Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Trends in recreational walking trail usage in Ireland during the COVID-19 pandemic: Implications for practice

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ABSTRACT

Despite its potential utility for the outdoor recreation sector, there is no centralised surveillance system for recreational walking trails in Ireland and thus trail usage in Ireland during the COVID-19 pandemic is unknown. This paper aims to report trends in footfall count data on Irish trails during the COVID-19 period and to triangulate findings with openly available mobility data. This descriptive study analysed changes in footfall counts gathered from passive infrared sensors on 33 of Ireland's recreational walking trails between January 2019 and December 2020. The relationship between Google Community Mobility Report (GCMR) data and footfall counts was analysed to corroborate trends in footfall data. Total footfall increased by 6% between 2019 and 2020 on trails included in this analysis. Notably, mean trail usage was between 26% and 47% higher in October–December 2020 than during the same period in 2019. A strong correlation between GCMR data from 'parks' and footfall count data was found. The conclusions of this study are twofold. Firstly, the COVID-19 pandemic increased trail usage in Ireland, especially on trails closer to urban areas and there is potential for this to be a lasting legacy. Secondly, combining multiple data sources can provide trail managers with more detailed representations of trail usage and currently these are not harmonised. Future research should examine ways to encourage sustained recreational walking trail use in new users and implement novel ways to coordinate datasets across systems to monitor visitors on Irish recreational walking trails.

Management implications: This paper presents a number of implications for trail management teams to consider:

- Openly available datasets pertaining to mobility, such as Google Community Mobility Reports, can be utilised to corroborate data collected from footfall sensors in place on trails. Furthermore, there may be potential for Google Trends data to help trail management teams gauge interest in specific trails and parks during defined time frames.
- There is considerable potential to sustain the COVID-19 legacy of increased trail use, especially for trails closer to urban areas, through promotional campaigns and continued trail maintenance.
- There is a need to work across sectors and disciplines within the recreational walking system to identify potential data sources and opportunities for further data collection.

1. Introduction

In March 2020, the World Health Organisation announced the coronavirus-19 (COVID-19) outbreak as a global pandemic (World Health Organization, 2020). Governments across the globe formulated responses to reduce the spread of the virus, including movement restrictions, the closure of schools, retail, workplaces and leisure facilities, restricted public transport and more recently, the introduction of a vaccination programme. Ireland implemented one of the most stringent containment strategies compared to its international counterparts (Hale, et al., 2021). In the months following March 2020, free movement was only allowed in the months of July and August. For all other months in 2020, movement restrictions of varying distances between 2 km and 10 km were mandated in the Irish population. These movement restrictions, combined with the closure of non-essential businesses, caused drastic changes in the proportion of the Irish population who worked and studied from home in 2020 (Eurofound, 2020). A recent survey found that during various stages of the COVID-19 lockdown 68% of people

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began to work remotely (McCarthy, Bohle-Carbonell, ÓSíocháin, & Frost, 2020). These changes to the working life of a large proportion of the Irish population had knock on effects on mobility patterns. The Central Statistics Office (2021) used aggregated anonymised mobile phone data to calculate that 75% of the Irish population remained within 10 km of their home during various stages of the pandemic. In a recent systematic review of 66 studies international examining the changes in population physical activity levels before and during the COVID-19 pandemic, the majority of studies included in the review reported decreased physical activity levels during the pandemic period (Stockwell, et al., 2021). Along with changes to overall lifestyle habits, the shift in regular mobility patterns may be a factor in the documented decreases in population physical activity levels (Stockwell et al., 2021).

Due to the closure of sports clubs, leisure facilities and gyms, people were required to avail of existing infrastructure in close proximity to their home to be physically active, such as cycle paths and walking trails. Before the COVID-19 pandemic, research conducted by Sport Ireland suggested that two thirds (66%) of individuals in Ireland walked at least once per week for recreation, with recreational walking being Ireland's most popular form of physical activity (Sport Ireland, 2019). Further studies from Sport Ireland indicate that participation in recreational walking at least once a week increased to 80% during various stages of the pandemic (Sport Ireland, 2020). However, the small sample size of 1000 and the nature of the self-report data limit the conclusions one can draw from the findings relating to peri-pandemic recreational walking behaviours in Ireland. Furthermore, although these data provide an indication that walking has increased over the course of the COVID-19 pandemic, the data does not differentiate between walking for transport or recreation. Similarly, it does not identify the location of where the walking takes place. Consequently, the use of Ireland's recreational walking trails throughout the same period is unknown. This mitigates against the implementation of targeted behaviour change and infrastructural measures to sustain these apparent increases. The benefits of increasing recreational trail use would extend beyond the physical and mental health benefits of engaging in physical activity in nature. Studies have highlighted that walking in nature can be a way of reducing state anxiety and increasing cognitive control (Berman, Jonides, & Kaplan, 2008; Kotera, Lyons, Vione, & Norton, 2021; Lawton, Brymer, Clough, & Denovan, 2017). In addition to the individual level benefits experienced by those who use trails for recreation and leisure, visitors to protected areas worldwide has been estimated to contribute hundreds of billions of dollars annually (Balmford et al., 2015).

