Abstract

Spatial education interventions in the built environment may increase engagement with urban greenspace.

This research was a natural experimental study with mixed-method evaluation and repeated cross-sectional design. Twenty-four directional wayfinding signs were installed within an urban park to create a 3 km signposted walking route through the park's amenities in a clockwise direction. Manual counts on one path and bi-directional automated active infrared counts on six paths along the intervention route were conducted at baseline and 12-month follow-up. A QR code accessed intercept survey was open throughout the follow-up phase to capture user experiences, views, and attitudes toward the intervention.

There was no consistent difference in manual counts at baseline or 12-month follow-up between intervention and control parks. Automated counts showed no consistent significant change in clockwise footfall between baseline (median automated count range across six counters: 10 - 130 clockwise counts per day) and follow-up (Autumn to Winter follow-up median automated count range across six counters: 13 – 103 clockwise counts per day; Spring to Summer follow-up median automated count range across six counters: 13 - 124 clockwise counts per day). However, 23% (11 out of 48 people) of clockwise travelling route users reported they were following the signs at 12-month follow-up. Intercept survey respondents (n = 27) appeared to be infrequent park users (number of respondents for 'my first visit': 7, and 'one to two times per month: 9), with the new signs making them feel less anxious about exploring unfamiliar areas, while motivating them to walk further than originally planned and helping them to 'take notice' of the landscape.

Directional wayfinding for recreational walking appears to help infrequent users engage with urban greenspace.

Keywords

greenspace; wellbeing; wayfinding; walking; natural experiment; parks

Background

Urban Parks and greenspace use

The value of health benefits associated with outdoor recreation was estimated to be between £6.2 – 8.4 million within the United Kingdom for 2020, which was related to a 58% increase in the number of people gaining health benefits from outdoor exercise, in comparison to 2009 (Office for National Statistics, 2022). Public Health England, now known as the Office for Health Improvement and Disparities, recognise the health and well-being value that greenspaces can provide to the general population and have made recommendations at policy, practice, and research levels to improve access to greenspace (Public Health England, 2020).

With the increasing evidence base for the potential health benefits of using greenspace, it is particularly germane to understand access to and use of greenspaces within urban environments. This is because urban dwellers regularly report having limited contact with 'natural ecosystems', and thus limited access to the potential health and wellbeing benefits of such spaces (Wolch et al., 2014), Within the United Kingdom, urban park's status as non-statutory services renders them vulnerable to local authority budget cuts and under-resourcing in terms of funding and management(Smith et al., 2023), which is coupled with increasing planning priorities placed on urban development to the detriment of greenspace (Baur et al., 2013). With more than half of the world's population now living in urban spaces, which is predicted to increase to 68% by 2050 (United Nations, 2018), the health of urban residents is a contemporary and relevant public health issue.

Research has highlighted a range of social, physical, and psychological determinants of people's intention of greenspace visits and urban park use (Wan et al., 2020). For example, the facilities provided and green 'aesthetics' of an urban park can influence visitation intentions (McCormack et al., 2010), as well as the provision of seating facilities being highlighted as an influential factor on urban park use for older adults and those with mobility impairments (Ottoni et al., 2016). Beyond physical infrastructure, perceptions of safety are also important, with people avoiding urban parks in which they feel unsafe occupying (Sreetheran and van den Bosch, 2014), and community engagement and ownership contributing to park users reporting more positive experiences and attitudes toward urban parks that are responsive to user needs (Baur et al., 2013). This is only a cursory overview but highlights that there is a complex interplay of multiple factors that influence use of urban parks and greenspaces.

In this paper, we focus on socio-cultural and physical environmental factors that may influence access to urban greenspaces. 'Access' can refer to multiple personal and societal constraints, such as distance from greenspace, physical barriers within greenspace, psychological barriers (i.e. safety perceptions), cultural barriers, financial barriers, and lack of information (Forest Research, 2022). Lack of knowledge about routes has been cited as a barrier to recreational walking in greenspace (Kelly et al., 2019) therefore, the provision of information about greenspaces may remove, or at least alleviate, this barrier for some members of the population. The provision of information, such as maps or signage, is a form of education intervention that has potential to increase psychological capability, i.e. knowledge of routes, within the individual and make them more likely to engage in recreational walking through greenspaces, according to the COM-B behaviour change theory (Michie et al., 2011). Small-scale retrofitting interventions for greenspace use, such as mapping and signage, may encounter less barriers to implementation in comparison to infrastructure changes (Aldred et al., 2019), whilst still being able to influence public space engagement by the local community (Rossini, 2019; Unt and Bell, 2014; Ward Thompson et al., 2019). Furthermore, such interventions may be more feasible for a range of stakeholders to deliver, such as charitable groups and friends of parks groups, by being lower cost than larger scale infrastructure changes.

Whilst limited, there have been a range of previous research studies evaluating the effect of small-scale environmental interventions on physical activity levels, perceived wellbeing, and increased engagement with urban greenspaces. Grunseit et al. (2019) reported on a natural experimental study observing the impact of a new 8.5 km recreational trail loop on walking and cycling in Northern Sydney, Australia. Here, results suggested that the accessible loop influenced an increase in trail use and potential increase in total physical activity, particularly amongst children. Similar in focus, Clark et al. (2014) found that the introduction of a marketing campaign, incremental distance markings, and directional wayfinding on recreational trails in Southern Nevada had no significant effect on increased trail traffic from baseline to the 12-month follow-up. However, total trail use across control and intervention trails saw an increase over the observation period. The methodological approach of the study was limited as the authors were not able to ascertain the demographics of users, nor the context of trail use to gain a better understanding of the impact of the intervention (Clark et al., 2014).

Although not specifically focused on recreational walking in urban greenspaces, Benton et al. (2021) recently conducted a natural experimental study on the influence of urban canal pathway improvements on usage, physical activity, and wellbeing measures in Greater Manchester, United Kingdom. Reported results showed an increase in the total number of people observed using the canal path at the intervention site compared to the comparative canal paths across a 12-month follow-up, with authors concluding that environmental interventions showed potential for increasing physical activity and wellbeing behaviours. Furthermore, Veitch et al. (2018) reported on increases in urban park visitation in Melbourne, Australia due to the installation of a play-scape in which researchers observed a 76% increase in park visitor counts from baseline to 12-month follow-up.

In summary, there is increasing research using natural experimental designs, which show mixed but promising results on the influence of environmental changes to the built environment on physical activity and other wellbeing behaviours. Many of the natural experimental studies that assess the influence of environmental interventions on physical activity lack robust methodologies, which increase their risk of bias (Benton et al., 2016; Humphreys et al., 2017). However, there are demands from leading experts in physical activity research to make greater use of natural experimental studies to tackle the public health issue of physical inactivity (Craig et al., 2022; Ogilvie et al., 2020). This study offers novelty in its contribution through firstly adding to the limited research on spatial education interventions in the built environment, specifically using wayfinding signage, within the United Kingdom. Secondly, it offers a methodological contribution through sharing novel approaches to conducting and evaluating natural experimental studies through mixed-method designs, as well as transparently reporting on local context and community co-production in such interventions [citation removed for review].

The current research project

This was a collaborative project with Delapré Abbey Preservation Trust and Northamptonshire Sport. Our current research project proposed the installation of signage along several existing paths within an urban park to create a signposted 3 km circular route, which would take users through key park amenities (i.e. woodland, lake, heritage Abbey building, and historic battlefield). Our previous work in the study location had suggested that local communities largely supported the implementation of wayfinding signage within parks and public footpaths to enhance users' knowledge of nearby walking routes [citation removed for review]. Our initial public survey to gauge public opinion about the project and to assess our hypothesised logic model ([citation removed for review], Supplementary File 1) suggested that the installation of signage could address individual barriers to recreational walking, such as perceptions of safety, wayfinding anxiety, knowledge of the area, and route planning. Furthermore, the survey provided an opportunity for the local community to identify key information that they would like to appear on signage for recreational walking routes. The most common responses were: 1. directional arrows, 2. total distance of the route, 3. consistent colours and fonts, 4. a map of the route, 5. local information of interest, 6. emergency contact information [citation removed for review]. The findings from the survey subsequently informed the design of the signage described in the current research article.

The overall aim of the research project was to investigate the effect on visitors' physical activity behaviours and greenspace engagement by installing directional wayfinding, to create a looped walking route, within an existing urban park. The research project objectives were: 1. to examine whether the intervention increased the number of people using the intervention site in comparison to matched comparison sites using manual observations, 2. conduct objective 1 with automated observations to assess the feasibility of this method within the intervention site, and 3. to assess whether the intervention users' perceptions of the wayfinding materials align with the hypotheses provided within the initial logic model.

Methods

Study design

The current research project was a natural experimental study with an intervention site and two control sites. An overview of the social, health, and geographical context of the current research can be found in Supplementary File 1. A mixed-method approach was used for the process evaluation of the intervention. The rationale for this concerns the recognition of the complexity of physical activity as a human behaviour, which cannot be sufficiently understood through single method designs (Anguera et al., 2017). Furthermore, the need for triangulation of both quantitative and qualitative data to gain greater contextual understanding of interventions to promote physical activity in greenspaces has been highlighted in a systematic review on the topic (Hunter et al., 2015). Therefore, observational data collected via manual and automated counts were triangulated with route-user intercept survey data in the current study. Ethical approval was granted by the Faculty Ethics Committee (Ethics Code: 202102). The project protocol was registered prior to data collection on Open-Source Framework [citation removed for review].

Delapré Walk: 3 km walking route intervention

Delapré Park has approximately 8.22 km of footpaths however, prior to the intervention, there were only two wayfinding information boards within the park (Figure 1). The most used route was from Delapré Abbey, through Charterwood, around Delapré Lake, and back to Delapré Abbey through Charterwood, according to Strava Global Heatmap (Strava Inc, San Francisco, USA). The intervention installed 24 directional wayfinding signs (Figure 1) that directed visitors on a circular route through the park's key features: Charterwood, Delapré Lake, the South Lawn, the Historic Battlefield, Delapré Abbey, and the Walled Garden (Figure 2 and 3). As there were multiple access points to Delapré Park, the signs were designed so visitors could start following the route at any entry point. The signs directed visitors in a clockwise direction using four sign variations (Supplementary File 1), mainly due to budget restrictions, with one information board about the project located on the driveway into the park from London Road (Supplementary File 1).

