

## Highlights

### **Reducing socioeconomic inequalities in access to and participation in community-based running and walking activities: a longitudinal ecological study of parkrun events 2010 to 2019**

Robert A. Smith, Paul P. Schneider, Rami Cosulich, Helen Quirk, Alice M. Bullas, Steve J. Haake, Elizabeth Goyder

- Access & participation in parkrun in England improved every year from 2010-2019.
- However, the rate of improvement slowed down, especially after 2013.
- New events disproportionately improved access for high deprivation areas.
- High deprivation areas started to close the gap in participation from 2010-2013.
- From 2013 participation stabilised, and remains lower in high deprivation areas.

# Reducing socioeconomic inequalities in access to and participation in community-based running and walking activities: a longitudinal ecological study of parkrun events 2010 to 2019<sup>\*,\*\*</sup>

Robert A. Smith<sup>a,\*,1</sup>, Paul P. Schneider<sup>a,1</sup>, Rami Cosulich<sup>a</sup>, Helen Quirk<sup>a</sup>, Alice M. Bullas<sup>c</sup>, Steve J. Haake<sup>b</sup> and Elizabeth Goyder<sup>a</sup>

<sup>a</sup>*School of Health and Related Research, 30 Regents Court, Sheffield, United Kingdom, S1 4DA,*

<sup>b</sup>*Advanced Wellbeing Research Centre, Sheffield Hallam University, Olympic Legacy Park, Sheffield, S9 3TU, UK*

<sup>c</sup>*Sports Engineering, Sport and Physical Activity Research Centre, Sheffield Hallam University, S10 2LW*

## ARTICLE INFO

### Keywords:

parkrun  
physical activity  
socioeconomic deprivation  
ecological study  
Relative Index of Inequality

## ABSTRACT

**Objectives:** To conduct a longitudinal ecological analysis of the geographic access to and participation in free weekly outdoor physical activity events (“parkrun”) in England from 2010 to 2019, and related socioeconomic and ethnic inequalities, to inform policies to support participation in physically active community events.

**Methods:** We use distance to the nearest parkrun event as a proxy for geographic access, and calculate this for each English Lower Layer Super Output Area (LSOA) each month from January 2010 to December 2019. We then report the trends in geographical access to and participation in parkrun by Index of Multiple Deprivation quintile. We also report trends in the Relative Index of Inequality (RII) by deprivation for participation and access. We go on to investigate trends in LSOA level determinants (e.g. deprivation and ethnic density) of parkrun participation between 2010 and 2019, using multivariable Poisson regression models.


**Results:** Mean distance to the nearest parkrun event decreased from 34.1 km in 2010, to 4.9 km in 2018. Throughout the period, parkrun events tend to be situated closer to deprived areas compared to less deprived areas. Participation rates increased superlinearly (greater than linear increase) from 2010 to 2013 before slowing to linear growth. Participation over the period exhibits a clear socioeconomic gradient, with people from deprived areas having consistently lower participation rates over the period. parkrun participation rates became more equitable between 2010 to 2013 (RII improved from 189 to 39), before stabilising at an RII between 32.9 and 39.6 from 2014 to 2019. The results of the Poisson regression model validate this finding; the coefficients on IMD score initially increased from -0.047 in 2010 to -0.037 in 2013, and then remained relatively stable to 2019 (-0.035).

**Conclusions:** Access to and participation in parkrun events has increased over the past 10 years. The period can be split into two distinct phases: from 2010 to 2013 increases in participation and improvements in access were super-linear, and inequality in participation fell dramatically. From 2013 to 2019 increases in participation were linear, and inequality in participation remained stable. Despite parkrun’s ambitions of creating inclusive events and engaging with deprived communities, the socioeconomic gradient in participation rates remained high and stable since 2013. Gaining a better understanding of the reasons why parkrun grew so quickly may be useful for other physical activity movements, while further analysis of the relatively lower participation rates by those from areas with higher socioeconomic deprivation is important for developing initiatives to encourage physical activity in these communities.

\*R.S., P.S. R.C. are joint funded by the Wellcome Trust Doctoral Training Centre in Public Health Economics and Decision Science [108903] and the University of Sheffield. H.Q. is funded by an NIHR School of Public Health Research (SPHR) post-doctoral launching fellowship. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

\*\*We would like to thank Mike Graney (Head of Analysis at parkrun) and Chrissie Wellington (Global Head of Health and Wellbeing at parkrun) for providing area level parkrun participation data.