Madden and colleagues define footfall as a time-series statistic which is used to calculate the number of visitors to a specific location within a defined timeframe (Madden, Ramsey, Loane, & Condell, 2021). The footfall count of a recreational walking trail is not only an insight into visitation but has also been used as a primary indicator of the economic value of a trail (Bowker, Bergstrom, & Gill, 2007). Therefore, it is imperative to ensure that data are gathered using methods which are systematic and rigorous, as well as utilising multiple sources of data to accurately depict the overall usage of a trail (Schägner, Maes, Brander, Paracchini, & Hartje, 2017). Although research on park visitation has increased in recent years (Pickering, Rossi, Hernando & Barros, 2018), Schägner et al. (2017) note that our understanding and exploration of novel and systematic methods of gathering accurate footfall counts is limited. Rather, efforts are placed on understanding the economic value of various types of outdoor recreation, although footfall counts are often used as an indication of an outdoor recreation spaces' economic value. The management of recreational trails in Ireland is complex. There are a multitude of diverse organisations tasked with the maintenance, development, and monitoring of these trails. Consequently, despite the usefulness of footfall data for trails, there is no uniform method of monitoring usage across multiple trail types in the country.

Work by Cessford and Muhar (2003) and a more recent scoping study of trail sensor technologies by Madden et al. (2021) provide insight into the plethora of methods which could be used by park managers in monitoring visitor numbers to recreational walking trails. Recent studies have tried to move away from traditional observational methods of visitor monitoring by utilising tools such as public Wi-Fi networks (Traunmueller, Johnson, Malik, & Kontokosta, 2018), machine learning (Staab, Udas, Mayer, Taubenböck, & Job, 2021) and microwave radars (Thórhallsdóttir, Ólafsson, & Jóhannesson, 2021) to monitor park visitation and footfall. However, as highlighted by Madden et al. (2021) each come with their own limitations and some may be of use to park managers when others may not. Given the limitations of existing datasets and data collection methods related to walking behaviour, such as unreliable footfall counts, self-report data and ad-hoc data collection procedures, the collation of multiple forms of data pertaining to trail use, including social media (Wood, Guerry, Silver, & Lacayo, 2013) and big data (Rice & Pan, 2021), has been recommended albeit with caution. For example, Google Community Mobility Reports (GCMR), an openly available source of mobility data, has been criticised due to its lack of consideration for seasonality (Rice & Pan, 2021). However, despite the inherent biases and limitations associated with openly available mobility data, many studies have utilised such data to help with understanding and managing the spread of COVID-19 (Ilin, et al., 2021) and to explore how, and where, people are recreating during various stages of the COVID-19 pandemic period (Schweizer, et al., 2021). To date in Ireland openly available mobility data have not previously been used to understand recreational walking or trail usage. Doing so may provide a broader depiction of how Irish trails were used throughout the pandemic and may help inform future decisions relating to park visitation and management strategies and intervention development.

In summary, while Ireland boasts a plethora of recreational walking trails with diverse terrains and lengths, of varying difficulties and levels of accessibility, little is known about the extent to which they were utilised over the course of the COVID-19 pandemic due to the sporadic nature of data collection and collation. Therefore, the purpose of this paper is twofold. Firstly, it aims to analyse footfall count data from 33 trails maintained by two state-owned organisations to analyse the trends in recreational trail usage before and during the period of the COVID-19 pandemic. Secondly, this study also sought to examine the relationship between the objectively measured footfall counts and openly available mobility data (GCMR) in order to gauge the feasibility of using these data sources to corroborate trends in recreational walking trail use. Google Trends (GT) data relating to walking were also analysed to complement trends found in footfall count data.

2. Methods

2.1. Research design

This is a descriptive study which analysed changes in recreational walking trail use data obtained from footfall counters located on 33 recreational trails in Ireland between January 2019 and December 2020. Trail location coordinates were obtained and inputted into ArcGIS in order to obtain distances from urban areas. The trends identified in these data were compared with trends found in the openly accessible GCMR and GT datasets for the same period.

2.2. Trails

All trails included in the analysis consist of a combination of terrains including mountainous, coastal, forest and road and vary in level of difficulty and length, ranging from 8 km to approximately 130 km. Three trails included in the analysis were popular tourist trails (e.g., the Cliffs of Moher coastal route, the Burren Way and the Wicklow Way). A list of all trails and their characteristics can be found in Supplementary File 1.

2.3. Trail use data

Initially, footfall count data were obtained from three agencies for over 50 recreational walking trails in multiple Microsoft Excel spreadsheets. Following screening for missing data and anomalies in footfall counts (i.e., unreliable count due to a dead battery, vandalism and cobwebs over the sensor), footfall count data for 33 sites (2019 & 2020) from two state level agencies were included in the final analysis. All trails were individually calibrated according to the type of trail (linear/looped) prior to the acquisition of the data and counts were adjusted accordingly. For example, linear trail counts assumed that trail users would pass the counter twice and the final reports had taken this into account.

2.4. Google Community Mobility Reports and Google Trends data

Following the initial outbreak of COVID-19 in March 2020 Google begun releasing their Community Mobility Reports (GCMR), which are sets of aggregated anonymised mobility data which aimed to be useful in decision making relating to minimising the spread of COVID-19 (Fitzpatrick & DeSalvo, 2020). Data produced in the GCMR datasets relate to changes in mobility activity in various areas of society such as residential areas, workplace areas and parks, using aggregated anonymised sets of data from Google users who have their location history setting turned on (Google, 2021). The proportion of Google users who have their location settings turned on is currently unknown (Rice & Pan, 2021). For the purposes of this study, areas denoted as 'parks' were used in the analysis. Google defines parks as public gardens, castles, national forests, campgrounds or observation decks (Google, 2021). Google compare mobility changes to their baseline days which represent a normal value for that day of the week in each region (Google, 2021). The baseline value presented for this analysis represents the median value from the period January 3, 2020 to February 6, 2020. Google Trends (GT) provides data on the relative popularity of search terms or topics within a predefined time frame and geographic location inputted into the Google search engine (Google, 2021). Google Relative Search Rates (GRSR) do not represent total searches of a particular topic or search word, but the relative proportion of a search topic in relation to all search inquiries in a predefined time frame and geography. For the purposes of this paper, data pertaining to mobility in parks, and the topic of 'walking' were analysed for GCMR and GT datasets during the COVID-19 period, respectively. Google Trends data were obtained for 2019 and 2020. GCMR data were available from March 1, 2020 to December 31, 2020. To analyse these data, CSV files were downloaded from each of the respective datasets and graphs were generated using Microsoft Excel to depict trends over time.

