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# Sociodemographic Factors Affecting Outdoor Exercise Trips During the COVID-19 Lockdown

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## Abstract

We employ a state-of-the-art modelling framework to determine the significant factors affecting rates of outdoor exercise trips during Scotland's COVID-19 lockdown, using data from public surveys conducted by Transport Scotland. The random parameters ordered probit modelling approach is used for its ability to account for the potential effect of unobserved heterogeneity stemming from explanatory variables. The framework is extended further to also allow for detection of heterogeneity among the means of random parameters. We show that various sociodemographic factors (relating mainly to household social grade, employment status and disability) significantly influenced the frequency at which outdoor exercise trips were made during lockdown. Specifically, those who are self-employed, those from a social DE household (the household's main income earner is employed in a manual occupation or is unemployed) and those with a health problem or disability, were shown to be significantly more likely to complete no outdoor exercise during lockdown, and therefore, these groups are at greater risk of the associated mental and physical illnesses. Model results are linked to issues surrounding transport equity, as personal vehicle ownership was found to significantly affect the rate of outdoor exercise trips made by disabled individuals. Policy implications are discussed with regards to mitigating the effects of the pandemic on the future health state of groups exhibiting low exercise levels.

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**Keywords:** COVID-19; Exercise; Public health; Random parameters ordered probit; Unobserved heterogeneity

## 1. Introduction

The COVID-19 pandemic, and subsequent government-enforced lockdowns, has had myriad effects on travel behaviour across the globe (Abdullah, et al., 2020; Jenelius & Cebecauer, 2020; Lavery, et al., 2020). In Scotland,

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during the March 2020 lockdown, significant reductions in bus, rail and car journeys and a significant increase in active travel (walking and cycling) were recorded. Trip purposes also differed considerably from pre-lockdown norms (Downey, et al., 2021; Transport Scotland, 2020). The lockdown travel behaviour of Scottish residents has been heavily influenced by working restrictions imposed during the March 2020 lockdown. Those employed in occupations allowing remote working were advised to telecommute, while many others were furloughed (UK Government, 2020). Recent research has found that reduced office hours and telecommuting, often increase levels of physical activity (Cook & Gazmararian, 2018). As a result, Scottish residents who telecommuted or were furloughed during lockdown may have had more freedom to be physically active. “Key workers” (employed in healthcare, care homes, emergency services etc.) are unlikely to have benefitted from the same freedoms, as they were required to continue with their normal commuting and working patterns during lockdown. Recent data from Sport England (2020) suggests this was the case, as occupational factors affected the physical activity rates of English residents during lockdown, for example, lower socioeconomic groups and key workers were less likely to complete frequent physical activity (Sport England, 2020). Despite this, overall physical activity among the wider population surged compared to pre-lockdown levels.

This study examines the rate of outdoor exercise trips made by Scottish residents during the COVID-19 lockdown, using data from Transport Scotland’s *COVID-19 Public Attitudes Surveys* (Transport Scotland, 2020). The survey data include demographic and behavioural characteristics of respondents, information about their travel behaviour, before and during the outbreak of COVID-19, as well as their attitudes and expectations about future mobility. Given the mental and physical health benefits of outdoor exercise (Anderson & Durstine, 2019; Camacho, et al., 1991), it is important to determine which demographic and social groups have benefitted from high, or suffered from low, exercise rates. Individuals belonging to certain social groups (e.g. certain occupations or lower income groups) have been at greater risk of COVID-19 infection and mortality (Bambra, et al., 2020). Similarly, vulnerable groups (often disabled and/or elderly individuals) have experienced higher rates of COVID-19 mortality, and during lockdown were advised to “shield” (self-isolate indefinitely) by the UK Government. It is important to determine whether these groups were unable to complete frequent exercise during the pandemic, as low physical activity during this period has the potential to exacerbate pre-existing social and health inequalities. For this purpose, we investigate the sociodemographic and behavioural influencers of outdoor exercise trips made during the COVID-19 lockdown in Scotland.

## 2. Data

Transport Scotland (Scotland’s government agency for transport) conducted triweekly public attitudes surveys of Scottish citizens throughout the spring 2020 lockdown and subsequent phases of restriction easing (Transport Scotland, 2020). We study the weekly outdoor exercise trips made by Scottish residents during the most stringent lockdown period (24<sup>th</sup> March – 27<sup>th</sup> May 20) via respondents’ answers to mobility-related questions. Sociodemographic characteristics (e.g., gender, age, disability, employment status, social grade and ethnic background) and behavioural attributes (mode of travel, and altered personal behaviour as a result of COVID-19) were also recorded. UK Government definitions of social grades are as follows: Social AB (those in managerial/professional occupations), Social C1 (those in supervisory/junior managerial occupations or in full-time education), Social C2 (skilled manual occupations) and Social DE (semi/unskilled manual occupations or unemployed). The original survey question gauged the occupation of the household’s main income earner, therefore the social grade variable is referred to as ‘household social grade’ from here on.

