking to school/work expose us to harmful levels of air pollution?
- Does built environmental change influence active travel?

Neighbourhood

- How far do children roam from their home location?
- How long do children spend indoors and outdoors?
- What factors influence/determine being outdoors?
- How big are children's neighbourhoods and what drives their size and shape?
- How does neighbourhood change influence X?

Exposure

- Is greenspace accessible? If so, is it used? If so, what kind of activity occurs in greenspace?
- Are children/adults exposed to 'environmental bads' and does this have an negative effect on health? Is this relationship socially patterned or moderated by urbanicity?
- What are the longitudinal effects of systematic change in exposure on health/behaviours?

# What is SPACES?

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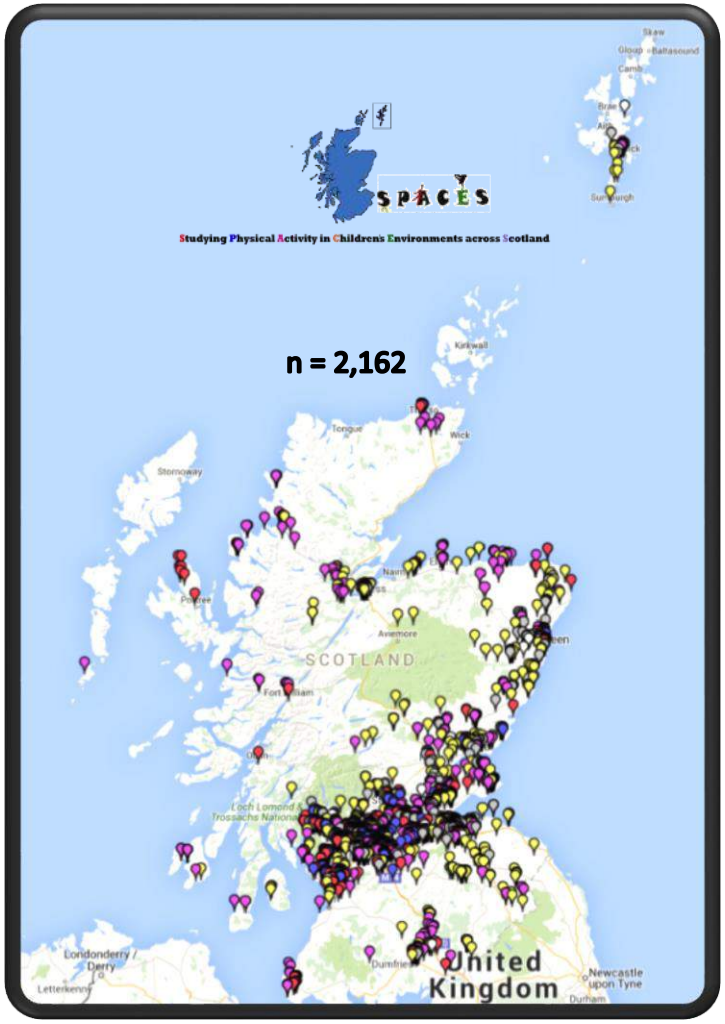
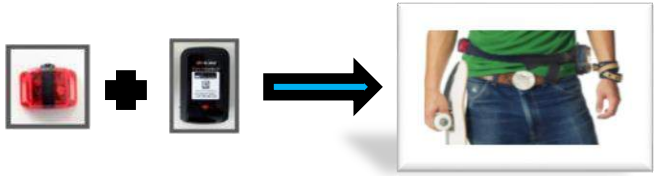



**GUS original Birth Cohort 1**
**C. 5,000, born between 2004-2005**

**GUS sweep 8, n = 2,402**
**(2014-2015)**
**10/11 years old**

Growing Up in Scotland



8 days
Waking hours

# Initial considerations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- Cost
  - GPS device - £60
    - Purchased 170 and borrowed 230
  - Activity monitor - £150
    - Purchased 225 and hold 175 for other projects.
  - Project cost - ~£500k
- Ethics
  - Sensitive issue for ethics committees and educational authorities
  - 'Tracking' 'Big Brother' 'real-time observation'
  - Data is translated into unidentifiable numbers to represent outcome
    - Mins spent in greenspace, mins spent walking to shop.
    - Never presented at individual level.


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# PILOT 1

# Piloting work and issues identified

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Pilot 1

- One urban school (n=32), one rural school (n=40)
- Asked to wear both devices for 8 consecutive days

*Actigraph GT3X+, Actigraph, Pensacola, FL, USA*

*Garmin Foretrex 301 as worn on the wrist*

# Piloting work and issues identified

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## Compliance issues

" To begin the watch thing was pretty cool as it felt like I was Ben 10…."

"After one day it started digging into my wrist and…was really annoying"

| Number of days | % of sample with valid data |
|---|---|
| 1 day | 95.7 |
| 2 day | 78.6 |
| 3 day | 62.9 |
| 4 day | 30 |

# Modification

# Piloting work and issues identified

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## Modification of GPS device choice and placement

- More accurate device – QSTARZ BT-Q1000XT
  - Indoor/outdoor estimate
- Easier interface
- Central location
- More comfortable
- Both should be worn at same time
- Less burdensome

# PILOT 2

# Piloting work and issues identified

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# Piloting work and issues identified

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- Initial charging devices bought in bulk.
- When packaged and sent to survey office staff they were unable to fit through the letterbox.
- The dimensions of the charger were too big.