2.5. Trail location analysis

GPS coordinates for each counter location (see Fig. 1) were obtained from the relevant parties and inputted into ArcGIS Online, a GIS software package, in order to conduct analyses for each trail. For trails where the exact GPS coordinates were not available, the location of the trailhead was used. The Euclidean distance between the location of the sensor or trailhead and the nearest border of an urban area were calculated and categorised as either within or outside 2 km, according to the 'World Population Density Estimate 2016' ArcGIS map layer (Economic & Social Research Institute, 2021 May 13). The categorisation of within or outside 2 km was chosen for our analysis as the initial movement restriction implemented by the government in March 2020 mandated the Irish population to remain within 2 km from their home for a period of approximately 6 weeks.

2.6. Data analysis

Descriptive analyses were conducted on footfall count data to highlight overall trends. In order to investigate the statistical significance of differences between monthly footfall counts, Wilcoxon signed-rank tests were employed. Spearman's correlation tests were used to obtain the correlation coefficients between percentage change in baseline for GCMR 'parks' data and percentage change in footfall counts. GCMR baseline is based on mobility in predefined societal areas from a five week period from January 3 to February 6, 2019. GCMR data were available from March 2020 to December 2020 only. To coincide with the timeline of baseline values of GCMR data, the mean value of footfall counts for all trails in January 2019 and February 2019 was calculated to act as the baseline value for footfall. The temporal granularity of the data obtained for footfall counts was presented as monthly values precluding the analysis weekly periods, similar to that used in GCMR.

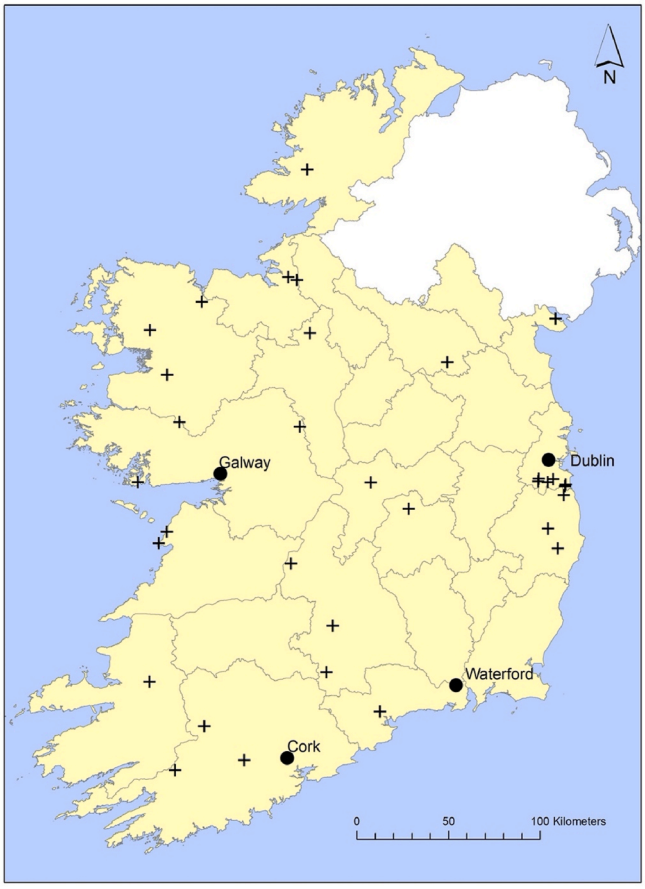

Fig. 1. Location of each trail (AdministrativeAreas - OSi National Statutory Boundaries, ArcGIS).

3. Results

3.1. Did recreational trail usage change during the COVID-19 pandemic in Ireland?

Total footfall counts for all trails (n = 33) increased by 6% in 2020 when compared with 2019 footfall counts. This increase was found to be statistically significant ($z = -2.254$, $p = .024$). Footfall increased for 26 of the 33 trails whereas 7 out of 33 trails saw a decrease in 2020 from the previous year. The largest decreases were found on trails that are usually used by thousands of domestic and international tourists each year, such as the Cliffs of Moher and the Burren Way. These trails saw decreases in overall footfall of 65% and 74%, respectively. The removal of these two popular tourist trails (Burren Way and Cliffs of Moher Coastal Route), found a statistically significant increase in total footfall counts between 2020 and 2019 of 17% ($z = -2.254$, $p = .024$).