\*Corresponding author

 rasmith3@sheffield.ac.uk (R.A. Smith)

ORCID(s): 0000-0003-0245-3217 (R.A. Smith); 0000-0003-3552-1087 (P.P. Schneider); 0000-0003-2716-4681 (H. Quirk); 0000-0003-2857-4236 (A.M. Bullas); 0000-0002-4449-6680 (S.J. Haake); 0000-0003-3691-1888 (E. Goyder)

<sup>1</sup>Joint first author

## 1. Introduction

In 2004, a group of runners started a small 5 km event called the ‘Bushy Park Time Trial’ in London. The event grew into ‘parkrun’, a ‘community-based recreational running initiative’ [7] (p.6) which now has over 1,400 free weekly events in 22 countries worldwide. At the time of writing 6.3 million people have taken part, many of whom were not previously engaged in running, or even physically active, prior to parkrun [10, 12, 6]. Early research showed that regular participants in parkrun experienced increases in weekly physical activity levels, improved fitness, and reported health benefits such as better weight control and mental wellbeing [12]. This has led to parkrun being identified as an exemplar intervention in the WHO Global Action Plan on Physical Activity 2018–2030 [9], and by the Royal College of General Practitioners (RCGP) as a form of social prescribing aimed at increasing patient physical activity [5].

As a grass-roots, citizen led community organisation, parkruns are established by enthusiastic volunteers in their local community [13]. As a result there is a risk that, as with other public health interventions, parkrun events may not be as available, or as well attended by people living in deprived areas as in less deprived areas [3]. In 2018, Sport England announced funding to help create 200 new parkrun events in England, with a core aim to improve participation among women and girls and those from socioeconomically deprived areas. Previous studies used determinants of access to and participation in parkrun [2, 1] to determine the optimal location of these new events. This body of work showed that, despite similar geographical access to parkrun events, people from more deprived areas and areas with higher ethnic density had lower participation rates than less deprived areas with lower ethnic density. However, as a cross-sectional study with data from a single year, it was not possible to understand how access to and participation in parkrun had changed over time [2]. Therefore, parkrunUK made additional data available with the specific objective of improving understanding of the trends in access and participation.

This paper utilises this rich dataset, which contains the number of parkrun finishers from each of the 32,844 Lower layer Super Output Areas (LSOAs) in England for each of the 522 weeks over the ten year period from 2010 to 2019. It combines this with data from the Office for National Statistics (ONS) data on LSOA characteristics and parkrun event data from the parkrunUK website, to better understand the trends in access to and participation in parkrun. We then repeat the analysis of the socioeconomic determinants of parkrun participation, previously for 2018 [2] for each year from 2010 to 2019.

## 2. Methods

### 2.1. Ethical Statement

Ethical approval was obtained from the Sheffield Hallam University Ethics Committee (ER10776545). We did not collect any personal information, but only used aggregate secondary data at the Lower layer Super Output Area level from parkrun and publicly accessible data from the Office for National Statistics. It is therefore not possible to identify individuals. The parkrun Research Board approved this research project, and three of its members (AMB, EG, HQ, SSJH) were actively involved in it.

### 2.2. Data sources and variables

Data on the number of finishers from each of the 32,844 LSOAs on the 522 Saturdays in the years from 2010-2019 inclusive was obtained from parkrunUK. The geographical location and start date for each parkrun event was obtained from the parkrunUK website. The rest of the data was obtained from the ONS. Descriptions of variables and sources are provided in Table 1 below. All underlying data is provided open source (link github). In the open source data number of finishers is provided aggregated by month, as used in the remainder of the analysis.

Access to parkrun was defined as the geodesic distance (direct linear distance) from the LSOA’s population-weighted centroid to the nearest event. For each of the 32,844 LSOAs, we computed the geodesic distances between its population-weighted centroid and all parkrun events that were in operation on the 15th of the respective month, and then selected the shortest distance. ‘Better’ access was defined as a shorter distance while ‘worse’ access was defined as a longer distance.

Participation for a given LSOA was measured as the number of times anyone living in the LSOA finished a parkrun event in England in the respective month. Four finishers could therefore be the result of one individual finishing four events, or four individuals finishing one event each.

The socioeconomic deprivation of LSOAs was measured using the 2015 Index of Multiple Deprivation (IMD), a measure of relative deprivation. The IMD combines 37 indicators from seven domains (income, employment, education and skills, health and disability, crime, housing and services, and living environment) into a single score. The

**Table 1**

Variables &amp; sources of data in analysis

Variable	Description	Source
run_count	number of finishers per month/year	parkrunUK
run_rate	derived from run_count and LSAO populations	derived
imd	Index of Multiple Deprivation scores for each LSOA	ONS, 2015
total_pop	total number of individuals in each LSOA	ONS, 2017
pop_density	population density for each LSOA	ONS, 2017
ethnic_density	Ethnic Density: percentage of population non-white-british	ONS, 2011
mn_dstn	distance from LSOA centroid to nearest parkrun (derived)	derived from ONS, 2011
perc_non_working_age	derived from ONS data on age-groups in each LSOA	ONS, 2015

score ranges from 0 (least deprived) to 100 (most deprived). Ethnic Density, the percentage of the population reporting as non-White-British, was estimated as 100 minus the percentage reporting as White British and was obtained from the ONS dataset.