The trip rates were recorded as discrete, ordered outcomes (zero, one, two-three, four-five, six-seven, and more than seven trips). Due to underrepresentation of several of these categories, the dependent variable was aggregated as follows: Level 1 (no trips), Level 2 (one, two or three trips), Level 3 (four or five trips) and Level 4 (six or more than six trips). Table 1 and Figure 1 show the distribution of responses for the dependent variable during two of Transport Scotland’s surveys (Wave 1 and Wave 2), and the overall Lockdown Sample (which is a combination of Waves 1 and 2). The responses collected during Wave 1 (conducted w/c 5<sup>th</sup> May 2020) and Wave 2 (w/c 18<sup>th</sup> May 2020) were merged into a single dataset, given that the distribution of responses is similar in both periods and the conditions in which the questionnaire was answered (i.e., during the most stringent lockdown) were also consistent. A Kolmogorov-Smirnov test was conducted to verify this assumption; results were insignificant ( $p$ -value > 0.05), therefore there is no significant variation in the distributions of Wave 1 and Wave 2. The initial dataset contained information from 2,000 respondents, however 603 were discarded due to incompleteness (hence,  $n=1397$ ).

Table 1. Frequency of weekly outdoor exercise trips made during lockdown

Group	Frequency of response (% in parentheses)			
	Level 1 (no trips)	Level 2 (one to three trips)	Level 3 (four to five trips)	Level 4 (six or more trips)
Wave 1	106 (14.72%)	149 (20.69%)	77 (10.69%)	388 (53.89%)
Wave 2	143 (21.12%)	118 (17.43%)	60 (8.86%)	356 (52.58%)
Lockdown Sample (n=1397)	249 (17.82%)	267 (19.11%)	137 (9.81%)	744 (53.26%)

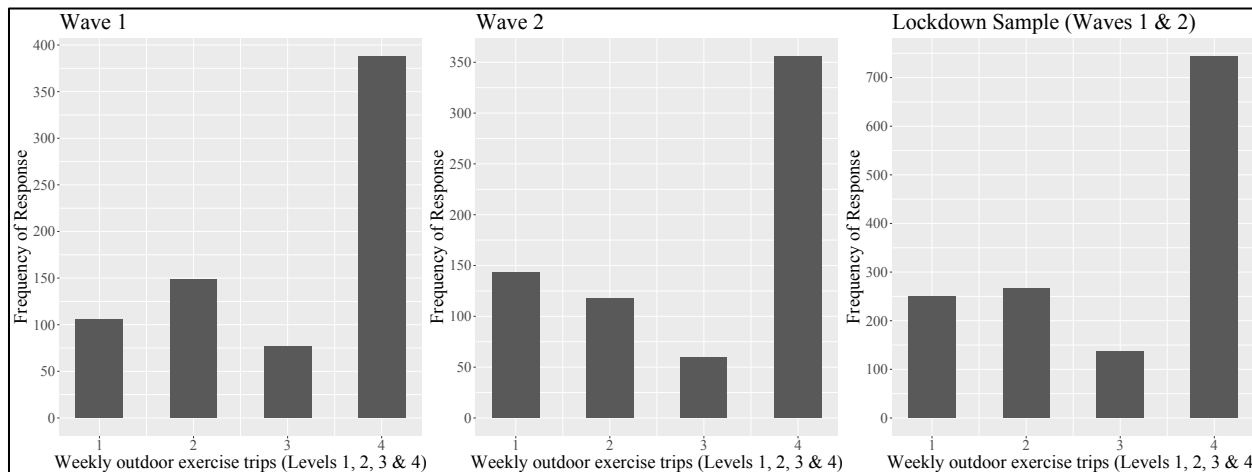


Fig. 1. Distribution of responses for weekly outdoor exercise trips (Wave 1, Wave 2 & overall Lockdown Sample)

Table 1 shows that the majority of respondents (53.26%) completed frequent outdoor exercise trips (six or more per week) during lockdown. A possible explanation may be that the majority of the Scottish population had greater freedom to complete frequent outdoor exercise trips because of their lockdown working situation. Gyms were closed during lockdown, so high outdoor exercise trip rates during lockdown may also be due to people seeking alternative ways to remain physically active. There was, however, a considerable proportion of respondents (17.2%) who made no outdoor exercise trips during lockdown. This may be related to how certain groups perceive the risk of COVID-19 infection, as it is likely that certain groups, such as, elderly individuals or those with pre-existing health conditions, acted cautiously in the early stages of the pandemic. Key workers, who continued to work full-time during the pandemic, may not have had the same freedom to exercise as those who telecommuted or were furloughed, and may contribute to the zero trips category. To provide further insights into the factors affecting the outdoor exercise trips of Scottish residents, statistical models were estimated.