Fig. 2 is a depiction of all sites (n = 33) and total footfall counts by month in 2020. Each grey line depicts one trail, with the red and black lines displaying the mean scores of all trails in 2019 and 2020, respectively. The most notable trend in the graph is that following the announcement of COVID-19 as a pandemic and the subsequent stay at home order issued by the government on the March 27, 2020, there was a 57% decrease in mean footfall between March 2020 and April 2020 (z = −4.154, p = .000). In the same period in 2019, there was an increase of 33% in mean footfall (z = −3.922, p = .000). As movement restrictions began to ease and intercounty and national travel were reintroduced, the mean scores of all trails in 2020 surpassed the mean scores of the same time in 2019 and remained at a higher level than the 2019 average for the remainder of the year. Our analysis illustrates the months of June, July and August in both years as the months with the highest footfall. June, July and August have been noted to be the months of the year with the lowest average rainfall in Ireland and highest temperatures (Walsh, 2012). On the June 29, 2020 strict travel restrictions in Ireland were lifted by the Irish government, allowing travel between counties. Following these measures footfall counts (mean) peaked in August, showing a statistically significant increase between August 2019 and August 2020, the month for which footfall counts peaked in both years (z = −2.0, p = .042). During the final quarter of 2020, there was a 26% increase in mean footfall in October (z = −3.067, p = .002), a 47% increase in mean footfall in November (z = −3.141, p = .002) and a 30% increase in December (z = −3.067, p = .002) compared to the same months in 2019.

3.2. Was recreational trail usage higher for trails within walking distance of an urban area?

When compared with 2019, trails within 2 km of urban areas saw higher mean trail usage during the June to December period in 2020. Fig. 3 depicts the mean trail usage scores for trails within and outside a 2 km distance from urban areas for 2019 and 2020. All trails saw a decrease in mean trail usage following the announcement of the COVID-19 pandemic in late March 2020. However, in April 2020, mean footfall counts on trails within 2 km of urban areas were 102% higher than trails outside of this distance during the initial stringent lockdown period (Fig. 3). Footfall counts on trails greater than 2 km from an urban area were lower in April 2020 when compared to April 2019 (z = −3.5, p = .000). There was no significant difference in footfall counts on trails within 2 km of an urban area during this period (z = −1.689, p = .91). As movement restrictions eased and intercountry travel resumed between May and August 2020, mean footfall counts on trails outside of 2 km from urban centres saw a statistically significant increase of 130% (z = −3.393, p = .001); while trails within 2 km of urban areas saw a lesser increase in mean usage of 4% which did not meet the criteria for statistical significance (z = −0.459, p = .646). As movement restrictions were reintroduced in mid-September into early October and the Irish population were required to stay within 5 km of their home, trails further than 2 km from urban areas saw mean footfall decrease by 38% between August and October 2020 (z = −2.581, p = .010), whilst trails within 2 km or less from urban areas saw an increase of 9% between the same period (z = −0.711, p = .477). In October 2020, trails within 2 km of an urban area had mean footfall counts that were 60% higher (z = −2.701, p = .007) than the same time in 2019. Following this period, trails within 2 km of an urban area saw higher mean usage scores than those outside of 2 km for the remainder of the year. In December 2020, mean footfall counts were 22% higher on trails within 2 km of an urban area (z = −2.845, p = .004) and 34% higher on trails outside of this threshold (z = −1.860, p = .063) compared with December 2019.

3.3. Do other datasets corroborate footfall trends?

Mobility in park areas as reported in GCMR data followed similar trends to total footfall counts on the trails included in our analysis during the COVID-19 pandemic. Fig. 5 highlights mobility in parks, between March 2020 and December 2020 plotted against total footfall counts for the 33 trails included in this analysis for the same period. There was a significant positive association between the percentage change in footfall data from baseline and percentage change in GCMR park data from baseline in March to December 2020 (rho = 0.67, n = 10, p = .035). Both sets of data follow a similar trend: experiencing a sharp decrease following the initial stay-at-home order in March; peaking in August; and experiencing fluctuations during the lockdowns in the final four months of the year. Similar trends to those found in the analysis of footfall count data were found in GT datasets for the 2020 period. Fig. 4 below depicts Google Trends data, highlighting the relative search rate for the topic 'walking' in Ireland between in 2019 and 2020. Noteworthy is the sharp increase in search rates for the topic 'walking' between weeks 9 and 11 in 2020, during the initial period when the COVID-19 outbreak was declared a pandemic. The most popular time for the topic of 'walking' to be searched in Ireland was in August, which was also the month which saw the highest footfall counts on trails included in our analysis.