The wooden posts for the signs and automated active infrared counters were installed on 4th March 2021 (start of the baseline phase), the signs were then added to the posts on 26th August 2021, with an official opening event on 29th August 2021 (start of the intervention phase). The signs remain in place to date, but automated active infrared counter monitoring of footfall finished on 29th August 2022 (end of the intervention phase) therefore, the wooden posts that the counters were attached to were removed on 19th October 2022 and re-used by the Abbey's gardening volunteers to create flower beds. The project had planned for a two-year follow-up however, the local authority and the Trust received funding to upgrade several footpath surfaces, which would have likely influenced visitors' route choices. Throughout the project, information posters were erected at Delapré Abbey and on the automated infrared counters to let visitors know that footfall monitoring was taking place as well as signposting to online and hardcopy participant information sheets.

Figure 1. Existing Park wayfinding on information boards (left) and intervention wayfinding (right). *Single column fitted image, colour image required*

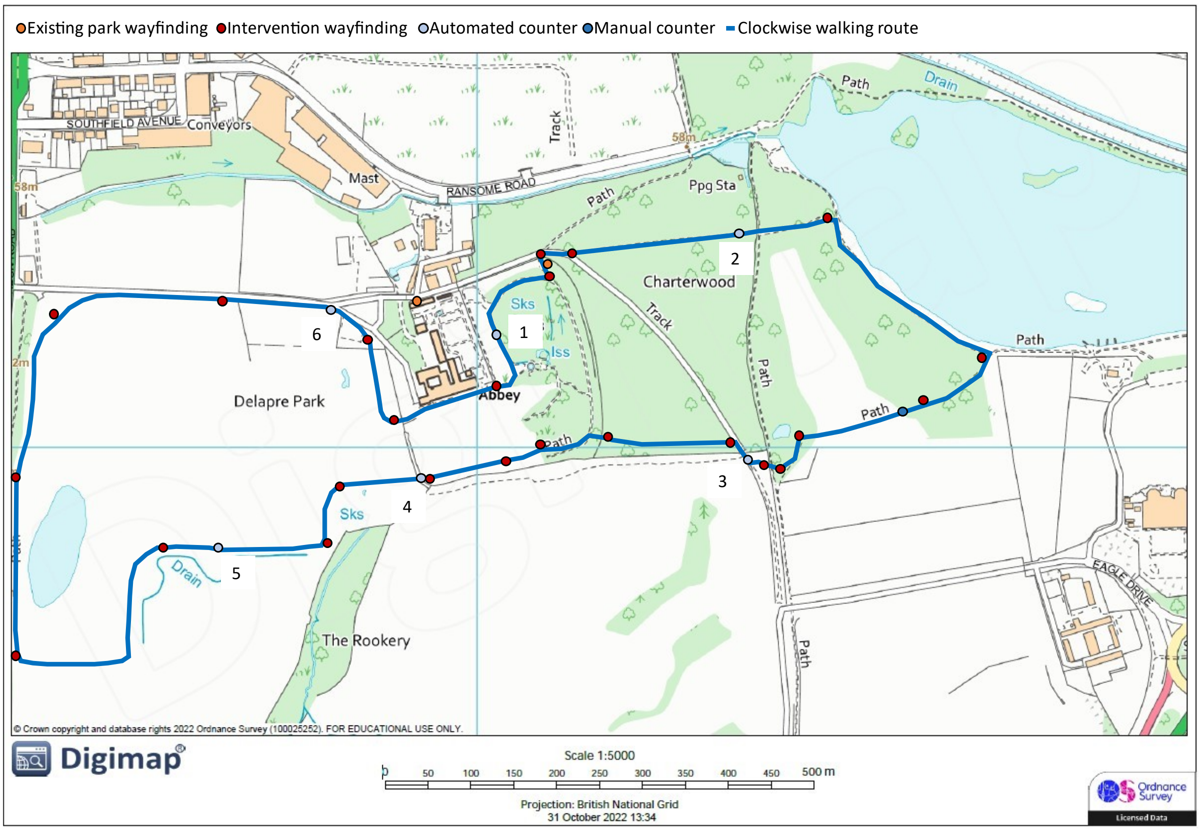

Figure 2. Map of the existing and intervention wayfinding, and counter locations. Numbers indicate automated active infrared counter ID. *Single column fitted image, colour image required*

Figure 3. Video of the Delapré Walk 3 km walking route intervention in Delapré Park, Northampton, United Kingdom. URL: https://youtu.be/U3WHKkVOcOw. *Single column fitted image, colour image required*

Manual observations

Observation dates

The ‘popular times’ function on Google Maps (Google, California, USA) was used to determine the most suitable observation days and times within the intervention (Delapré Park) and control parks (Hunsbury Hill and St. Crispin’s Park). The methods to identify suitable control parks is provided in Supplementary File 1. ‘Popular times’ suggested that Saturday and Sunday had the highest footfall in a week and footfall within the parks tended to occur between 09:00 to 18:00, peaking between 11:00 – 14:00. Therefore, manual observations took place on Saturday and Sunday at 08:30 – 09:30, 11:30 – 12:30, 14:30 – 15:30, 17:30 – 18:30, simultaneously at Delapré Park, Hunsbury Hill, and St. Crispin’s Park (Baseline: 26th – 27th June 2021; 12-month follow-up: 2nd – 3rd July 2022). Previous research testing the reliability and validity of the SOPARC has suggested that strong agreement for whole park usage can be achieved with four 1-hour observation periods per day for two days, in comparison to 96 hours of observation across seven days (Cohen et al., 2011). Observations were scheduled on dates when there were no major events scheduled at Delapré Park, following guidance from a previous natural experimental study in a similar context (Veitch et al., 2017). The current study had a similar observations schedule to Benton et al. (2021) and thus it was assumed that there were sufficient clusters to achieve statistical power.

Observers were provided with training and inter-rater reliability assessments, which are outlined in Supplementary File 1. Two observers per park counted the number of people that passed their observation station, in either direction, per one-hour observation period (Supplementary File 1). Observers coded the assumed observable demographics of visitors who were using the path independently (children in pushchairs or being carried were not counted) and repeat-counting occurred where the same visitor used the path twice within one observation period. Further observational coding took place at Delapré Park as the observers recorded the visitors’ direction of travel along the path and during the 12-month follow-up, the observers asked visitors heading in a clockwise direction if “they were following the walking route signs on their walk, today?” with answers coded as ‘Yes’ or ‘No’.

Automated active infrared counter observations

Six automated active infrared bi-directions counters (DE outdoor counter, SensMax Ltd, Riga, Latvia) were installed at natural bottlenecks along the intervention walking route (Supplementary File 1). The counters were installed at a height of 1 – 1.18 metres and width of 2 – 2.65 metres apart. The SensMax counters have been assessed for validity and reliability to estimated seasonal footfall [citation removed for review]. It was originally planned to use eight counter locations however, vandalism at the start of the project reduced the counter locations to six. Data from the counters were downloaded weekly using a DE collector remote (SensMax Ltd, Riga, Latvia) and stored on EasyReport 14.1. PRO software (SensMax Ltd, Riga, Latvia) between 1st May 2021 – 25th August 2021 (baseline phase) and 26th August 2021 – 25th August 2022 (intervention phase). Data that was collected on public holidays or major events were removed from final analyses.

Online intercept survey

Use of intercept surveys have been highlighted in previous studies of a similar nature for their value in providing greater contextual understanding to physical activity behaviours and triangulation with quantitative data (Aldred and Croft, 2019; Benton et al., 2021; Grunseit et al., 2019). Therefore, an online intercept survey was made available to park visitors through a QR code and website link on each intervention sign. The signs encouraged intervention route users to scan the QR code at the end of their walk to provide some further insight about their visitation habits, effects on physical activity and wellbeing (Supplementary File 2), which were reflective of the project's initial logic model ([citation removed for review]; Supplementary File 1). In addition, the intercept survey was also utilised to provide demographic context and to provide some understanding to any changes in automated active infrared counts (Aldred and Croft, 2019) for example, we asked "please select the option that best reflects you. By completing today's walk around the new signposted walking route, I am...

- Replacing another walking route that I would normally complete at Delapré Abbey
- Replacing another walking route that I would normally complete elsewhere
- Using the same route that I walked when the signs were not installed
- Adding a new walk to my typical week"

Weather

As weather conditions are associated with outdoor physical activity (Chan and Ryan, 2009), daily average temperature, average wind speed, and total rainfall were recorded from a local weather station (Weather Underground, 2022). Weather conditions were also recorded subjectively during manual observation dates. Our previous unpublished work, using the same data, suggested that temperature and rainfall were positively and negatively associated with automated infrared counts within Delapré Park, respectively.

Data Analysis

Quantitative analysis

SPSS Statistics (v28.0.1.0, IBM, New York, USA) was used to conduct the statistical analyses. The syntax and outputs for the analyses can be found in the Supplementary File 1. *P* value was set at ≤ 0.05.

Differences in assumed demographics within manual observations

For manual counts in intervention and control parks, a chi-squared test was used to determine differences in assumed demographics between baseline and 12-month follow-up. In circumstances where there were less than five cases either Fisher's exact test (2 x 2 model) or Fisher Freeman-Halton (3 or more group model) was used, instead of a chi-squared. A Bonferroni correction was applied in cases where a significant difference was found in tests that used three or more groups to adjust for familywise error.

Automated active infrared counts - Handling outliers

Following 482 observation days, days without missing daily counts ranged from 390 to 482 days (Counter ID-1: 468 days; ID-2: 390 days; ID-3: 396 days; ID-4: 480 days; ID-5: 357 days; ID-6: 482 days). Daily counts on UK and England public holidays or major events at Delapré Abbey were removed (124 days of 482 observation days) from analyses for each counter. Box and Whisker plots were used to assess the presence of daily count outliers for each counter in each direction of travel (clockwise or counter-clockwise). Daily counts were removed from analyses if they were identified as an 'extreme outlier' by SPSS. Forty 'extreme outlier' daily counts were removed from analyses (Counter ID-1: 5 days, 5 days; ID-2: 0 days, 2 days; ID-3: 3 days, 3 days; ID-4: 1 days, 1 days; ID-5: 3 days, 3 days; ID-6: 6 days, 8 days, clockwise, counter-clockwise, respectively). The data analyses below were conducted using between 373 to 279 days of daily counts for the clockwise direction of travel (Counter ID-1: 360 days; ID-2: 309 days; ID-3: 298 days; ID-4: 373 days; ID-5: 279 days; ID-6: 371 days) and between 379 to 284 days of daily counts for the counter-clockwise direction of travel (Counter ID-1: 366 days; ID-2: 313 days; ID-3: 305 days; ID-4: 379 days; ID-5: 284 days; ID-6: 376 days).