### 2.3. Data Analysis

The open source dataset contains data for all 32,844 English LSOAs for each month from January 2010 to December 2019, including only events which took place on Saturdays. As an ecological study, all analyses are conducted at the level of the LSOA, and results are not weighted by population size.

#### 2.3.1. Descriptive statistics

We investigate longitudinal trends in geodesic distance (access) and participation by IMD quintile using descriptive statistics and charts. We report both the number of finishers per 1,000 persons and the mean distance to nearest event for each of the IMD Quintiles by month and year.

#### 2.3.2. Relative Index of Inequality

The relative index of inequality (RII) is a strictly non-negative regression-based index which is commonly used to describe the size of the effect of socioeconomic status on an outcome [8]. It is the ratio of the predicted outcome in the least deprived area compared to the predicted outcome in the most deprived area. Since it is a regression-based index it takes account of all the data-points and is less sensitive to outliers at the extremes. A RII of 1 indicates no socioeconomic gradient in the outcome of interest, a value higher than 1 indicates a higher predicted value for less deprived groups, while a RII lower than 1 indicates a higher predicted value for more deprived groups.

We calculate the RII, for both geodesic distance (access) and participation. The RII for geodesic distance was computed as the ratio of the predicted distance to the nearest parkrun event from the least compared to the most deprived LSOA, using a linear regression model with IMD as the only predictor. The latter was calculated as the ratio of the predicted number of finishers from the least compared to the most deprived LSOA, using a univariable Poisson regression model with a log link with total population as the offset variable. For geodesic distance, a RII > 1 indicates that less deprived areas are further from their nearest parkrun, while for participation an RII > 1 indicates that less deprived areas have a higher parkrun participation rate.

#### 2.3.3. Determinants of access and participation over time

We conclude by replicating our previous analysis of the determinants of community level parkrun participation, using a log-link Poisson regression model for aggregate data for each year from 2010 to 2019. As control variables we use: population density, ethnic density, distance to nearest event and percent of the population of non-working age. Total population was used as an offset. We report mean coefficient estimates and standard errors for each year.

All analyses was undertaken in R version 4.0.2 (2020-06-22). All code is available online here: (Anonymous)

## 3. Results

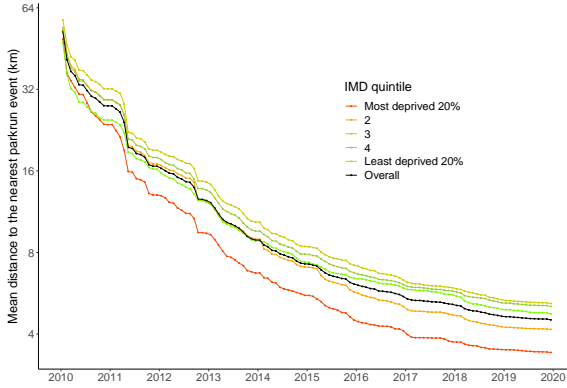
### 3.1. Descriptive Statistics

Table 2 shows a summary of the monthly dataset which contains 3,547,152 rows, one row for each unique LSOA each month with a mean IMD score of 21.7 (IQR = 9.7 - 30.1), mean total population 1,627 (IQR = 1,437 - 1,750),

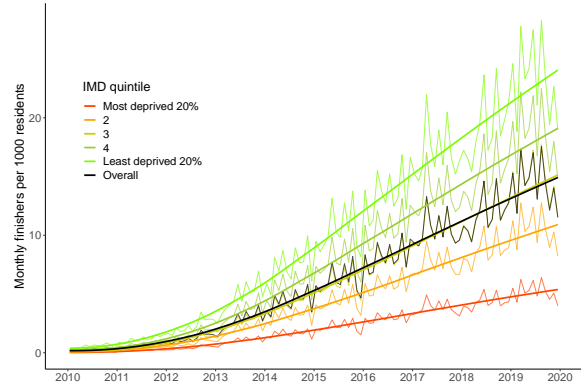
**Table 2**

Descriptive Statistics for time invariant LSOA characteristics (N = 32,844)

Variable	Mean	Min	Pctl(25)	Median	Pctl(75)	Max
IMD score	21.7	0.5	9.6	17.4	30.0	92.6
Ethnic density (%)	13.8	0	2.3	5.2	16.7	99.3
Population	1,666	934	1,437	1,572	1,750	7,976
Pop density (pop/km <sup>2</sup> )	4,423	2.5	1,288	3,551	5,924	99,024
Non-working-age (%)	42.4	0	38.3	42.4	46.0	71.8



**Figure 1:** Mean geodesic distance to nearest event from Jan2010 to Dec2019, by IMD quintile. See also Table 4.



**Figure 2:** Mean monthly parkrun finishers per 1,000 persons from Jan2010 to Dec2019, by IMD quintile. See also Table 5.