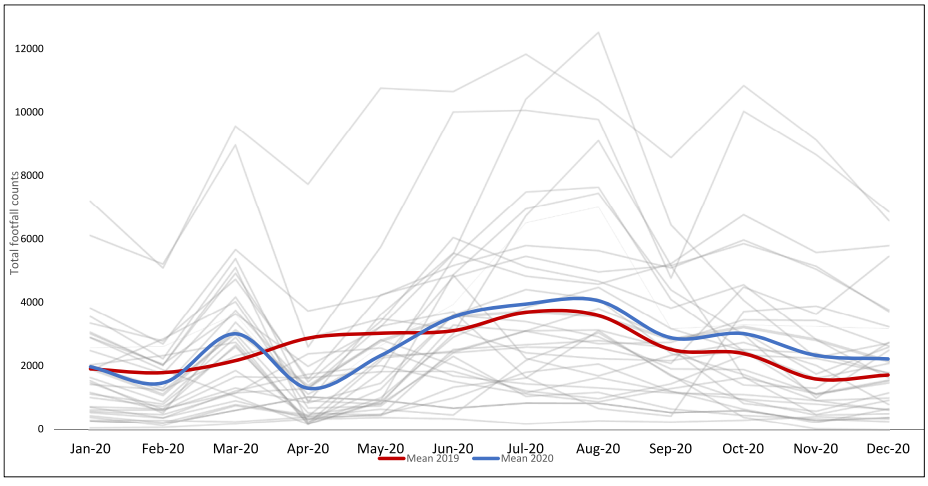

Fig. 2. Total footfall counts by month in 2020. Each line represents one trail. Red and blue lines represent mean values for footfall counts in 2019 and 2020, respectively. Initial lockdown (16 March-14 May): closure of schools and non-essential businesses and services i.e. bars, restaurants, hotels. Strict movement restrictions (no travel <2 km) from homes unless for necessary purposes– Societal reopening (15 May-11 September): Reopening of bars, restaurants, hotels etc. on a staged basis. Gradual lifting of movement restrictions (<5 km from home and for essential purposes only from May 18 to full intercountry travel on July 1). Lockdown gradual reintroduction (11 September-31 December).: Closure of non-essential businesses and services, reintroduction of 5 km movement restriction from 19 October – 1 Dec. Removal of some restrictions (i.e. indoor dining reintroduced, county level movement restriction) from 1 December. Strict lockdown measures reintroduced from 22 December until 12 January 21). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

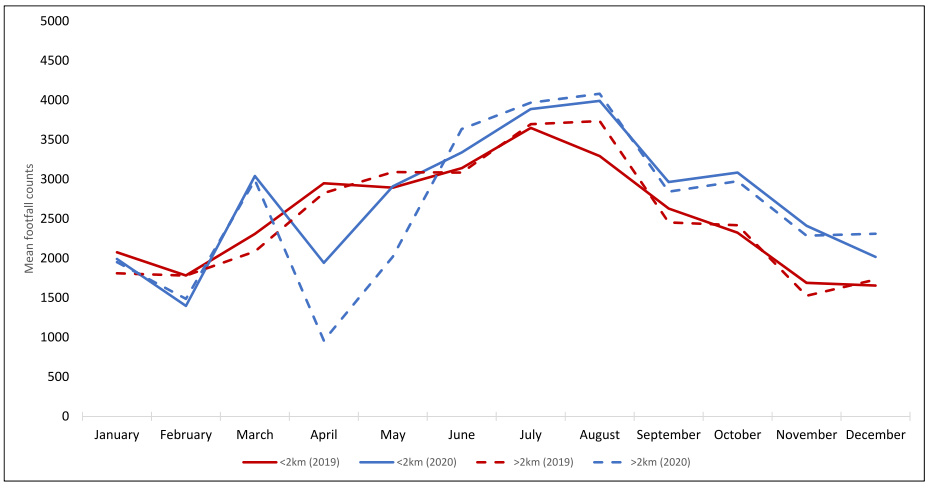

Fig. 3. Mean footfall counts of trails within 2 km and further than 2 km from light urban/urban areas - 2019 and 2020. Initial lockdown (16 March-14 May): closure of schools and non-essential businesses and services i.e. bars, restaurants, hotels. Strict movement restrictions (no travel <2 km) from homes unless for necessary purposes– Societal reopening (15 May-11 September): Reopening of bars, restaurants, hotels etc. on a staged basis. Gradual lifting of movement restrictions (<5 km from home and for essential purposes only from May 18 to full intercountry travel on July 1). Lockdown gradual reintroduction (11 September-31 December).: Closure of non-essential businesses and services, reintroduction of 5 km movement restriction from 19 October – 1 Dec. Removal of some restrictions (i.e. indoor dining reintroduced, county level movement restriction) from 1 December. Strict lockdown measures reintroduced from 22 December until 12 January 21). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

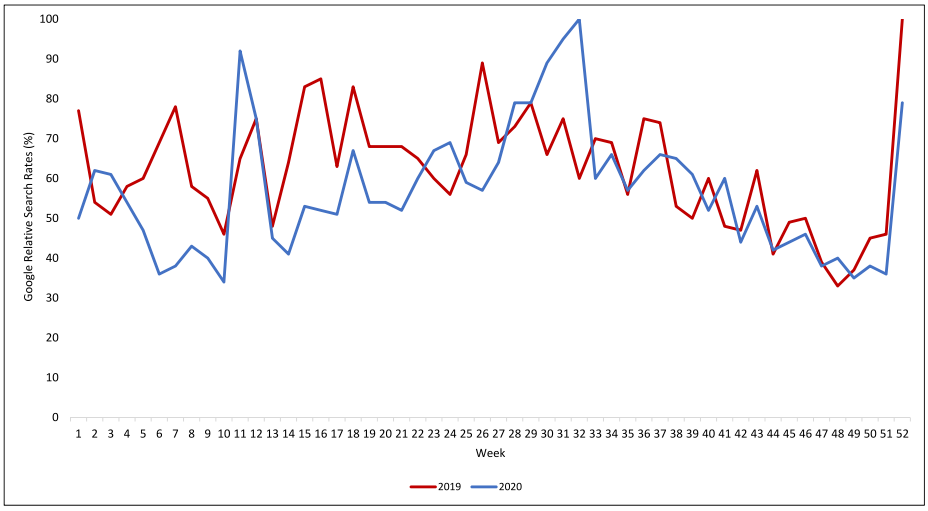

Fig. 4. Fig. 4: Google Relative Search Rates on the topic of 'walking' in 2019 and 2020. Initial lockdown (16 March-14 May): closure of schools and non-essential businesses and services i.e. bars, restaurants, hotels. Strict movement restrictions (no travel <2 km) from homes unless for necessary purposes– Societal reopening (15 May-11 September): Reopening of bars, restaurants, hotels etc. on a staged basis. Gradual lifting of movement restrictions (<5 km from home and for essential purposes only from May 18 to full intercountry travel on July 1). Lockdown gradual reintroduction (11 September-31 December). Closure of non-essential businesses and services, reintroduction of 5 km movement restriction from 19 October – 1 Dec. Removal of some restrictions (i.e. indoor dining reintroduced, county level movement restriction) from 1 December. Strict lockdown measures reintroduced from 22 December until 12 January 21). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