- Potential engagement Implications for a number of sub population groups (e.g. rural, deprived)

# Sources of concern - processes

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## Variability in GPS pouch size

### Issue

- GPS device held in a pouch then attached to an elastic belt
- Large variability in size of the pouch

### Implication(s) for Participant

- Device can easily fall out and become lost
- May have implications in more vigorous activities

### Solution

- Modified pouch that incorporates a Velcro strap

# Real-time and post-processing

# Sources of concern – real-time and post processing


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GPS memory and battery life

- Memory storage
  - User defined 'epoch' setting
  - Manual claims 400,000 points over 40 days every 5 seconds, 12 hours/day
  - In practise this is not the case (~50,000 over 8 days)
  - Protocol was set to record every 15 seconds, 24 hours/day but found memory full after 6.5 days
    - Immediate protocol change to 'waking hours'

- Battery life
  - Manual claims up to 42 hours
  - In practise this is not the case (~30 hours)
  - Impact on participant engagement
    - Charged overnight

# Sources of concern – real-time and post processing

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GPS data post processing

- Built
  - 
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Figures courtesy of University of San Diego PALMS system

# Participant response

# Main study participants

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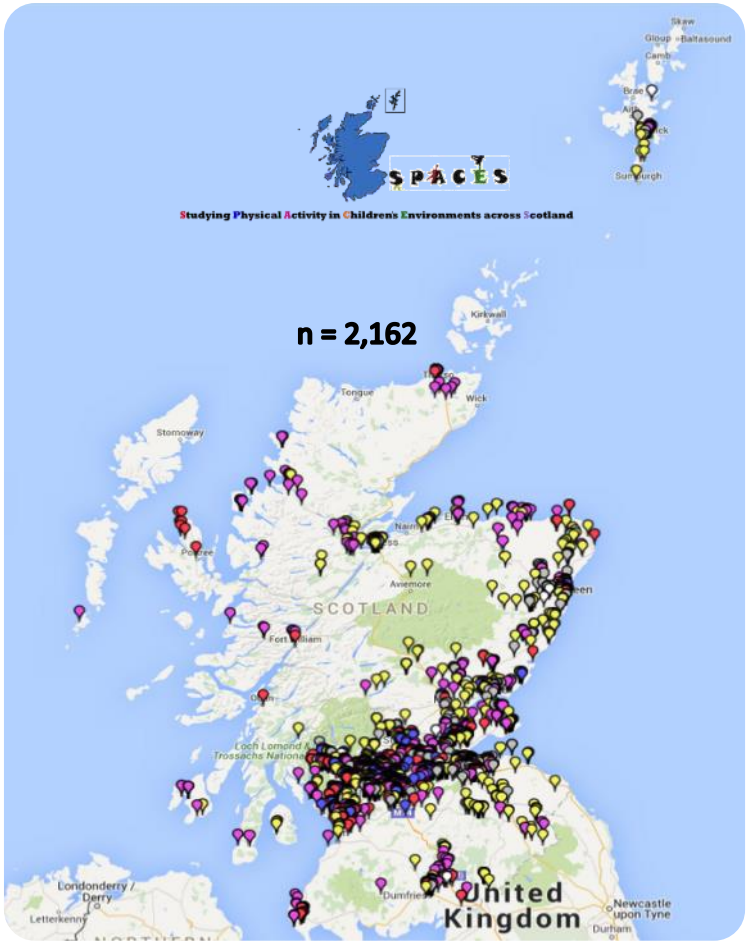