Incidence rate ratios

Hourly manual observation counts for Delapré Park (total counts, clockwise counts, counter-clockwise counts), Hunsbury Hill, and St. Crispin's Park were assessed for Poisson distribution using a one-sample Kolmogorov-Smirnov test ($p > 0.05$ – Poisson distribution assumed) and comparison between mean and variance of daily counts (similarity between mean and variance – Poisson distribution assumed). If Poisson distribution was assumed, then the Value/degrees of freedom ratio was assessed for closeness to 1 (value/degrees of freedom ratios outside of the 0.8 to 1.2 range were deemed to violate equi-dispersion). Every park violated Poisson regression assumptions therefore, negative binomial regression models with incidence rate ratios (IRRs) were used to determine changes in route use between intervention and control parks within baseline and 12-month follow-up for 'all characteristics', 'women', and 'Black, Asian and Minority Ethnicities (BAME)'. Women and BAME group sub-analysis was conducted as these groups tend to have greater concerns about greenspace use (Sreetheran and van den Bosch, 2014). Daily mean temperature (˚C) was included as a covariate (Benton et al., 2021; Chan and Ryan, 2009). Total rainfall was not included as there was no rainfall.

Daily automated active infrared counts for each Counter ID and direction of travel were assessed for Poisson distribution using a one-sample Kolmogorov-Smirnov test ($p > 0.05$ – Poisson distribution assumed) and comparison between mean and variance of daily counts (similarity between mean and variance – Poisson distribution assumed). If Poisson distribution was assumed, then the Value/degrees of freedom ratio was assessed for closeness to 1 (value/degrees of freedom ratios outside of the 0.8 to 1.2 range were deemed to violate equi-dispersion). Every Counter ID violated Poisson regression assumptions therefore, negative binomial regression models with incidence rate ratios (IRRs) were used to determine changes in route use at each Counter ID between baseline, Autumn to Winter follow-up, and Spring to Summer follow-up. Daily mean temperature and daily total rainfall were included as covariates.

Intercept survey

Descriptive statistics were used to present closed-ended intercept survey data due to a small sample size (27 responses). Questions that used an agreement Likert scale reported the frequency of 'strongly agree' responses to mitigate the tendency of acquiescence response bias, to focus on how the firmest attitudes relate to activity, as well as health and social outcomes, in accordance with guidance from Sport England (Sport England, 2021). Open text response data were analysed using qualitative content analysis (QCA). A directed, deductive, approach to QCA (Hsieh and Shannon, 2005) was used whereby analysis was guided by the underpinning logic model of the research project [citation removed for review] as well as previous literature in the area. Once qualitative survey data were extracted, data analysis involved three stages, involving data preparation, organisation and reporting. During preparation, researchers immersed themselves in the data through reading the data several times to understand key themes. During data organisation semantic units were coded, with similarities and differences compared. Converging units were categorised together corresponding to our key theory and relationships between units were developed, with some areas combined or discarded to produce main categories. Secondary analysts checked this coding and the comprehension of three main categories, which are presented in the results section with supporting quotes (Assarroudi et al., 2018).

Results

Manual observation counts

Assumed demographics

Table 1 provides information on baseline (26th – 27th June 2021) and 12-month follow-up (2nd – 3rd July 2022) assumed demographic characteristics from manual observations. Across all parks there was a descriptive decrease in the grand time point sum counts between baseline (Delapré Park Total: 106; Counter-clockwise: 36; Clockwise: 70; Hunsbury Hill: 47; St. Crispin's Park: 137 counts) and 12-month follow-up (Delapré Park Total: 98; Counter-clockwise: 50; Clockwise: 48; Hunsbury Hill: 25; St. Crispin's: 115 counts).

There were differences in assumed gender counts within parks at baseline and 12-month follow-up at Delapré Park for total counts (within women representation at baseline: 59.2% and follow-up: 40.8%, within men representation at baseline: 45.3% and follow-up: 54.7%) and clockwise counts (within women representation at baseline: 63.5% and follow-up: 36.5%, within men representation at baseline: 46.2% and follow-up: 53.8%), and Hunsbury Hill (within women representation at baseline: 83.3% and follow-up: 16.7%, within men representation at baseline: 47.2% and follow-up: 52.8%). There were differences in assumed age group counts within Delapré Park total counts only (within child and teen representation at baseline: 78.3% and follow-up: 21.7%, within adult representation at baseline: 47.8% and follow-up: 52.2%, within senior representation at baseline: 55% and follow-up: 45%). There were no other reported differences in assumed demographic representation within parks at baseline and 12-month follow-up.

Table 1. Sum of demographic counts for each park. Demographics are assumed from manual observation using the SOPARC observation form.

	Delapré Park (intervention)				
	Total	**Counter-clockwise**	**Clockwise**	**Hunsbury Hill (control)**	**St. Crispin's Park (control)**
Sum of manual counts	**Baseline; 12-month follow-up**				
Time points					
08:30 – 09:30	12; 15	2; 10	10; 5	6; 4	31; 24
11:30 – 12:30	36; 59	13; 35	23; 24	17; 10	46; 26
14:30 – 15:30	48; 13	18; 2	30; 11	10; 2	35; 29
17:30 – 18:30	10; 11	3; 3	7; 8	14; 9	25; 36
Grand time point sum	106; 98	36; 50	70; 48	47; 25	137; 115
Gender					
Women	58; 40	18; 17	40; 23	30; 6	57; 54

Men	48; 58	18; 33	30; 25	17; 19	80; 61
p value	**0.047**	0.14	**0.049**	**0.001**	0.39
Ethnicity					
BAME[b]	9; 5	1; 0	8; 5	4; 3	10; 16
White	97; 93	35; 50	62; 43	43; 22	127; 99
p value	0.34	0.42	0.86	0.69	0.09
Age group					
Child and Teen	18[c]; 5[c]	9; 5	9; 0	11; 3	28; 23
Adult	77; 84	24; 42	53; 42	27; 13	85; 69
Senior	11; 9	3; 3	8; 6	9; 9	24; 23
p value	**0.02**	0.16	**0.02**	0.23	0.89
Activity type					
Walking	99; 92	33; 45	66; 47	45; 24	113; 104
Running	0; 2	0; 1	0; 1	0; 0	3; 3
Cycling	7; 4	3; 4	4; 0	2; 1	21; 8
p value	0.28	1.00	0.08	1.00	0.11

[a] Gender was used as coding was based on the perceived assumption of others (Heidari et al., 2016). [b] Black, Asian, and Minority Ethnicity. [c] Significantly different from expected frequencies following Bonferroni post-hoc test. Significant differences are highlighted in **bold**, $p \leq 0.05$.

Change in manual counts

At baseline, there were no consistent differences in counts between the intervention (Delapré Park) and the control parks (Hunsbury Hill and St. Crispin's Park across all characteristics, women, and BAME groups; Table 2). At 12-month follow-up, within all characteristics there was only one significant difference between Delapré Park and Hunsbury Hill, due to a decreased median total count at Hunsbury Hill in comparison to baseline, which was also observed in the women sub-analysis. During the 12-month follow-up observation in Delapré Park, 23% (11 out of 48 people) said they were following the signposts whilst travelling in a clockwise direction along the route. However, there were no consistent differences, in counts between Delapré Park and the control parks (Hunsbury Hill and St. Crispin's Park) at baseline and 12-month follow-up, when Delapré Park counts were sub-analysed based on the direction of travel along the observed footpath (counter-clockwise or clockwise).

Table 2. Change in median manual observation counts per hour between intervention and control parks at baseline and 12-month follow-up. Data displayed as median counts per observation (interquartile range) and incident rate ratio (95% confidence intervals).

Total	**Delapré Park (intervention)**[a] **Median counts per observation (IQR)** **IRR (95% CI)**	**Hunsbury Hill (control)** **Median counts per observation (IQR)** **IRR (95% CI)**	**St. Crispin's Park (control)** **Median counts per observation (IQR)** **IRR (95% CI)**
All characteristics		**Baseline**	
	Total		
	11.5 (10.5) 1	5 (4.75) 0.45 (0.16 – 1.28) *p* = 0.13	17.5 (9.75) 1.29 (0.47 – 3.56) *p* = 0.62
	Counter-clockwise		
	3 (5.5) 1	5 (4.75) 1.30 (0.44 – 3.79) *p* = 0.64	17.5 (9.75) **3.86 (1.35 – 11.1)** ***p* = 0.01**
	Clockwise		
	6 (7.75) 1	0.70 (0.24 – 2.03) *p* = 0.51	1.98 (0.71 – 5.52) *p* = 0.19
		12-month follow-up	
	Total		
	9.5 (4.75) 1	**2.5 (3.5)** **0.29 (0.92 – 0.89)** ***p* = 0.03**	17 (7.75) 1.24 (0.43 – 3.6) *p* = 0.69
	Counter-clockwise		
	2 (3.5) 1	2.5 (3.5) 0.60 (0.18 – 1.96) *p* = 0.40	17 (7.75) 2.57 (0.86 – 7.69) *p* = 0.09
	Clockwise		
	5 (7) 1	2.5 (3.5) 0.55 (0.18 – 1.68) *p* = 0.29	17 (7.75) 2.41 (0.84 – 6.88) *p* = 0.10

Women		Baseline	
	Total		
	7 (5)	3.5 (3)	7 (1.5)
	1	0.51 (0.17 – 1.51)	0.98 (0.35 – 2.80)
		p = 0.22	*p* = 0.97
		12-month follow-up	
	Total		
	4 (2)	**1 (1)**	6.5 (5.5)
	1	**0.17 (0.05 – 0.65)**	1.52 (0.50 – 4.59)
		***p* = 0.01**	*p* = 0.46
BAME[b]		Baseline	
	Total		
	0 (0.25)	0 (0.5)	1.5 (2)
	1	0.44 (0.09 – 2.16)	1.10 (0.28 – 4.31)
		p = 0.31	*p* = 0.90
		12-month follow-up	
	Total		
	0 (0.5)	0 (0.25)	1 (5.5)
	1	0.78 (0.15 – 4.04)	3.15 (0.77 – 12.9)
		p = 0.76	*p* = 0.11

[a] Delapré Park counts were analysed as total counts and sub-analysed based on the direction of travel along the observed path. [b] Black, Asian, and Minority ethnicities. IQR – interquartile range. IRR – incidence rate ratio. CI –confidence interval. Significant incident rate ratios displayed in **bold**.