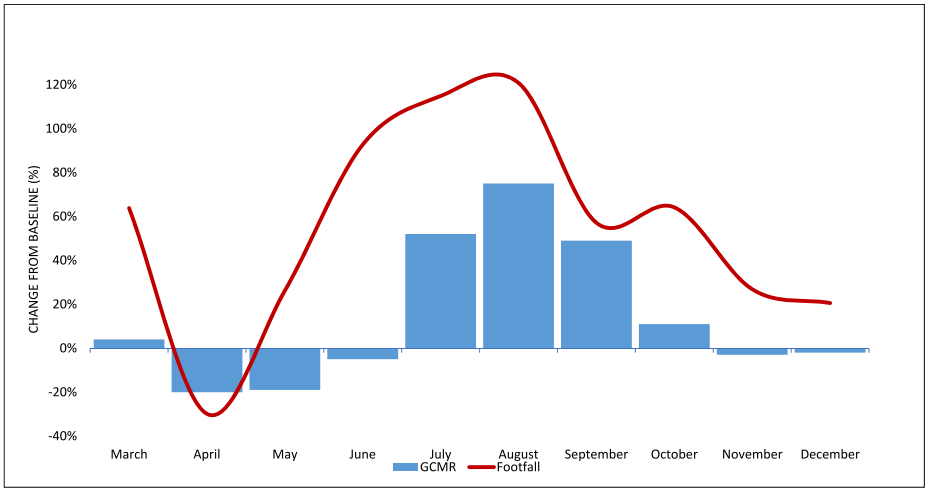

Fig. 5. Percentage change in footfall and percentage change in mobility in 'parks' according to GCMR data. Blue bars represent % change from baseline in GCMR data. Red line represents % change from baseline in footfall counts. Initial lockdown (16 March-14 May): closure of schools and non-essential businesses and services i.e. bars, restaurants, hotels. Strict movement restrictions (no travel <2 km) from homes unless for necessary purposes. Societal reopening (15 May-11 September): Reopening of bars, restaurants, hotels etc. on a staged basis. Gradual lifting of movement restrictions (<5 km from home and for essential purposes only from May 18 to full intercounty travel on July 1). Lockdown gradual reintroduction (11 September-31 December): Closure of non-essential businesses and services, reintroduction of 5 km movement restriction from 19 October – 1 Dec. Removal of some restrictions (i.e. indoor dining reintroduced, county level movement restriction) from 1 December. Strict lockdown measures reintroduced from 22 December until 12 January 21). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

4. Discussion

The overall purpose of this paper was to analyse footfall count data from 33 Irish recreational walking trails to describe trends in footfall counts before and during the COVID-19 pandemic. Furthermore, trends in openly available mobility data from GCMR and GT data were analysed to supplement and corroborate trends in footfall count data. This paper also aims to explore how data from a variety of sources may be used to understand trail usage. Our results suggest that there was a 6% overall increase in recreational trail usage in Ireland compared to the previous year. Footfall counts fluctuated throughout the varying movement restrictions implemented by the Irish government, and trends suggest that the increase in trail usage was maintained regardless of lockdown intensity. Trails that were within 2 km of an urban area were used more frequently during times of governmental movement restrictions than trails outside of 2 km. Similar trends can be observed within the GCMR data when compared to footfall count data during the same period. To the authors knowledge, this is the only study of recreational walking trail usage in Ireland that has used objective footfall sensors and publicly available mobility data, notwithstanding against the contextual backdrop of the COVID-19 pandemic.

4.1. COVID-19: A catalyst for increasing trail usage in Ireland?

The findings of our analysis indicate that there was an overall increase in recreational trail usage during the COVID-19 period, which bucks international trends of decreasing physical activity levels during the pandemic (Stockwell et al., 2021). Some of the trails included in this analysis, i.e., the Cliffs of Moher coastal route and the Burren Way, are in Clare, one of the most popular tourist destinations in the country, which is visited by over one million domestic and international tourists per year (Fáilte Ireland, 2019). Given visitation to major tourist trails was reduced in 2020 due to domestic and international travel restrictions, we anticipate that the documented 6% increase in footfall found here is a conservative finding. After removing the Cliffs of Moher coastal route and the Burren Way from our analysis, we found a 17% increase in footfall counts which may be a more accurate reflection of the increase documented here. Sport Ireland reported an increase (~14%) in people walking for recreation at least once a week during the pandemic (Sport Ireland, 2020). The trails included in our analysis that were within 2 km of an urban area saw little fluctuation in footfall counts throughout 2020 compared to more remote trails. Furthermore, in December 2020, mean footfall counts of trails within 2 km of urban areas were 22% higher than December in the previous year. This sustained increase in mean footfall counts in the final months of the year suggests that individuals may have chosen to maintain the habit of trail visitation, even when other physical activity and exercise options were available. It must be noted, however, that other factors including seasonal changes, weather and public holidays have been noted to contributed to annual trends in trail visitation (Genge, Innes, Wu, Wang, & Wang, 2021). However, as there were no drastic changes in total rainfall and mean temperature in Ireland between 2019 and 2020 (Met Éireann, 2021), one could argue that weather may not have been major contribution to the increase in footfall counts recorded here. However, the closure of physical activity and exercise facilities such as gyms and leisure centres during certain phases of lockdown required a shift in where the Irish population chose to recreate. Our results highlight that recreational walking trails could have acted as a substitute for previous recreation destinations. In a 2016 study, Verplanken and Roy aimed to unpack what impact changes within an individuals' life course has on promoting sustainable lifestyle behaviours. Interestingly, they concluded that moments of uproot and discontinuity within an individual's life, such as relocation, result in a temporary moment when people are more receptive to interventions to change lifestyle behaviours in a sustainable way (Verplanken and Roy, 2016). Within the context of this paper, the COVID-19 pandemic has resulted in significant disruption of daily life and presents an opportunity to further understand and sustain the increase in trail usage documented here.