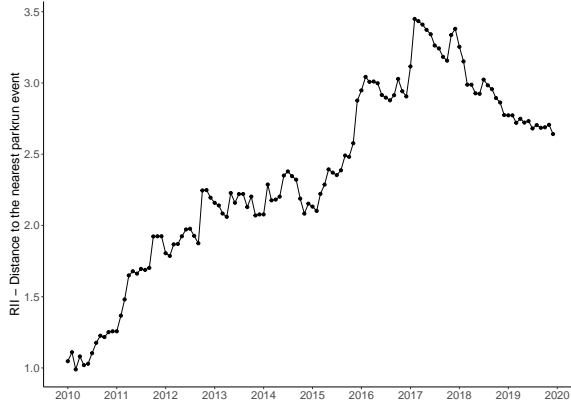
mean percent non-working age of 41.5% (IQR = 38.3-46.0%) mean ethnic density of 13.8% (IQR = 2.3% - 16.7%) mean population density of 4,423 persons per square kilometer (IQR 1,266 - 5,865) mean distance to nearest event of 12.2 km (IQR 2.9 km - 13.4 km).

Figure 1 shows the mean geodesic distance to the nearest parkrun event (access) for each of the IMD quintiles (and overall in black) over time. A table containing the numeric values can be found in Table A1 in the supplementary material. The mean distance decreased super-linearly in the first four years (from 34 km in 2010 to 10 km in 2013), and took another six years to reduce to less than 5 km. Geodesic distance to the nearest event had no clear socioeconomic gradient from 2010 to 2013, but from 2013 onwards was generally better in more deprived areas.

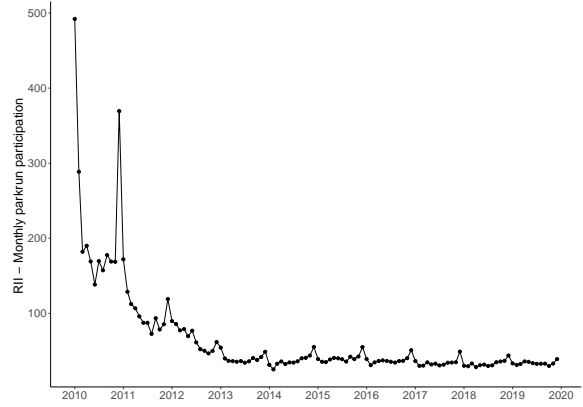
Figure 2 shows the number of finishers per 1,000 persons for each IMD quintile, and overall, for each month in the study period. A table of the numeric values can be found in Table A2 in the supplementary material. The participation rate showed a general positive trend (ignoring seasonal fluctuations) in all deprivation quintiles. In all cases participation can be seen to increase exponentially from 2010 to 2013, before exhibiting linear growth from 2014 to 2019. There is a clear difference between the participation rates for different IMD deprivation quintiles, with the most deprived 20% of LSOAs having participation rates that have been between 87% and 78% lower than that of the least deprived 20% of LSOAs. By 2019 the most deprived quintile of the population had similar participation rates as the least deprived did in 2013, six years earlier.

### 3.2. Trends in Relative Index of Inequality in Access

Figure 3 below shows the RII for access, measured as the geodesic distance to the nearest parkrun event, over the period. An RII of 1 represents equality of geodesic distance for more and less deprived areas, while an RII above 1 means that less deprived areas had greater geodesic distances to their nearest parkrun event than more deprived areas. We can see that the distance to nearest event was equitable in 2010 but became increasingly inequitable, in favour of more deprived areas, until 2017 (i.e., new parkrun events were situated nearer to more deprived areas and further away from less deprived areas). By 2017 the least deprived LSOA had almost 3.5 times the predicted geodesic distance to the nearest parkrun event compared to the most deprived LSOA. This fell to approximately 2.71 by the end of 2019.



**Figure 3:** RII in geodesic distance to nearest parkrun event by month from Jan10 to Dec19.



**Figure 4:** RII in parkrun participation by month from Jan10 to Dec19.

Figure 4 shows the RII for monthly parkrun participation. An RII of 1 represents equality of participation between more and less deprived areas, while an RII above 1 means that less deprived areas have higher participation rates than more deprived areas. Initially in 2010, the socioeconomic gradient of parkrun participation was extremely steep, regression based predictions of participation rates (RII) were 189 times higher in the least deprived LSOA compared to the most deprived LSOA. Subsequently, the RII fell from 2010 to 2013, at which point the measure stabilised such that the least deprived area had around 35 times the predicted number of finishers as the most deprived area. We also found that the relationship exhibits yearly seasonality from the year 2013 onwards, with December being the most inequitable and January the most equitable months.

### 3.3. Poisson regression model of the determinants of participation from 2010 to 2019.

The results of the Poisson regression models, one for each year from 2010 to 2019, are displayed in Table 3 below. The dependent variable is number of finishers per year, and the independent variables include the LSOA IMD score, ethnic-density (%), population density<sup>2</sup>, distance to nearest event (in km) and percent of the population non-working age (%).