Automated active infrared counts

Change in automated counts

Daily counts from six automated active infrared counters, positioned along the intervention route, suggested that overall, there was no consistent change in route-use following the installation of new directional wayfinding signs (Table 3). The results for Counter ID-2 suggested that route use decreased during follow-up however, this was likely due to visitors using an adjacent path, as evidenced by 90% of visitors using the adjacent path during an ad-hoc manual observation 21st August 2022 (Supplementary Data Set).

Table 3. Change in median daily counts between baseline, autumn to winter follow-up, and spring to summer follow-up across the six automated active infrared counter locations in the clockwise and counter-clockwise direction of travel.

Counter ID	**Baseline 1st May – 25th Aug 2021**	**Autumn to Winter Follow-up 27th Aug 2021 – 28th Feb 2022**	**Spring to Summer Follow-up 1st Mar – 25th Aug 2022**
Clockwise	**Median daily counts (IQR) Reference**	**Median daily counts (IQR) IRR (95% CI)**	**Median daily counts (IQR) IRR (CI)**
1[a]	35 (23) 1	32 (24) 0.98 (0.74 – 1.30) *p* = 0.89	45 (26) 1.22 (0.94 – 1.58) *p* = 0.13
2[b]	78 (44) 1	66 (43) 0.93 (0.70 – 1.24) *p* = 0.02	**47 (29)** **0.64 (0.48 – 0.86)** ***p* = 0.002**
3[c]	107 (50) 1	86 (59) 0.92 (0.69 – 1.22) *p* = 0.56	104 (50) 0.98 (0.73 – 1.31) *p* = 0.87
4[b]	57 (28) 1	54 (34) 1.05 (0.79 – 1.38) *p* = 0.75	59 (31) 1.09 (0.85 – 1.41) *p* = 0.49
5[a]	10 (8) 1	**13 (13)** **1.55 (1.12 – 2.18)** ***p* = 0.008**	**13 (9)** **1.44 (1.12 – 2.15)** ***p* = 0.021**
6[a]	130 (61) 1	103 (42) 0.86 (0.65 – 1.14) *p* = 0.300	124 (57) 0.99 (0.77 – 1.28) *p* = 0.95
Counter-clockwise			
1[b]	58 (31) 1	47 (31) 0.87 (0.66 – 1.15) *p* = 0.33	60 (39) 1.10 (0.85 – 1.42) *p* = 0.49
2[b]	53 (25) 1	**42 (26)** **0.73 (0.55 – 0.97)** ***p* = 0.03**	**31 (18)** **0.62 (0.46 – 0.82)** ***p* < 0.001**
3[c]	126 (49) 1	93 (61) 0.85 (0.64 – 1.12) *p* = 0.24	124 (32) 0.97 (0.72 – 1.30) *p* = 0.82
4[b]	77 (31) 1	64 (37) 0.91 (0.69 – 1.20) *p* = 0.50	75 (30) 1.00 (0.78 – 1.29) *p* = 0.99
5[b]	10 (8) 1	13 (7) 1.10 (0.79 – 1.54) *p* = 0.57	14 (7) 1.22 (0.90 – 1.67) *p* = 0.20
6[a]	152 (62) 1	109 (44) 0.83 (0.62 – 1.01) *p* = 0.19	139 (58) 0.96 (0.75 – 1.24) *p* = 0.76)

[a] Daily mean temperature and daily total rainfall significantly associated with counts. [b] Daily total rainfall significantly associated with counts. [c] Daily mean temperature significantly associated with

counts. IRR – incidence rate ratio. IQR – interquartile range. CI – confidence interval. **Bold** indicates significant IRR. Refer to Figure 2 to see counter locations.

Intercept survey

The intercept survey was completed by 27 people (18 during autumn to winter follow-up and 9 people during spring to summer follow-up). Fifteen women and 10 men completed the intercept survey (two 'unknown' gender, there were no non-binary, intersex, or transgender identifying respondents) with the predominant age group and ethnicity being 46 – 60 years old, white British, respectively (full demographics provided in Supplementary File 1). 'One – two times per month' (nine responses) and 'my first visit' (seven responses) were the most frequent visitation habits by survey respondents with the majority (*n* = 10) of respondents finding out about the new signposted route during their visit to the park. Thirteen respondents (58%) stated that the signposted route was adding a new walk to their typical week while the second most common response (*n* = 7, 25%) was that the route was replacing another walk they would typically complete at the park. Only four respondents (15%) said they were walking the route before the signs were installed. Survey respondents suggested their physical activity levels were fairly active to active (*n* = 12, 13, respectively, Supplementary File 1) and by using the signposted route, 11 respondents reported an increase of 1 or more days where 30-minutes of moderate to vigorous physical activity was completed, while 13 respondents reported "no change".

The intercept survey assessed attitudes that were outlined in the initial logic model to explore respondents' perceptions of these attitudes following exposure to the walking route intervention. The statements where 'strongly agree' was the most frequent response included:

- "I feel less anxious about using unfamiliar paths",
- "I feel less anxious about getting lost",
- "I feel motivated to walk or run further than I originally planned", and
- "I am likely to use this signposted walking route again."

These firmest attitudes (Supplementary File 1) suggested "lowered wayfinding anxiety" and "more motivated to spend longer using the intervention" were the most impactful components of the initial logical model to "change judgement of the physical environment" and subsequently suggested "increased usage of the intervention" as a possible "change in behaviour" [citation removed for review].

Fourteen survey respondents provided an open-text answer to "provide a short paragraph of how the signposted walking route has helped your experiences of nature, heritage, physical activity, or well-being.". The rationale for this questioning concerns the research teams desire to gain greater contextual understanding of the interactions between the intervention, physical activity behaviours and engagement with the urban greenspace amongst park users. Analysis of this open-text data focused on three categories to represent the data: Discovering new spaces, Wellbeing and, Confidence and safety.

Discovering new spaces

Responses suggested that participants felt the signposted route helped them to discover new spaces and enabled visitors to explore unfamiliar areas, which has been commonly highlighted as a barrier to walking (Kelly et al., 2019):

“This has enabled me to safely walk around an area I'm unfamiliar with.”

Female, 46 – 60 years old

Signage appeared to facilitate visitors’ appreciations of the ‘beauty’ of the route, which aligns with wellbeing enhancement by ‘taking notice’, one of the ‘five ways to wellbeing’ (Government Office for Science, 2008). This appeared particularly important for those using the space for the first time, who had limited existing knowledge of the area:

“Easier to navigate for first timers like me.”

Male, 31 – 45 years old

Wellbeing

An emphasis on perceived positive influence on subjective wellbeing was present amongst the participants, something highlighted in the literature as an outcome of engagement in greenspaces (Garrett et al., 2021). Responses included:

“It is very pleasant to walk the path, especially in sunshine! It refreshes the mind and lifts ones mental energy levels.”

Female, 46 – 60 years old

Perceptions of wellbeing appeared to be related by increased position emotions experienced in engaging with the space, plus increased interaction with others, meaning many respondents spoke of their intentions to repeat the route:

“Beautiful morning walk had today, the sun is shining, and I am greeting the occasional walker, usually with a dog, with a smile. This is my first guided walk, good and clear markings, will definitely do this again. Well done.”

Male, 46 – 60 years old

Confidence and safety

The wayfinding signs were hypothesised to increase confidence and reduce anxieties of using unfamiliar greenspace in the project's initial logic model [citation removed for review]. In support of this previous work, participants cited these areas in their responses as a potential benefit of the wayfinding intervention:

> "It'll encourage more people who are unsure about walking in some public places."
>
> Female, 46 – 60 years old

Others explained that signposted routes were "good for confidence etc." and "support safer walking". This also appeared to be the case for those who also preferred not to use wayfinding signage, but felt there was a benefit in bringing others to the area:

> "Whilst I prefer to find my own routes and explore, I can see the benefits of signposting and think it would encourage some people to walk more."
>
> Female, 31 – 45 years old

Finally, eighteen respondents 'strongly agreed' that they would "support the installation of signposted walking routes in other public parks across Northamptonshire", with only two disagreements. In addition to this, in both open-text questions, respondents stated a 'you are here' marker, 'routes of different lengths', and 'seating on the route' could be further improvements to the route, which could be generalised to similar projects. The provision of seating may not be the first consideration when people are designing recreational walking route signage, but seating can make routes more accessible for people with limited mobility or health conditions who need to rest frequently while walking (Ottoni et al., 2016).

Discussion

Overall, there were no consistent changes in route use across sign intervention follow-up periods when using manual or automated observation methods. However, 23% of route users travelling in a clockwise direction were following the new signage at the 12-month follow-up stage. Intercept survey responses suggested that the signs were useful for helping people explore unfamiliar areas, lowered wayfinding anxiety and increased motivation, with 18 of 27 respondents 'strongly agreeing' that they would support the installation of similar interventions across the county because the signs would 'encourage' people to visit spaces they were unfamiliar with.

Experience more insightful than footfall

The lack of observed change in footfall does not necessarily mean that this intervention failed to promote park visits as new park users may follow the intervention route while frequent users might change their choice of routes. This may cause counteraction in observed footfall and thus reinforces the need for mixed-method approaches to natural experimental studies to ensure social and contextual changes are evidenced. The three main themes presented from the qualitative intercept survey data (discovering new spaces, wellbeing and, confidence and safety) also highlight the potential value of such interventions in increasing the use of urban greenspaces for local community wellbeing, as well as the need to capture the qualitative experiences of engagement in such spaces. Furthermore, as this intervention was retrofitted in an existing park, it was likely that most visitors were frequent users of the park and thus, familiar with many paths within the park. Therefore, the current intervention was likely more influential on visitors who use the park less frequently. This postulation was supported by our intercept survey with most respondents stating that they visited the park infrequently (‘one – two times per month’: n = 9, ‘my first visit’: n = 7).

This small-scale intervention was conceived to support less frequent park visitors to increase their use of parks to gain health benefits from greenspace and physical activity exposure. Furthermore, the narrative of health inequalities urges interventions to support the members of the population who are least likely to visit parks to start visiting parks more frequently, as this proportion of the population are likely to experience the greatest health benefits from exposure to parks, in comparison to frequent park users (Lovell et al., 2020; Public Health England, 2020). Therefore, natural experimental studies of infrastructure-based interventions need to not only observe possible changes in footfall but, more importantly, be able to distinguish between regular users and new users, at baseline and follow-up, to truly identify the benefits of the interventions for those populations who were least likely to use the space before the intervention (Aldred and Croft, 2019; Craig et al., 2022). The need to distinguish also resonates for qualitative enquiries, with previous research finding that distinguishing between ‘regular walkers’ and ‘casual/non- walkers’ can facilitate intervention design and community engagement or promotion (Davies et al., 2012; Elliott et al., 2021).