Given that regular physical activity is the prime modality for the prevention of numerous non-communicable diseases and has also been advocated for resilience against COVID-19 (Sallis, et al., 2021) and other infectious diseases (Chastin, et al., 2021), it may be in the interest of public health to design interventions to help sustain this increase in recreational walking trail visitation. However, care should be exercised in this process. Although maximising efforts to increase trail usage may have an impact on population health and wellbeing, caution must be exercised by park managers and trail management teams to ensure trail users adhere to local public health guidelines relating to COVID-19 such as physical distancing (Wynveen, et al., 2021). Furthermore, increases in trail and park visitation may have caused unforeseen implications for park managers relating to litter management. In a study conducted by Jones and McGinlay (2020) in the United Kingdom, a survey of 438 people living in the Peak District Area highlighted that 70% of respondents had witnessed littering in the Peak District National Park on their visits during the COVID-19 pandemic. Intensifying public outreach and education of the Leave No Trace principles by Leave No Trace Ireland may assist in minimising the impact of increased trail use on soil, wildlife, and vegetation (Leave No Trace Ireland, 2021). Minimising the impact of litter on trail aesthetics may help prevent reductions in the therapeutic effects of a trail, as research has highlighted that litter can influence a wilderness users' perception of their experience in a wilderness area or trail (Roggenbuck, Williams, & Watson, 1993, pp. 187–197).

4.2. Can openly available data sources be used to support footfall count data on Irish trails?

This study indicates that openly available mobility data may help corroborate trends in trail footfall counts in order to improve the validity of overall trends. This is important because footfall data analysed within this study came from a limited number of trails. Therefore it is not possible to draw definitive conclusions from these data alone. Indeed, the use of openly available mobility data is becoming more evident in similar studies published internationally during the time of the pandemic (Venter, Barton, Gundersen, Figari, & Nowell, 2021). As highlighted above, trends showing increased mobility in areas Google deemed as 'parks' around the time of the initial stay-at-home order in March 2020 corroborate those found in footfall counts on the trails included in this analysis. Previous work has recommend the inclusion of alternative forms of data such as social media when combined with other forms of trail monitoring data for nature-based tourism (Teles da Mota & Pickering, 2020). In a 2013 study, Wood and colleagues aimed to understand whether social media data from the website 'flickr' could be used to estimate visitation rates in 836 recreational sites around the world (Wood et al., 2013). Wood et al. (2013) concluded that the social media data used in their study could serve as a reliable proxy for park visitation rates. Similarly, work conducted by Ciesielski and Sterenczak (2021) and Hausmann et al. (2017) highlight the ability for social media data to be used as a useful tool for decision makers relating to forest and park management. However, the inherent biases of using social media data and big data in conjunction with traditional trail data has been discussed elsewhere and the interpretation and use of these data must be done with caution (Elwood, Goodchild, & Sui, 2012; Goodchild, 2013; Pickering, Rossi, Hernado, & Barros, 2018). Furthermore, although global smartphone ownership has increased, sociodemographic factors including age and gender have been noted to influence internet usage, smartphone ownership and social media behaviours, which may limit the overall representativeness of the openly available mobility data included in this study (Pew Research Center, 2016).

Within the Irish context, the potential for multiple sources of data, including big data and social media, to be combined when measuring the overall usage of a trail requires further exploration within the

outdoor recreation research community. Our analysis of GT data found an increased rate of searches directed towards the topic of walking in Ireland during the COVID-19 pandemic period. This may suggest that baseline knowledge of walking related routes, trails and information could be low in Ireland. Although GT does not provide any demographic data or suggest causality in terms of the increase in walking behaviour, it can provide a valuable indication of the public interest in each topic during a particular time (Jun, Yoo, & Choi, 2018, pp. 69–87). For example, GT data has been utilised by Ding and colleagues to highlight the increase in internet searches for 'exercise' during various stages of the COVID-19 pandemic across multiple geographies (Ding, del Pozo Cruz, Green, & Bauman, 2020). The heterogeneous types of data that exist which could be utilised to explore trail usage require exploration beyond those included in this paper and it must be noted that GT data may act as a useful complement to these data. The analysis conducted here simply provides insight into the utility openly available mobility data sources to help explain and corroborate trends in objective footfall sensors as opposed to using these data as proxy measures. Despite this opportunity, the multiple sources of data pertaining to recreational trail usage in Ireland are underutilised and underexplored and given Irish communities' rediscovery of trails within their vicinity over the course of the COVID-19 pandemic, gathering accurate data on footfall and usage of these trails is as important as ever for land managers and for conservation purposes.