The Index of Multiple Deprivation regression coefficient is negative in every year over the ten year period (i.e. more deprived areas have lower parkrun participation). However the coefficient on IMD has increased throughout from -0.047 in 2010 to -0.035 in 2018, meaning the effect of a single unit increase in IMD score (controlling for covariates) changed from -4.7% in 2010 to -3.5% in 2018. Most of this change occurred between 2010 to 2013. It is also worth noting that the coefficient on the Ethnic Density variable has also increased over time. The effect of a 1% increase in ethnic density decreased, from a 2% reduction in participation in 2010 to a 1.3% reduction in 2018. (i.e. the effect of ethnic density, the percentage of non-white-british persons in the community, on parkrun participation has fallen over time).

We have also run a quasi-poisson regression model, the results of which are shown in Table 6 in the appendix. These results suggest that the confidence intervals around the coefficients are larger than suggested by the regular Poisson regression model, perhaps due to the high number of LSOAs which would have had no finishers during these years.

<sup>2</sup>Note that we use thousand persons per km<sup>2</sup> here to enable easier interpretation of the regression coefficients

**Table 3**  
Results of the Poisson log-link generalised linear model for each year from 2010 to 2019.

	<i>Dependent variable: Annual number of finishers (population offset)</i>									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
IMD Score	−0.050*** (0.0003)	−0.047*** (0.0002)	−0.044*** (0.0001)	−0.038*** (0.0001)	−0.037*** (0.0001)	−0.036*** (0.0001)	−0.036*** (0.0001)	−0.036*** (0.00005)	−0.035*** (0.00004)	−0.035*** (0.00004)
Ethnic-Density	−0.014*** (0.0002)	−0.013*** (0.0001)	−0.012*** (0.0001)	−0.013*** (0.0001)	−0.013*** (0.0001)	−0.013*** (0.00005)	−0.012*** (0.00004)	−0.011*** (0.00004)	−0.010*** (0.00003)	−0.009*** (0.00003)
Pop Density	−0.021*** (0.001)	−0.021*** (0.001)	−0.019*** (0.0005)	−0.017*** (0.0003)	−0.019*** (0.0003)	−0.018*** (0.0002)	−0.018*** (0.0002)	−0.016*** (0.0002)	−0.013*** (0.0002)	−0.012*** (0.0002)
Distance(km)	−0.090*** (0.0003)	−0.105*** (0.0003)	−0.125*** (0.0003)	−0.125*** (0.0002)	−0.134*** (0.0002)	−0.122*** (0.0002)	−0.112*** (0.0002)	−0.101*** (0.0002)	−0.098*** (0.0002)	−0.087*** (0.0001)
Non-working-age	−0.001** (0.0005)	−0.001*** (0.0003)	−0.001*** (0.0002)	−0.004*** (0.0001)	−0.004*** (0.0001)	−0.004*** (0.0001)	−0.005*** (0.0001)	−0.005*** (0.0001)	−0.005*** (0.0001)	−0.005*** (0.0001)
Constant	−3.382*** (0.024)	−2.886*** (0.015)	−2.441*** (0.010)	−1.795*** (0.007)	−1.449*** (0.006)	−1.286*** (0.005)	−1.106*** (0.004)	−0.997*** (0.004)	−0.936*** (0.003)	−0.799*** (0.003)
Observations	32,844	32,844	32,844	32,844	32,844	32,844	32,844	32,844	32,844	32,844
Log Likelihood	−161,145.200	−283,450.000	−405,001.400	−613,260.700	−780,058.200	−888,144.200	−1,044,555.000	−1,160,194.000	−1,229,169.000	−1,390,105.000
Akaike Inf. Crit.	322,302.300	566,912.000	810,014.700	1,226,533.000	1,560,128.000	1,776,300.000	2,089,123.000	2,320,400.000	2,458,350.000	2,780,222.000

*Standard errors in parenthesis.*

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01



## 4. Discussion

This article aimed to investigate the trends in community level access to and participation in parkrun, a community running and walking event, in England between 2010 and 2019. This fills an important gap in the literature as an exemplar of how community events to increase physical activity can grow, and adds to our understanding of how that growth occurs in different communities. The comprehensive dataset provided by parkrun shows that access and participation improved over the ten year period. However these improvements exhibited diminishing returns (initial improvements were bigger than later improvements).

Geographic access to parkrun events was equitable in 2010; parkrun events were situated at similar geodesic distances from more deprived areas and less deprived areas. However, as parkrun grew, more events were launched in areas with higher deprivation (e.g. cities) than in less deprived areas such as rural village locations (note in Table 2 the coefficient for population density decreased, suggesting more participation in rural areas). Perhaps because of these disproportionate improvements in access for people from more deprived areas, participation among these communities also increased disproportionately until 2013.