Sufficient follow-up period

The Department for Transport recommend at least a 12-month follow-up period for interventions that change the built environment. However, interventions that target walking may need a longer follow-up period to detect footfall change. For example, the ‘Fitter for Walking’ project (2008 – 2012) made several low-cost infrastructure improvements to improve the walking environment across 12 English local authorities (e.g., new lighting, dropped curbs, promotion and awareness), which resulted in a decline in pedestrian footfall at the 12-month follow-up, the same duration as the current study, followed by an increase in pedestrian footfall at the 14 – 20-month follow-up (Adams and Cavill, 2015). Similar conclusions about follow-up periods were made in Japan, where the postal delivery of 21 walking route maps over a 21-month period to 1,200 households and monthly walking events did not increase self-reported walking in Japanese older adults (Kubota et al., 2019). The current study had planned for a 24-month follow-up period but the opening of a neighbouring mountain bike park and plans to upgrade the footpath surfaces within the intervention park would have likely influenced route use and confounded any findings.

Logic model attitudes

Lowered anxiety of using unfamiliar routes and getting lost, and greater motivation to walk further than originally planned, were the firmest attitudes expressed in the intercept survey, suggesting that they may be the most impactful for changing behaviour through the installation of walking route signs. These findings align with the COM-B behaviour change wheel in which behaviour change through an education intervention (walking route signs) is more likely due to improvements in psychological capability and reflective motivation (Michie et al., 2011). Unfamiliarity of routes and concerns about getting lost have previously been highlighted as barriers to recreational walking (Kelly et al., 2019) and are reflective of low psychological capability. Within older adults cohorts in Wales, signs were seen as useful for overcoming spatial anxiety in unfamiliar areas but information about distances was essential to overcome uncertainties about walking commitment (Phillips et al., 2013). This narrative was also supported in our first article for the current research project [citation removed for review], which found that route distance was a key design component to include on wayfinding signs for recreational walking. Furthermore, an intercept survey respondent in the current article echoed this narrative, "the walking distance being signposted really helps to decide whether to take the walk or not." Therefore, there seems to be promising preliminary findings that wayfinding signs in greenspaces can be a useful intervention to help people overcome spatial anxiety in unfamiliar areas and further investigation into this area is warranted.

Regarding reflective motivation, data from the intercept survey hinted that the motivation to walk further than originally planned may stem from positive wellbeing experiences by viewing 'beautiful' and diverse 'historical' landscapes that the intervention route passed through, rather than motivation solely from the presence of signs. Notably, as a ripple effect of the current project, the local historical society commissioned portable information boards to inform visitors about the historical battlefield within the park. Therefore, wayfinding signs within greenspaces may contribute to wellbeing enhancements by helping people engage with their surroundings as well as facilitating physical activities, such as walking.

Strengths and limitations

There are best practice method recommendations to reduce the risk of bias in natural experimental studies (Benton et al., 2016; Humphreys et al., 2017), which have been outlined below alongside a description about how we attempted to meet each recommendation:

1. Better matching of control sites and more nuanced use of graded exposure and 2. The use of multiple control sites: The current study used an evidence-based process (Benton et al., 2021) to identify multiple control sites that had similar geographical and population demographic characteristics in comparison to the intervention site.

3. Controlling for confounding domains: The research accounted for confounders known to influence outdoor physical activity, such as weather, public holidays, and events.

4. Publishing study protocols with a priori analyses specified: Study protocols and analyses were published a priori [citation removed for review] and adhered to as much as feasibly possible, acknowledging that natural experimental studies need to be flexible (Crane et al., 2020).

5. Use of adequate outcome measurements: The research used multiple observation processes to monitor engagement with the intervention including automated, manual, and survey approaches to triangulate and contextualise the count data.

6. Better reporting of sample and interventions: The study reported assumed and self-reported demographic characteristics of visitors as well as providing details on study context in the methods, including a video of the intervention route so readers could experience the physical 'on the ground' context of the intervention.

7. Sample size calculations: This study used cluster data from a similar study (Benton et al., 2021) to estimate the required number of observations however, this method could have been strengthened by conducting a statistical estimate of the required number of observation clusters.

8. Measuring exposure to the intervention at the individual level: The study utilised an intercept survey to assess individual level exposure, but the research could have been strengthened by conducting postal surveys pre and post intervention with local residents to get a broader understanding of individual level exposure to the intervention. However, this process was beyond the budget constraints of the project.

Unfortunately, the project follow-up was cut short due to changes in the park that would likely influence footfall (path improvements and new amenities) however, the baseline data from the current project does provide an opportunistic moment to assess the impact of these planned changes to footpaths and amenities. Furthermore, it was determined that Return on Investment analysis, outlined in the a priori published protocol [citation removed for review] would not be possible as the context of the intervention did not fit in with existing economic calculators, such as Sport England MOVEs Tool and Department for Transport Active Travel Appraisal Tool (WebTAG).

Next stages of the project

A limitation in the current study is the lack of depth in contextual and qualitative understanding of any influences of the intervention on users. Whilst qualitative data was obtained via intercept surveys, these provide only descriptive insights at the manifest level. The authors acknowledge the limitations in this and do not wish to assert bold claims of inference based on this data alone. Rather, the data acted as supplementary to the quantitative observations and have highlighted the need for further qualitative investigation. This gap in qualitative understandings of physical activity interventions in greenspaces and appreciation for socio-cultural influences is a shortcoming in much research of this nature (Hunter et al., 2015; Rivera-Navarro et al., 2022). This is important as the social environment can act as a barrier to greenspace access (Fontán-Vela et al., 2021; Seaman et al., 2010) and there are calls to utilise qualitative research in natural experimental studies (Craig et al., 2022) to investigate causal mechanisms and better understand user experiences in greenspaces. Therefore, to address this gap and gain greater insight to the data presented in the current study, we have conducted go-along intercept interviews with park visitors to explore their reasons for visiting the park, the role of wayfinding signs to support their visit, and the wellbeing impacts of their visit. The article for this qualitative study is in preparation and will be published in due course.

Conclusions

Overall, the current study found that the retrofitted installation of wayfinding signage to create a 3 km recreational walking route did not increase footfall on the route's paths. However, during follow-up, 23% of intercepted route users said they were following the wayfinding signage and the intercept survey suggested that the route was 'adding a new walk to their typical week' for 58% of respondents. The intercept survey suggested that the use of wayfinding signs as an education intervention primarily reduced the anxiety of unfamiliar spaces and getting lost while increasing motivation to walk further, most likely due to route users taking notice of the landscape. The findings highlight the need for mixed-method research in this area to gain greater contextual understandings of the influences on behaviour that small-scale interventions may have.

Similar projects should aim to conduct longer follow-up periods as well as identify existing and new park visitors at baseline and follow-up to determine whether their intervention increases the number of new park visitors, who previously had low engagement with greenspaces, in addition to greater capturing of community voice to understand the context of park visitation habits related to the intervention. By following these recommendations, project leaders can better determine whether their greenspace interventions are actually addressing health inequalities, by helping non-users of greenspace become users, or are just encouraging current greenspace users to increase their use and thus potentially widening inequalities further. These are particularly pertinent considerations for green social prescription, which may be used as a vehicle to fund future greenspace interventions. On the basis of the current research findings, it is recommended that Municipalities may be able to increase greenspace visitation of infrequent greenspace users by providing wayfinding that helps residents explore unfamiliar recreational routes. However, early communication and co-production with residents is required to design effective wayfinding to ensure it meets local wants and needs.

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Supplementary File 1

Supplementary File contents appear in chronological order of reporting in the main article text.

Initial Hypothesised Logic Model

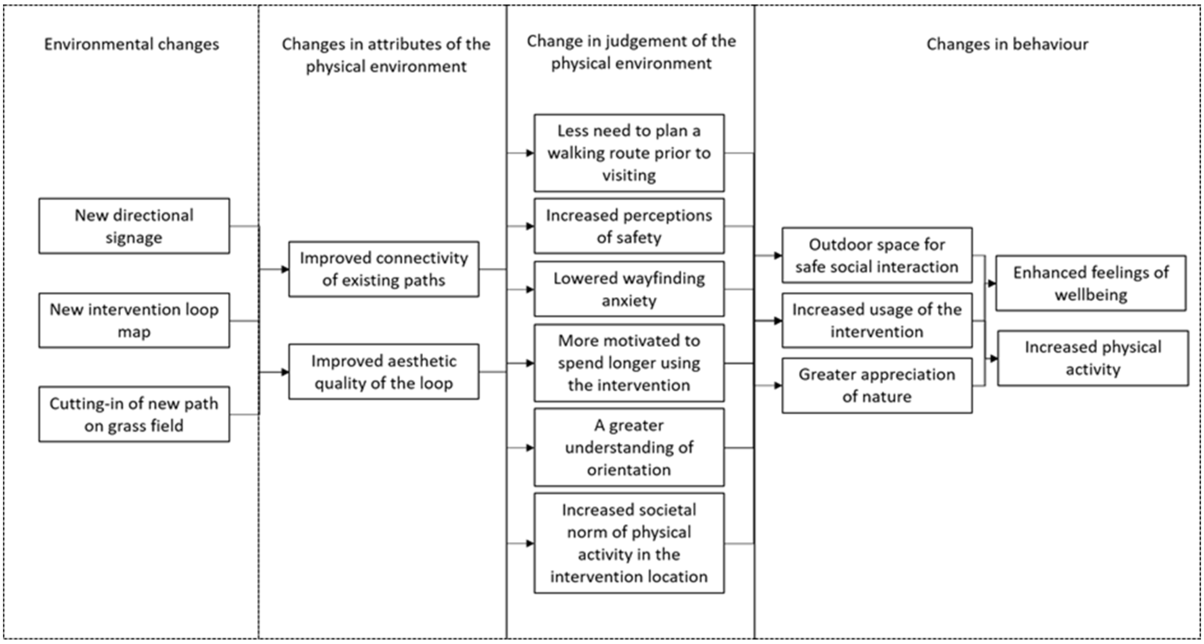


Figure 1. Initial hypothesised logic model originally published in (Ryan and Hill, 2022).