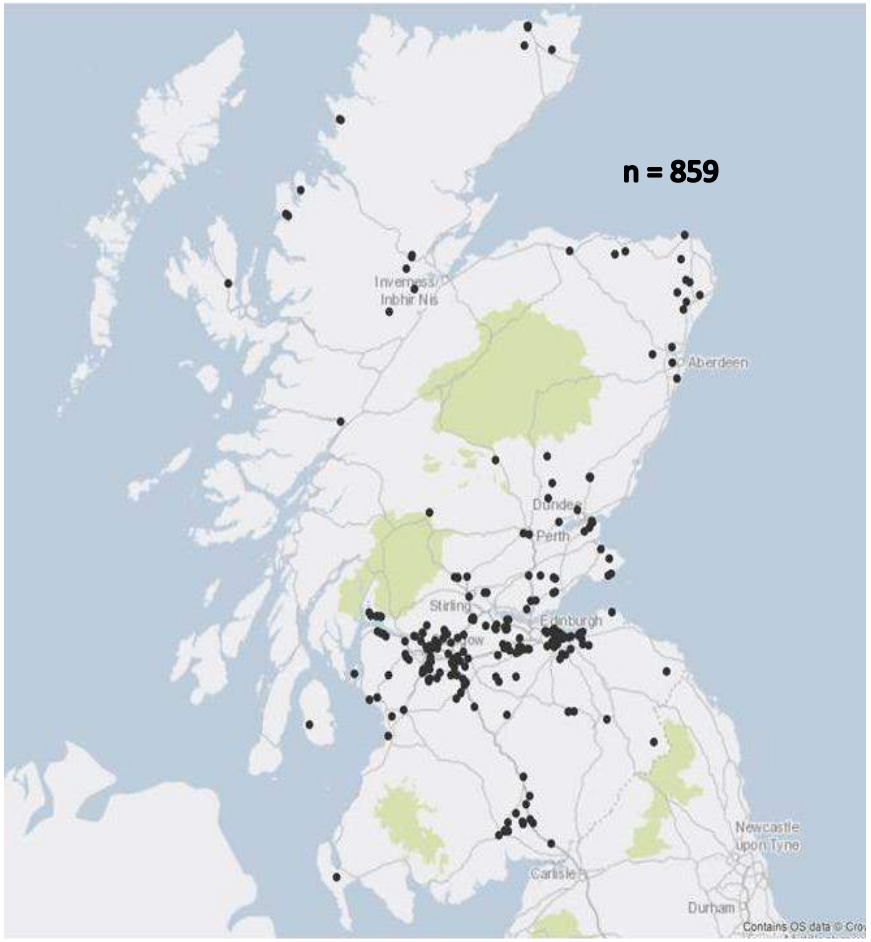

# Sample

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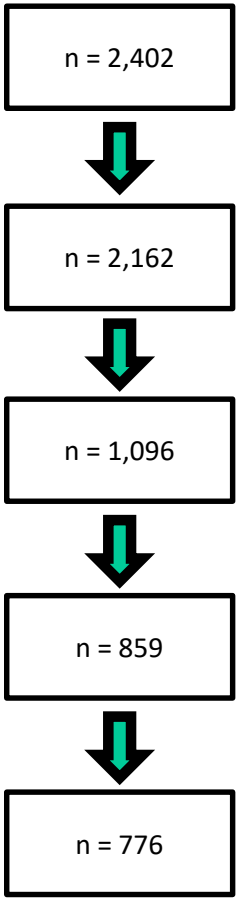
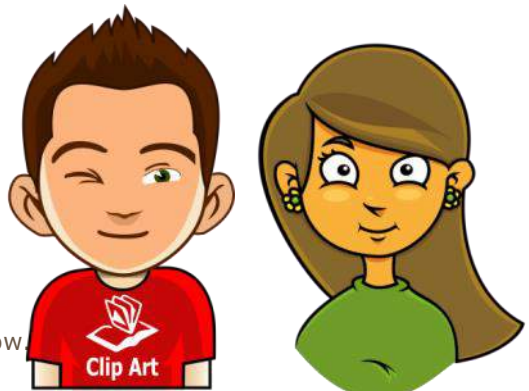
- 1,096 children agreed to take part
  - 51% of children contacted
- 859 children returned data
  - 78% of those agreed to take part
- 776 children provided sufficient data
  - 36% of those contacted
  - 71% of those who agreed to take part
  - 417 (54%) girls and 357 (46%) boys
- 39% overall response rate



# Sample non-response

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| Socio-economic demographic | SPACES sample | SPACES weighted sample | Sampling frame (original cohort or GUS sweep 8) |
|---|---|---|---|
| **Income (per annum)** | | | |
| <£3,999 - £9,999 | 1% | 3% | 3% |
| £10,000 - £19,999 | 9% | 20% | 16% |
| £20,000 - £28,999 | 15% | 18% | 14% |
| £29,000 - £37,999 | 15% | 14% | 15% |
| £38,000 - £49,999 | 17% | 14% | 16% |
| >£50,000 | 42% | 27% | 35% |
| **SIMD quintile (2012)** | | | |
| Most Deprived | 8% | 21% | 25% |
| 2nd | 13% | 18% | 18% |
| Middling | 22% | 19% | 19% |
| 4th | 27% | 21% | 20% |
| Least Deprived | 30% | 21% | 18% |
| **Highest educational qualification in household** | | | |
| No qualification | 1% | 3% | 5% |
| Lower level Standard Grades or equivalent | 2% | 3% | 4% |
| Upper level Standard Grades or equivalent | 13% | 19% | 20% |
| Higher Grades or equivalent | 34% | 39% | 33% |
| Degree level academic or equivalent | 49% | 35% | 38% |
| Other | 1% | 1% | 1% |

# Device loss

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| Demographic | Device loss (from n = 1096) |
|---|---|
| **SIMD quintile (2012)** | |
| Most Deprived | 13% |
| 2nd | 7% |
| Middling | 8% |
| 4th | 4% |
| Least Deprived | 5% |
| **Urban/Rural dwelling** | |
| Large urban | 5% |
| Other Urban | 7% |
| Small accessible towns | 10% |
| Small remote towns | 3% |
| Accessible rural | 7% |
| Remote rural | 2% |

# Acknowledgments


Studying Physical Activity in Children's Environments across Scotland


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