Despite parkrun events being situated closer to more deprived areas, we found a strong and persistent socioeconomic gradient in parkrun participation rates. Throughout the study period, LSOAs in the least deprived quintile had between 4.5 and 7 times higher parkrun participation rates than the most deprived quintile, and after a dramatic improvement between 2010 and 2013, the RII for participation remained at a stable level of 35. This result was confirmed by the multivariable analysis of the determinants of parkrun participation, which showed only marginal changes in the relationship between IMD and parkrun participation after 2013. Despite the continuous growth of parkrun in England, in 2019, the population residing in the least deprived quintile have over four times the participation rate of the population residing in the most deprived quintile.

In our previous paper, we showed that in 2018, areas in England with higher deprivation, and areas with higher ethnic density had lower parkrun participation rates [2]. In this paper we replicated this analysis for each year from 2010 to 2019. We found that, as with the descriptive statistics and univariate analysis (RII), the period can be split into two distinct phases: from 2010 to 2013 the effect of deprivation (IMD) reduced, and from 2013 to 2019 the effect remained stable. However, the effect of ethnic density appears to have declined over the entire period. Nevertheless the results for 2016, 2017 and 2019 are similar enough to validate our findings for 2018.

parkrun is commonly held up as an example of a movement which is effective at increasing physical activity in the community [10, 12]. The events themselves have been perceived to be inclusive and sociable [11, 7], and parkrun as an organisation has been particularly focused on making events accessible to everyone regardless of background and ability [10]. One way in which parkrun has attempted to improve accessibility is through the creation of new events. This culminated in a partnership with Sport England in 2018 which aimed to create 200 new events targeted specifically towards socioeconomically deprived communities. Our previous work suggested that improved geographic access to parkrun, while likely to increase overall participation, may also widen pre-existing inequalities in participation [1, 2]. This study validates these findings: geographical access to parkrun has consistently been better and has improved faster in more deprived areas, yet participation remains substantially lower compared to less deprived areas. It therefore seems unlikely that more events will substantially reduce inequalities in participation.

Further research is necessary to better understand why some communities are more engaged in parkrun than others. Understanding why engagement differs more or less at different times of the year may be a simple first step in this analysis, but a more robust mixed-methods approach to identifying modifiable factors which influence participation is more likely to generate feasible interventions. This could have a wider impact than just parkrun, since the mechanisms which affect participation in parkrun are also likely to influence physical activity participation and/or engagement in community events in general.

These findings have several implications for policy. Firstly, creating new events is likely to continue to increase overall participation in parkrun, but is unlikely to reduce the inequalities in participation that have been stable for the past six years. Strategies to encourage engagement with socioeconomically deprived communities (such as considering transport methods for non-car users as suggested in [4], could be incorporated into the creation of new events in order to maximize their impact, especially in socioeconomically deprived communities. Secondly, there does appear to be a trend of increasing engagement from areas with higher ethnic density. This is encouraging because it suggests that parkrun is becoming more successful at engaging with culturally diverse communities. parkrun could continue to promote participation in these communities (for example previous research has suggested engaging with community leaders or translating promotional materials into other languages [4].



#### 4.1. Limitations

The coefficients for 2018 do not perfectly match the coefficients of our previous paper [2]. There are several reasons for this; firstly this analysis includes the full year, whereas the 2018 study included only the period to 10th December, secondly parkrun updated their database, which led to some (seemingly) random variation between the two datasets, and finally we only include events held on a Saturday in this analysis, whereas in the previous analysis we included all parkrun events. This has no material impact on the findings or the implications for policy.

The measure of access used in this study, geodesic distance, does not measure the ability of different groups to attend events. A 5 km distance may be more difficult to transverse in a city than for those with a car in rural areas. A model which uses estimates of travel time using travel distance and predicted transport mode may yield a better proxy for travel access, and adding a consideration of other forms of perceived access (e.g. travel expense, safety) may improve our understanding of the determinants of participation.

The use of ethnic density in this analysis does not allow us to determine variation in participation by areas with higher percentages of specific ethnic groups. Future analysis could use more detailed ONS data on the LSOAs to better understand whether the effect is similar for all minority ethnic groups. All data code is available open source to enable others to build upon this work.

There are also several limitations that are similar from our previous analysis for 2018 [2]. Firstly, the data provided by parkrun gives the number of finishes by LSOA. The number of finishes tells us nothing about the number of unique runners, and one runner undertaking 5 runs is counted the same as five runners undertaking 1 run each. We feel confident this is a satisfactory simplification. Also important is that this is an ecological study at the level of the LSOA. As before we have been careful to state that effects exist at the level of the community, not necessarily the individual, so as not to commit an ecological inference fallacy.

#### 5. Conclusion

Geographic access to and participation in parkrun events has improved over the past 10 years. The period can be split into two distinct phases: from 2010 to 2013 participation and geographical access increased exponentially and inequality in participation fell dramatically, and from 2013 to 2019 participation increased linearly, and inequality in participation remained stable.