Study Context

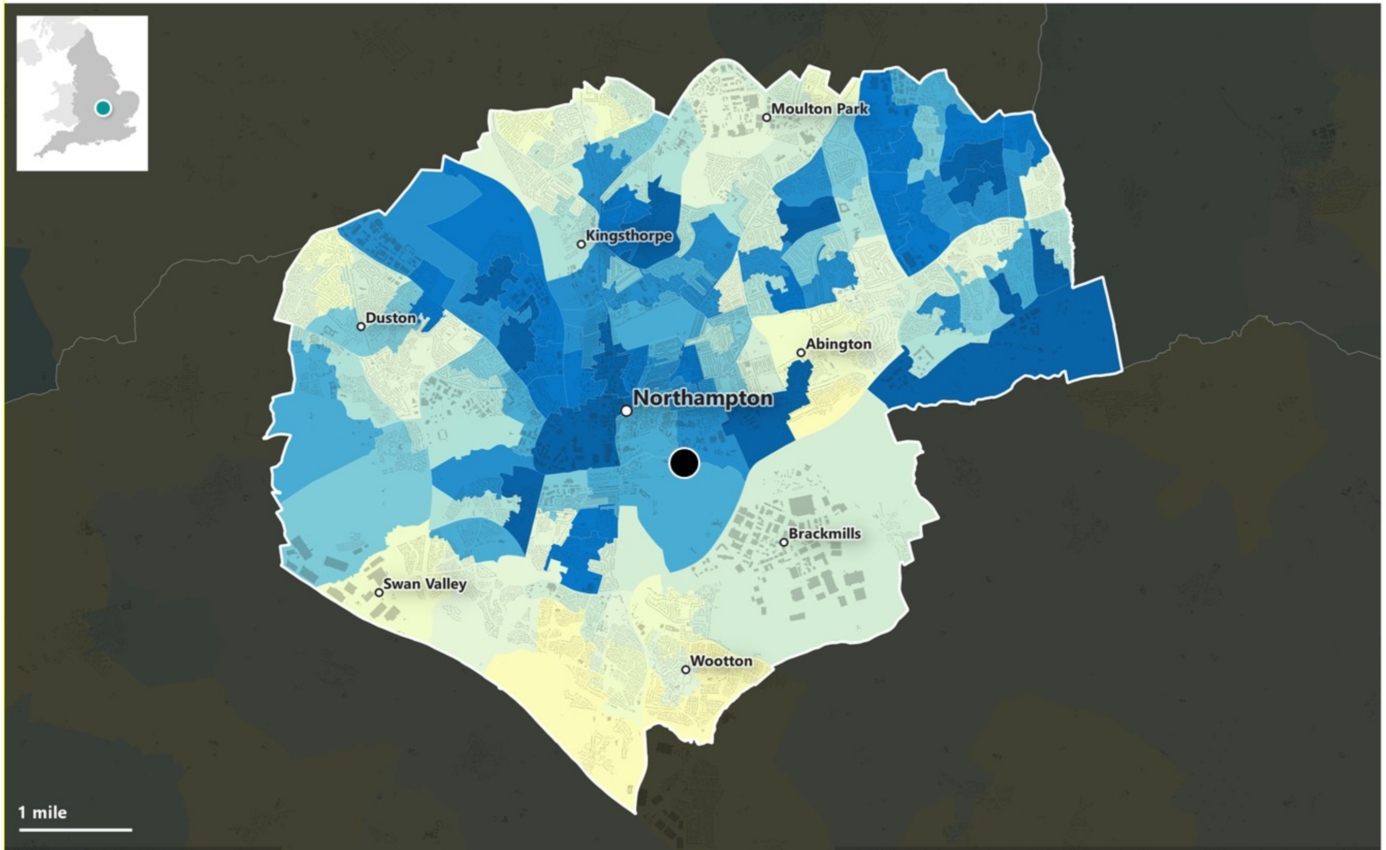
In respect to the social context, the park is renowned as the battlefield site of the 1460 Battle of Northampton and at the centre of the park is Delapré Abbey, which was originally a nunnery, and has been identified as a site for demolition numerous times. At the turn of the millennium, the building lacked a clear purpose and was in need of extensive and expensive repairs. The Friends of Delapré Abbey campaigned to restore the building with the vision to create a venue that would cater to the local community. Subsequently, the Delapré Abbey Preservation Trust was formed, and working together with Northampton Borough Council, plans were made with the Heritage Lottery Fund's help to deliver a major restoration project (Delapre Abbey Preservation Trust, 2018). In 2018, after extensive restoration works, the Abbey was opened to the local community. Since reopening, the Trust has worked with the local community to develop the park by providing heritage and wellbeing opportunities. The 'South Lawn' of the park is a frequent venue for events and the Trust launched the Delapré Wellbeing hub in 2021 to co-locate wellbeing services and offer a range of activities for social prescription referrals (Northampton Wellbeing Partnership, 2021).

The intervention was in the 550-acre Delapré Estate, Northampton, England. The park within the estate is identified as urban greenspace within the town, which had an estimated population of 224,610 people in 2019 (Northamptonshire County Council, 2020a). The 2020 Health and Wellbeing infographic stated that, in comparison to the rest of England, Northampton was significantly worse for the percentage of overweight or obese adults (68%), preventable adult deaths from cardiovascular disease (53 per 100,000), deaths from preventable cancer (87 per 100,000), older adult falls related hospital admissions (3,224 per 100,00), and life expectancy for men (79 years) and women (82 years), while the percentage of physically active adults was similar (63%) (Northamptonshire County Council, 2020b). Northampton has a greater proportion (23.3%) of Lower-Layer Super Output Areas (LSOAs) in English index of multiple deprivation deciles 1 and 2 (most deprived) than the 20% national division (Figure 2) (Northamptonshire County Council, 2020b).

Index of Multiple Deprivation 2019

Ministry of Housing, Communities & Local Government

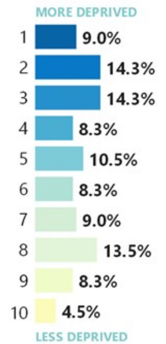
NORTHAMPTON



MHCLG, 2019. Contains National Statistics data © Crown copyright and database right 2020.

Local authority profile

% of LSOAs in each national deprivation decile



What this map shows

This is a map of Index of Multiple Deprivation (IMD) 2019 data for **Northampton**. The colours on the map indicate the deprivation decile of each Lower Layer Super Output Area (LSOA) for England as a whole, and the coloured bars above indicate the proportion of LSOAs in each national deprivation decile. The most deprived areas (decile 1) are shown in blue. It is important to keep in mind that the data relate to small areas and do not tell us how deprived, or wealthy, individual people are. LSOAs have an average population of just under 1,700 (as of 2017).

Figure 2. Northampton's Lower-layer super output areas index of multiple deprivation (2019). Black icon indicated the intervention site. Freely used without the need for permission (mySociety, 2021).

Intervention Directional Wayfinding Signs

Figure 3. Directional wayfinding signs designed for the intervention.

Intervention Information Board

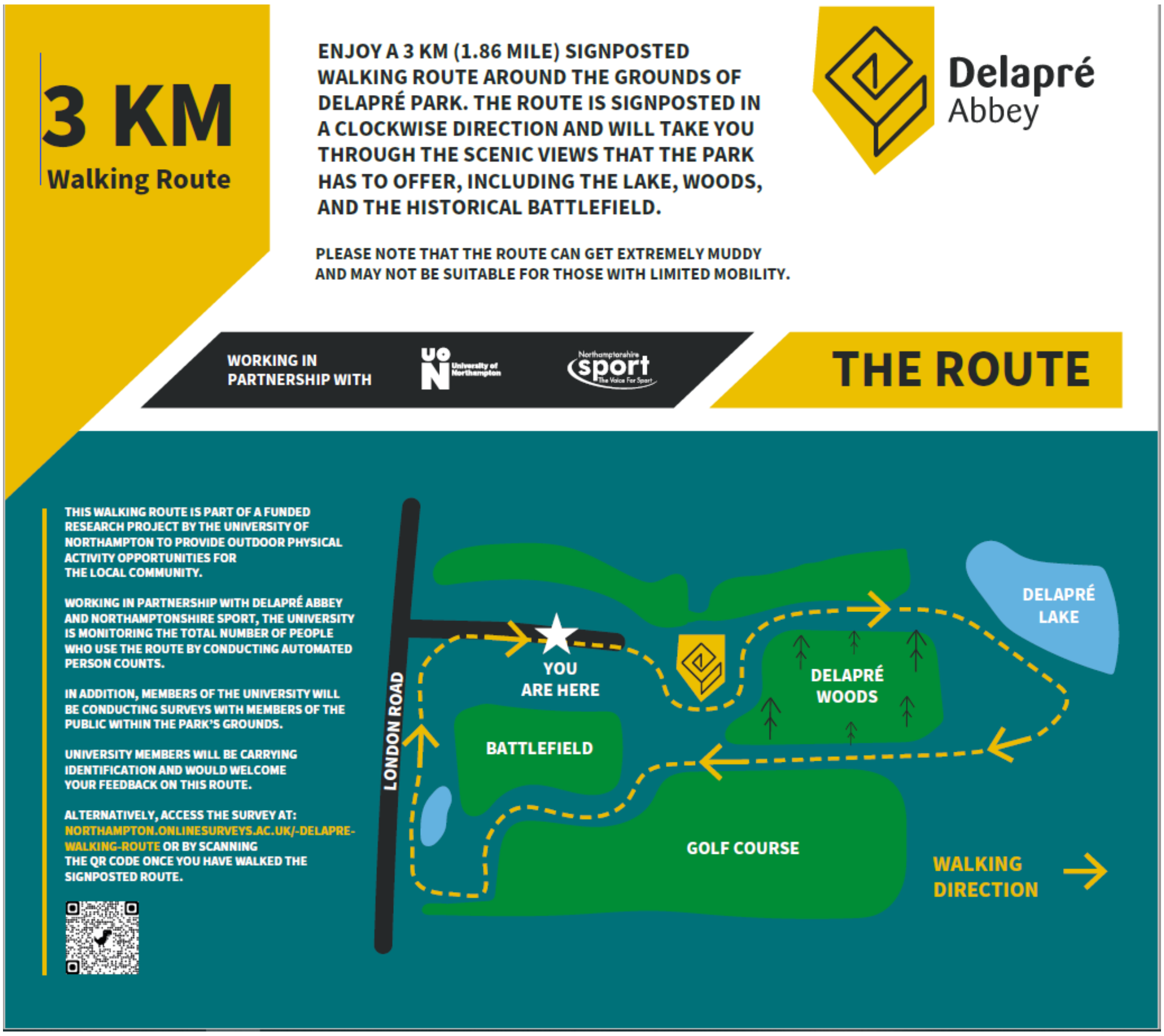


Figure 4. Intervention board placed on the footpath entrance to the park.