4.3. The need for a centralised surveillance system for trail usage data in Ireland

The potential for local authorities and researchers to utilise these robust and largescale datasets in unison, when making decisions relating to the provision and maintenance of green space is pertinent. There is a timely opportunity for data and resources to be shared across sectors and between disciplines within the recreational walking system in Ireland to aid in the development of a coordinated approach to the collection and collation of trail use data. Walking and trail use data is currently being collected by governmental and non-statutory bodies in Ireland on an ad-hoc basis and, if integrated, could help trail managers make decisions on trail maintenance, promotion and conservation strategies. Furthermore, there are multiple big datasets which gather step count and mobility data which could also be utilised by land managers to supplement trail use data such as Facebook Data for Good (Facebook Research, 2020), Fitbit (Fitbit, 2021), Apple Mobility Data (Apple, 2021) and Strava Metro (Strava, 2021). A harmonised data portal for trails and parks has been called for at the EU level (Schägner et al., 2017), yet the benefits of having a national level park and trail usage data portal has been relatively unexplored at the national level in Ireland. Embracing such 'imperfect' but pragmatic ways of gathering and synthesising data on trail usage supports the notion put forward by Ogilvie et al. (2020), that our model of evidence on which we base our public health decisions should resemble a 'dry-stone wall'. That is, efforts should be made to combine studies of differing methodologies, statistical approaches and heterogeneous sample populations. The same applies to monitoring visitors to parks and trails. The complexity of combining multiple data sources such as those presented here should be embraced in order to provide a more accurate depiction of Irish trail usage. In order to do so, the multisectoral and multidisciplinary organisations from health, tourism, recreation, transport and education who have a stake in the recreational walking system in Ireland must understand their roles within the system and their ability to contribute to the system.

The development of systems maps through group model building and collaborative conceptual modelling methods (Hovmand, 2014; Newell & Proust, 2012) may offer an opportunity for the stakeholders within the outdoor recreation research community to begin working beyond the confines of conceptual siloes and to understand the complexity of the systems in which they are embedded. Systems maps have been used by researchers as an exploratory tool to understand the complexities and nuances of 'wicked' public health problems such as obesity (Allender, et al., 2015) and physical activity at local (Cavill, Richardson, Faghy, Bussell, & Rutter, 2020) and national level (Rutter, Cavill, Bauman, & Bull, 2018; Bellew, et al., 2020). One purpose of systems maps is to allow system actors to gain a new perspective on the systems in which they work. However, a more practical application of a systems map is its ability to visually identify opportunities for data collection and existing data sources within a system (Friel, et al., 2017). Within the context of the recreational walking system in Ireland, the systems mapping process involving interdisciplinary stakeholders could be useful to explore currently available data sources, and opportunities for further data collection pertaining to trail use.

4.4. Strengths and limitations

Despite the strengths of this work, there are three main limitations that must be noted. Firstly, in relation to the footfall counters that are in place on the trails, previous work has critiqued the reliability of such devices and noted that the reliability and validity of results produced from counters can vary (Andersen, Gundersen, Wold, & Stange, 2013; Cessford & Muhar, 2003; Madden et al., 2021). For example, some trails are accessible on mountain bikes and the PIR sensors are unable to distinguish between the different types of trail user. Furthermore, aggregated mobility data, similar to that of GCMR data, is also unable to distinguish between types of users (Reif & Schmücker, 2020). However, it has been noted that these data can be beneficial if used in conjunction with other forms of data pertaining to trail or park visitation, as is presented here (Ciesielski & Sterenczak, 2021; Rice & Pan, 2021). Secondly, the type of data used in the present study preclude the consideration of user level characteristics, such as their demographic profile, physical activity behaviour, reasons for using the trail and their perceived barriers to trail use. These methodological limitations limit the potential for footfall count data alone to contribute to understanding the impact of trail usage on population level physical activity as well as informing future promotional campaigns and interventions. Thirdly, the temporal granularity, level of aggregation and length of data collection period can limit the analysis of big data (Rice & Pan, 2021). In the present study, there were differences in the temporal granularity of footfall count data and available GCMR data. However, this research represents the first effort to analyse long term empirical data pertaining to recreational walking trail use on several sites in Ireland, notwithstanding during the period of the COVID-19 pandemic. Furthermore, this study utilises multiple data sources not only to provide clarity to the trends observed in the objectively measured footfall count data, but also the ability for GCMR to be used to corroborate trends.

5. Conclusions

This paper provides an insight into the trends in recreational trail usage during the COVID-19 pandemic in Ireland. There are a number of key findings presented in this paper. Firstly, the analyses conducted here display an overall increase of 6% in trail usage in 2020 when compared with 2019. Trails that were within 2 km of urban areas had up to 102% higher mean footfall counts than those outside of 2 km during the most stringent COVID-19 lockdown phases in 2020. Not only does our analysis document the objectively measured increase in trail usage by the Irish public during various stages of the lockdown, but it also highlights the potential for openly available mobility data, such as GCMR, to be used in conjunction with footfall sensors in order to facilitate a more in-depth understanding of trends in footfall and recreational walking. Our data suggest that one potential positive legacy of COVID-19 could be the increased and sustained use of trails by the Irish population, even in the winter months. Integrating heterogeneous forms of trail use data could help trail and park managers plan evidence-based maintenance strategies for the future.

CRediT authorship contribution statement

Dylan Power: Conceptualization, Writing – original draft, Investigation, Data curation, Visualization, Formal analysis. **Barry Lambe:** Supervision, Conceptualization, Writing – review & editing. **Niamh Murphy:** Supervision, Conceptualization, Writing – review & editing.

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Appendix A. Supplementary data

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