The findings of this study suggest that prior to Covid-19 parkrun had reached a steady (linear) rate of growth in participation and the share of participation by different socioeconomic groups (e.g. quintiles of IMD). While increases in participation are likely to continue to increase for all socioeconomic groups, closing the gap in participation between the most and least deprived communities is likely to require changes to the organisation and delivery of events rather than just further increases in the number of events in more deprived areas.

Mixed methods research combining the power of the rich participation dataset provided by parkrun with a deeper understanding of the issues on the ground is essential for shaping effective interventions to boost participation overall, but particularly in socio-economically deprived communities.

## Appendix

**Table 4**

Mean geodesic distance to the nearest parkrun event by IMD quintile for each year from 2010 to 2019.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Overall	34.09 (0.06)	20.79 (0.04)	14.53 (0.03)	10.21 (0.02)	7.93 (0.01)	6.66 (0.01)	5.79 (0.01)	5.27 (0.01)	4.85 (0.01)	4.58 (0.01)
Most deprived 20%	30.57 (0.13)	16.84 (0.08)	11.21 (0.05)	7.72 (0.03)	6.02 (0.02)	5.03 (0.02)	4.29 (0.01)	3.86 (0.01)	3.6 (0.01)	3.46 (0.01)
2	35.64 (0.17)	21.52 (0.11)	14.86 (0.07)	10.19 (0.05)	7.72 (0.03)	6.36 (0.02)	5.35 (0.02)	4.82 (0.02)	4.43 (0.02)	4.2 (0.02)
3	38.82 (0.15)	23.94 (0.1)	16.9 (0.07)	11.95 (0.04)	9.18 (0.03)	7.77 (0.03)	6.73 (0.02)	6.05 (0.02)	5.61 (0.02)	5.25 (0.02)
4	35.52 (0.13)	22.2 (0.08)	15.7 (0.06)	11.12 (0.04)	8.61 (0.03)	7.29 (0.02)	6.39 (0.02)	5.88 (0.02)	5.44 (0.02)	5.13 (0.01)
Least deprived 20%	29.92 (0.1)	19.46 (0.06)	13.98 (0.04)	10.09 (0.03)	8.11 (0.02)	6.85 (0.02)	6.18 (0.02)	5.73 (0.02)	5.16 (0.01)	4.84 (0.01)

1 = most socioeconomically deprived quintile, 5 = least socioeconomically deprived quintile, Standard errors in parentheses.

**Table 5**

Mean monthly parkrun finishers per 1,000 persons by IMD quintile for each year from 2010 to 2019.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Overall	0.26 (0)	0.6 (0)	1.23 (0)	2.71 (0.01)	4.38 (0.01)	6.13 (0.01)	8.26 (0.02)	10.43 (0.02)	11.8 (0.02)	14.43 (0.02)
Most deprived 20%	0.07 (0)	0.18 (0)	0.42 (0)	1 (0.01)	1.61 (0.01)	2.21 (0.01)	2.97 (0.01)	3.82 (0.02)	4.3 (0.02)	5.22 (0.02)
2	0.15 (0)	0.37 (0)	0.81 (0.01)	1.93 (0.01)	3.14 (0.02)	4.32 (0.02)	5.85 (0.03)	7.53 (0.03)	8.66 (0.03)	10.52 (0.04)
3	0.21 (0)	0.52 (0.01)	1.1 (0.01)	2.54 (0.02)	4.24 (0.02)	5.89 (0.03)	8.12 (0.03)	10.37 (0.04)	11.83 (0.04)	14.59 (0.05)
4	0.34 (0.01)	0.77 (0.01)	1.55 (0.01)	3.37 (0.02)	5.58 (0.03)	7.87 (0.03)	10.65 (0.04)	13.35 (0.04)	15.08 (0.05)	18.51 (0.06)
Least deprived 20%	0.54 (0.01)	1.17 (0.01)	2.28 (0.02)	4.69 (0.03)	7.35 (0.03)	10.36 (0.04)	13.72 (0.05)	17.07 (0.05)	19.14 (0.05)	23.32 (0.06)

1 = most socioeconomically deprived quintile, 5 = least socioeconomically deprived quintile, Standard errors in parentheses.