Control Park Identification

It is recommended that control sites are used within natural experimental studies to reduce the risk of bias (Benton et al., 2016). Therefore, two control parks were identified using methods similar to Benton et al. (2021) and have been previously explained in detail (Ryan, 2021). Briefly, the process to identify control sites used publicly available data of LSOAs from the Office for National Statistics and Census 2011. The LSOA of Delapré Park (Northampton 028F and 027B) was matched with two similar LSOAs to act as control sites, from the 133 LSOAs in Northampton. The 133 LSOAs were filtered down in a phased order of similar characteristic identification:

Step 1: Population density (Census 2011) – reduced to 24 similar LSOAs.

Step 2: Distance from the nearest park, average size of the nearest park, average number of parks within 1 km radius, and average combined size of public parks within a 1 km radius (Access to public parks and playing fields, Great Britain, April 2020, Office for National Statistics) – reduced to 5 similar LSOAs.

Step 3: Index of multiple deprivation 2019 decile (Access to public parks and playing fields, Great Britain, April 2020, Office for National Statistics) – reduced to 3 similar LSOAs.

Step 4: Online inspection of parks within LSOAs to identify similarities in amenities between the potential control parks and Delapré Park. – reduced to 2 similar LSOAs and parks.

Step 5: The process identified Hunsbury Hill and St. Crispin's Park as appropriate control parks. The final step used Strava Metro (Strava Metro, Strava Inc., San Francisco, USA) to identify paths within the control parks that were a similar length and had similar footfall (Table 1).

Table 1. Strava Metro 'total activities' on selected Edges. Data accessed on 20th February 2021 (Strava, 2020).

Location	Path Length (km)	April 2020 (*n*)	May 2020 (*n*)	June 2020 (*n*)	July 2020 (*n*)	August 2020 (*n*)
Intervention – Delapré Park	0.24	25	25	25	15	20
Control - Hunsbury Hill	0.20	10	25	40	15	30
Control – St. Crispin's Park	0.36	30	45	25	20	15

Observer Reliability

Observations were undertaken by nine local university students across the course of the study. Observers received a 1-hour training two weeks before the scheduled observation date. The observers were informed about the purpose of the project, risk assessment procedures, and the ‘recording procedures for walking/jogging tracks’ using the System for Observing Play and Recreation in Communities (SOPARC) observation form (McKenzie and Cohen, 2006). Observers then watched a 30-minute video of people walking along a path on the University campus, on a 55-inch television screen. Observers were instructed to code every person (51 people) that they saw walk through the observation station on the video, using the SOPARC observation form (Figure 5), to assess inter-rater reliability.

Figure 5. Screenshot on the SOPARC reliability training video. *Observers were instructed to code every person that walked through the observation station (red box).*

Inter-rater Reliability Statistical Analysis

Inter-rater reliability for each demographic variable and total demographics (full demographics of each observed person) between nine observers was conducted using a Chi-Squared (gender). As there were low counts for Child, Teen, and Senior age groups, they were grouped together, whilst Adult remained as a single age group. A similar grouping procedure was conducted for Black, Asian, and Other ethnic groups (White remained as a single ethnic group). Exact Test adjustments were performed for age groups and full demographic groups as there were less than five counts. Reliability tests were not performed for physical activity demographics as the only observed activity was walking.

Manual Observation Reliability Results

Between observers, there was no difference in gender counts (χ^2 (8) = 0.88, p = 0.999; sum of counts: Female [n = 304, 67%], Male [n = 150, 33%]), age group counts (χ^2 = 8.09, p = 0.185; sum of counts: Adult [n = 443, 98%], Child, Teen, and Senior [n = 9, 2%]), ethnicity counts (χ^2 (8) = 4.77, p = 0.781; sum of counts: White [n = 366, 81%], Black, Asian, and Other ethnicity [n = 88, 19%]), and total demographics (χ^2 (32) = 17.7, p = 0.98; total sum of counts: 452).

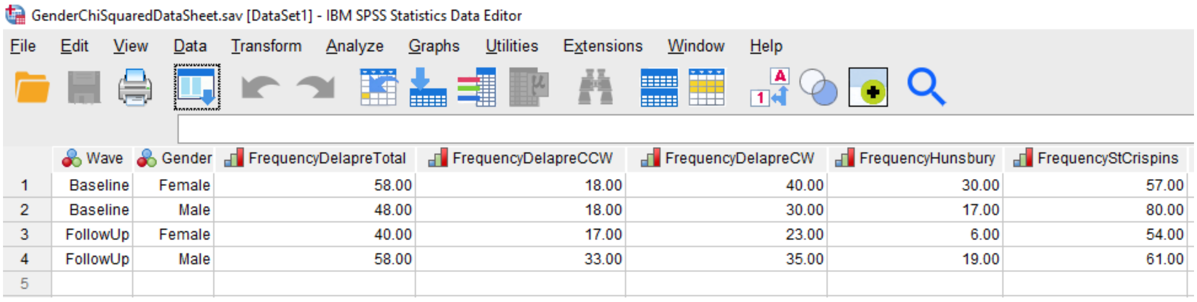
Intervention and control park manual observation points

Figure 6. Path used for manual observations (black box), counting the number of people who crossed the observation station (red line) at Delapré Park (Top Panels), Hunsbury Hill (Middle Panels), St. Crispin’s Park (Bottom Panels).

Automated Counter Locations

Figure 7. Images of automated active infrared counter ID locations along footpaths.

Assumed Demographic Data Analysis



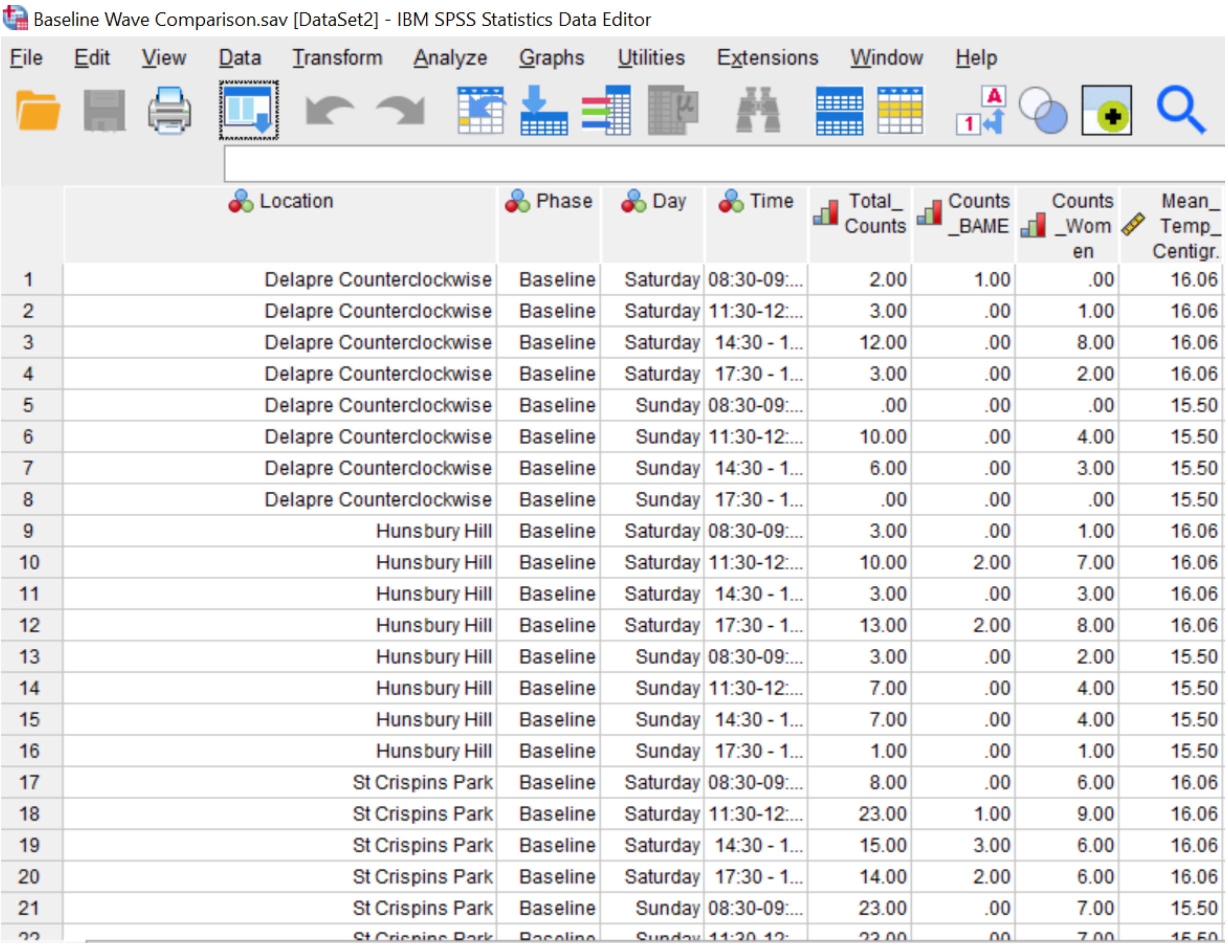
	Wave	Gender	FrequencyDelapreTotal	FrequencyDelapreCCW	FrequencyDelapreCW	FrequencyHunsbury	FrequencyStCrispins
1	Baseline	Female	58.00	18.00	40.00	30.00	57.00
2	Baseline	Male	48.00	18.00	30.00	17.00	80.00
3	FollowUp	Female	40.00	17.00	23.00	6.00	54.00
4	FollowUp	Male	58.00	33.00	35.00	19.00	61.00
5							

Figure 8. Example SPSS manual observation assumed demographic layout to assess differences between baseline and follow-up, weighted by the relevant Frequency column.

Assumed Demographic Syntax

```
CROSSTABS
  /TABLES=Gender BY Wave
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT EXPECTED ROW SRESID
  /COUNT ROUND CELL.
```

Manual Count Data Analysis


Baseline Wave Comparison.sav [DataSet2] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Graphs Utilities Extensions Window Help

	Location	Phase	Day	Time	Total_ Counts	Counts _BAME	Counts _Wom en	Mean_ Temp_ Centigr.
1	Delapre Counterclockwise	Baseline	Saturday	08:30-09:...	2.00	1.00	.00	16.06
2	Delapre Counterclockwise	Baseline	Saturday	11:30-12:...	3.00	.00	1.00	16.06
3	Delapre Counterclockwise	Baseline	Saturday	14:30 - 1...	12.00	.00	8.00	16.06
4	Delapre Counterclockwise	Baseline	Saturday	17:30 - 1...	3.00	.00	2.00	16.06
5	Delapre Counterclockwise	Baseline	Sunday	08:30-09:...	.00	.00	.00	15.50
6	Delapre Counterclockwise	Baseline	Sunday	11:30-12:...	10.00	.00	4.00	15.50
7	Delapre Counterclockwise	Baseline	Sunday	14:30 - 1...	6.00	.00	3.00	15.50
8	Delapre Counterclockwise	Baseline	Sunday	17:30 - 1...	.00	.00	.00	15.50
9	Hunsbury Hill	Baseline	Saturday	08:30-09:...	3.00	.00	1.00	16.06
10	Hunsbury Hill	Baseline	Saturday	11:30-12:...	10.00	2.00	7.00	16.06
11	Hunsbury Hill	Baseline	Saturday	14:30 - 1...	3.00	.00	3.00	16.06
12	Hunsbury Hill	Baseline	Saturday	17:30 - 1...	13.00	2.00	8.00	16.06
13	Hunsbury Hill	Baseline	Sunday	08:30-09:...	3.00	.00	2.00	15.50
14	Hunsbury Hill	Baseline	Sunday	11:30-12:...	7.00	.00	4.00	15.50
15	Hunsbury Hill	Baseline	Sunday	14:30 - 1...	7.00	.00	4.00	15.50
16	Hunsbury Hill	Baseline	Sunday	17:30 - 1...	1.00	.00	1.00	15.50
17	St Crispins Park	Baseline	Saturday	08:30-09:...	8.00	.00	6.00	16.06
18	St Crispins Park	Baseline	Saturday	11:30-12:...	23.00	1.00	9.00	16.06
19	St Crispins Park	Baseline	Saturday	14:30 - 1...	15.00	3.00	6.00	16.06
20	St Crispins Park	Baseline	Saturday	17:30 - 1...	14.00	2.00	6.00	16.06
21	St Crispins Park	Baseline	Sunday	08:30-09:...	23.00	.00	7.00	15.50
22	St Crispins Park	Baseline	Sunday	11:30-12:...	23.00	.00	7.00	15.50

Figure 9. Example SPSS manual observation data layout for Counter-clockwise Delapré Park analysis.

Incidence Rate Ratio Regression Assumption Syntax

```
NPAR TESTS
 /K-S(NORMAL)=Total_Counts
 /MISSING ANALYSIS
 /KS_SIM CIN(99) SAMPLES(10000).
DESCRIPTIVES VARIABLES=Total_Counts
 /STATISTICS=MEAN VARIANCE.
```

Negative Binomial Incidence Rate Ratio Regression Syntax

```
DATASET ACTIVATE DataSet1.
* Generalized Linear Models.
GENLIN Total_Counts BY Location (ORDER=ASCENDING) WITH Mean_Temp_Centigrade
 /MODEL Location Mean_Temp_Centigrade INTERCEPT=YES
 DISTRIBUTION=NEGBIN(1) LINK=LOG
```

```
/CRITERIA METHOD=FISHER(1) SCALE=1 COVB=MODEL MAXITERATIONS=100 MAXSTEPHALVING=5
  PCONVERGE=1E-006(ABSOLUTE) SINGULAR=1E-012 ANALYSISTYPE=3(WALD) CILEVEL=95 CITYPE=WALD
  LIKELIHOOD=FULL
/MISSING CLASSMISSING=EXCLUDE
/PRINT CPS DESCRIPTIVES MODELINFO FIT SUMMARY SOLUTION (EXPONENTIATED).
```

Automated Active Infrared Count Data Analysis

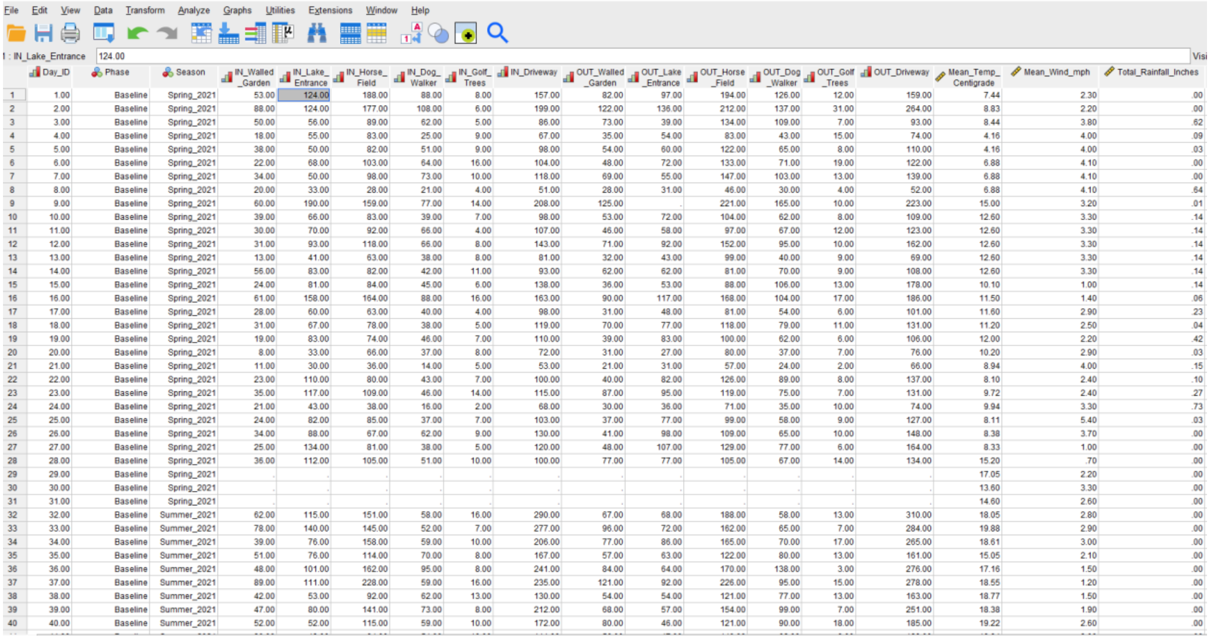


Figure 10. Example SPSS automated observation data layout for Total Delapré Park analysis.

Incidence Rate Ratio Regression Assumption Syntax

```
NPAR TESTS
  /K-S(NORMAL)=IN_Walled_Garden
  /MISSING ANALYSIS
  /KS_SIM CIN(99) SAMPLES(10000).
DESCRIPTIVES VARIABLES=IN_Walled_Garden
  /STATISTICS=MEAN VARIANCE.
```

Negative Binomial Incidence Rate Ratio Regression Syntax

```
GENLIN IN_Walled_Garden BY Phase (ORDER=DESCENDING) WITH Mean_Temp_Centigrade
Total_Rainfall_Inches
  /MODEL Phase Mean_Temp_Centigrade Total_Rainfall_Inches INTERCEPT=YES
 DISTRIBUTION=NEGBIN(1) LINK=LOG
  /CRITERIA METHOD=FISHER(1) SCALE=1 COVB=MODEL MAXITERATIONS=100 MAXSTEPHALVING=5
    PCONVERGE=1E-006(ABSOLUTE) SINGULAR=1E-012 ANALYSISTYPE=3(WALD) CILEVEL=95
CITYPE=WALD
    LIKELIHOOD=FULL
  /MISSING CLASSMISSING=EXCLUDE
  /PRINT CPS DESCRIPTIVES MODELINFO FIT SUMMARY SOLUTION (EXPONENTIATED).
```

Intercept Survey Respondents' Demographics

Table 2. Intercept survey respondents' demographics.

Demographics	Number of respondents
Gender	
Female	15
Male	10
Unknown	2
Ethnicity	
White British[a]	23
White Irish	1
Other Ethnicity[b]	2
Unknown	1
Age	
18 – 30 years	5
31 - 45 years	4
46 - 60 years	12
61+ years	5
Unknown	1
Level of Education	
Less than a high school diploma	1
High school degree or equivalent	2
College (GCE or equivalent)	9
Bachelor's degree (e.g. BA, BSc)	5
Master's degree (e.g. MA, MS, MEd)	3
Doctorate (e.g. PhD, EdD)	1
Professional degree (e.g. MD, DDS, DVM)	4
Unknown	2
Household Income	
Less than £18,000	2
£18,000-29,999	4
£30,000-51,999	6
£52,000-100,000	4
More than £100,000	4
Unknown	7

Postcode Index of Multiple Deprivation 2019 England Deciles[c]	
5	3
6	2
7	3
8	2
10	4
Unknown	12
Home postcode distance from intervention	
Within intervention town	9
Within intervention county	5
Outside intervention county	1
Physical Activity Level[d]	
Active	13
Fairly active	12
Inactive	0
Unknown	2

[a] Including English, Welsh, Scottish, and Northern Irish. [b] Self-reported ethnicities were "White" and "Bulgarian". [c] 1 – most deprived, 10 – least deprived. [d] Active – 5 or more days, Fairly active – 1 – 4 days, Inactive – 0 days, in response to the Sport England Single Item Metric question (Sport England, 2022).

Intercept survey attitudes responses

Table 3. Multiple choice responses to statements that reflected the initial project logic model (Ryan and Hill, 2022).

Question	Responses (*n*)				
By following this signposted walking route at Delapré Abbey...	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**	**No response**
I feel safer when walking or running	6	15	4	1	1
I feel less anxious about using unfamiliar paths	11	10	5	0	1
I feel less anxious about getting lost	11	9	5	1	1
I feel more confident about walking or running	9	10	7	0	1
I feel motivated to walk or run further than I originally planned	11	5	7	3	1
I feel motivated to walk or run at the park more frequently	5	11	7	2	2
I have a better understanding of the routes I can walk or run	6	12	5	2	2
It takes me less time to decide where to walk or run	4	14	5	2	2
I have visited new areas within the Park	9	5	9	2	2
I am likely to use this signposted walking route again	10	10	2	2	3
From using this signposted walking route at Delapré Abbey...					
I see a lot of people walking and running	4	16	3	2	2
I see people who are similar to me walking or running	3	18	2	2	2
I think it will encourage more people to walk or run	6	16	0	3	2
I will encourage my friends and family to use this signposted route	7	12	3	2	3

Walking and running seems like a popular activity within the local community	5	15	1	3	3

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