**Table 6**  
Results of the quasi-poisson log-link generalised linear model for each year from 2010 to 2019.

	<i>Dependent variable: Annual number of finishers (population offset)</i>									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
IMD Score	-0.050 (6.612)	-0.047 (0.355)	-0.044 (0.164)	-0.038*** (0.002)	-0.037*** (0.001)	-0.036*** (0.0005)	-0.036*** (0.0004)	-0.036*** (0.0004)	-0.035*** (0.0004)	-0.035*** (0.0004)
Ethnic-Density	-0.014 (4.378)	-0.013 (0.247)	-0.012 (0.117)	-0.013*** (0.002)	-0.013*** (0.001)	-0.013*** (0.0004)	-0.012*** (0.0003)	-0.011*** (0.0003)	-0.010*** (0.0003)	-0.009*** (0.0003)
Pop Density	-0.021 (20.631)	-0.021 (1.195)	-0.019 (0.568)	-0.017** (0.008)	-0.019*** (0.003)	-0.018*** (0.002)	-0.018*** (0.002)	-0.016*** (0.001)	-0.013*** (0.001)	-0.012*** (0.001)
Distance(km)	-0.090 (6.889)	-0.105 (0.527)	-0.125 (0.338)	-0.125*** (0.005)	-0.134*** (0.002)	-0.122*** (0.001)	-0.112*** (0.001)	-0.101*** (0.001)	-0.098*** (0.001)	-0.087*** (0.001)
Non-working-age	-0.001 (9.843)	-0.001 (0.540)	-0.001 (0.250)	-0.004 (0.003)	-0.004*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)
Constant	-3.382 (476.665)	-2.886 (26.058)	-2.441 (12.066)	-1.795*** (0.168)	-1.449*** (0.055)	-1.286*** (0.036)	-1.106*** (0.033)	-0.997*** (0.031)	-0.936*** (0.029)	-0.799*** (0.028)
Observations	32,844	32,844	32,844	32,844	32,844	32,844	32,844	32,844	32,844	32,844

*Standard errors in parenthesis.*

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Note the high standard errors for the quasi-poisson regression model due to the relatively low number of LSOAs with non-zero finishes.

## CRediT authorship contribution statement

**Robert A. Smith:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Software, Visualization, Writing 1–Original Draft Preparation, Writing 1–Review Editing;. **Paul P. Schneider:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Software, Visualization, Writing 1–Original Draft Preparation, Writing 1–Review Editing;. **Rami Cosulich:** Writing 1–Review Editing, Writing 1–Original Draft Preparation. **Helen Quirk:** Writing 1–Review Editing, Writing 1–Original Draft Preparation. **Alice M. Bullas:** Project Administration, Resources. **Steve J. Haake:** Project Administration, Resources, Writing 1–Review Editing. **Elizabeth Goyder:** Supervision, Writing 1–Review Editing.

## References

- [1] Author, 2019. [details removed for peer review] .
- [2] Author, 2020. [details removed for peer review] .
- [3] Bull, E.R., Dombrowski, S.U., McCleary, N., Johnston, M., 2014. Are interventions for low-income groups effective in changing healthy eating, physical activity and smoking behaviours? a systematic review and meta-analysis. *BMJ open* 4. doi:10.1136/bmjopen-2014-006046.
- [4] Fullagar, S., Petris, S., Sargent, J., Allen, S., Akhtar, M., Ozakinci, G., 2019. Action research with parkrun uk volunteer organizers to develop inclusive strategies. *Health Promotion International* doi:10.1093/heapro/daz113.
- [5] of General Practitioners, R.C., et al., . Parkrun practice initiative. 2018.
- [6] Haake, S., Quirk, H., Bullas, A., 2018. Uk ireland parkrun health wellbeing survey 2018. URL: <https://awrcparkrunresearch.wordpress.com/2018/10/2>.
- [7] Hindley, D., 2020. “more than just a run in the park”: An exploration of parkrun as a shared leisure space. *Leisure Sciences* 42, 85–105. doi:10.1080/01490400.2017.1410741.
- [8] Mondor, L., Cohen, D., Khan, A.I., Wodchis, W.P., 2018. Income inequalities in multimorbidity prevalence in ontario, canada: a decomposition analysis of linked survey and health administrative data. *International journal for equity in health* 17, 90. doi:10.1186/s12939-018-0800-6.
- [9] Organization, W.H., 2019. Global action plan on physical activity 2018-2030: more active people for a healthier world. World Health Organization.
- [10] Reece, L.J., Quirk, H., Wellington, C., Haake, S.J., Wilson, F., 2019. Bright spots, physical activity investments that work: Parkrun; a global initiative striving for healthier and happier communities. *British journal of sports medicine* 53, 326–327. doi:10.1101/19004143.
- [11] Sharman, M.J., Nash, M., Cleland, V., 2019. Health and broader community benefit of parkrun—an exploratory qualitative study. *Health promotion journal of Australia* 30, 163–171. doi:10.1002/hpja.182.
- [12] Stevinson, C., Wiltshire, G., Hickson, M., 2015. Facilitating participation in health-enhancing physical activity: a qualitative study of parkrun. *International journal of behavioral medicine* 22, 170–177. doi:10.1007/s12529-014-9431-5.
- [13] Wiltshire, G., Stevinson, C., 2018. Exploring the role of social capital in community-based physical activity: qualitative insights from parkrun. *Qualitative Research in Sport, Exercise and Health* 10, 47–62. doi:10.1080/2159676x.2017.1376347.