### 3. Methodology

Given the discrete, ordered nature of the dependent variable, discrete outcome modelling, in particular, the random parameters ordered probit (RPOP) modelling framework, was deemed appropriate for the statistical analysis (Washington, et al., 2020). The random parameters framework differs from the standard ordered probit, as it allows for the potential effects of unobserved heterogeneity associated with the observed independent variables to be captured. The random parameter modelling features a flexible model formulation enabling the parameter estimates of the explanatory variables to vary across the observational units (Intini, et al., 2020). Past research has shown that the inclusion of random parameters often results in significantly higher explanatory power of models, compared to traditional, fixed parameters approaches (Anastasopoulos & Mannering, 2009; Fountas, et al., 2019). To further optimize the modelling framework, allowances are also made to identify heterogeneity in the means of the random parameters, if present. This approach can capture additional layers of unobserved heterogeneity, as random parameters are allowed to vary by explanatory variables (Seraneeprakarn, et al., 2017; Washington, et al., 2020). For the remainder

of the paper, the standard, Fixed Parameters Ordered Probit (FPOP), the Random Parameters Ordered Probit (RPOP) and the Random Parameters Ordered Probit model with Heterogeneity in the Means (RPOPHM) will be referred to by their acronymic titles. The following models were estimated in R, using the package: ‘Rchoice’ (Sarrias, 2020).

#### 4. Model Estimation Results

This section displays the model estimation results for outdoor exercise trips made during lockdown. Table 2 shows the independent variables that significantly affected outdoor exercise trips, where the ‘percentage’ column refers to the proportion of the variable belonging to the indicator group, e.g. for ‘Age’, 16.96% of respondents were over 65, and 83.04% belonged to other age groups. Table 3 displays the estimation results for the FPOP and RPOPHM models.

Table 2. Significant independent variables included in the RPOPHM model

Variable description	Percentage
Mode of travel used prior to lockdown (1 if active travel, 0 otherwise)	14.89%
Mode of travel used prior to lockdown (1 if personal vehicle, 0 otherwise)	84.47%
Employment status (1 if self-employed, 0 otherwise)	9.95%
Household social grade (1 if AB, managerial/professional occupation, 0 otherwise)	37.51%
Household social grade (1 if DE, unskilled manual occupation or unemployed, 0 otherwise)	18.18%
Gender (1 if male, 0 if female)	46.42%
Health problem or disability (1 if yes, 0 if no)	15.25%
Age (1 if over 65, 0 otherwise)	16.96%
Directly affected by COVID-19 (1 if yes, 0 if no)	23.69%

Table 3. FPOP & RPOPHM model estimation results for outdoor exercise trips made by the ‘Lockdown Sample’

Variable	FPOP Model		RPOPHM Model	
	Coefficient	t-stat	Coefficient	t-stat
Constant	0.945	14.056	1.075	12.504
Mode of travel used prior to lockdown (1 if active travel, 0 otherwise)	0.298	3.301	0.357	3.182
Employment status (1 if self-employed, 0 otherwise)	-0.228	-2.205	-0.264	-2.085
Household social grade (1 if AB, managerial/professional occupation, 0 otherwise)	0.261	3.738	0.331	3.745
Household social grade (1 if DE, unskilled manual occupation or unemployed, 0 otherwise)	-0.204	-2.391	-0.228	-2.073
Gender (1 if male, 0 if female)	0.014	0.224	0.148	1.562
<i>Standard deviation of parameter density function</i>	–	–	0.783	3.772
Health problem or disability (1 if yes, 0 if no)	-0.408	-4.706	-1.010	-3.061
<i>Standard deviation of parameter density function</i>	–	–	1.225	3.594
Age (1 if over 65, 0 otherwise)	-0.063	-0.750	0.052	0.369
<i>Standard deviation of parameter density function</i>	–	–	0.951	3.130
Directly affected by COVID-19 (1 if yes, 0 if no)	-0.034	-0.456	0.049	0.440
<i>Standard deviation of parameter density function</i>	–	–	0.670	2.666
<i>Heterogeneity in the mean of ‘Health problem or disability’ random parameter : Mode of travel used prior to lockdown – personal vehicle</i>	–	–	0.711	1.941
Threshold 1	0.615	17.951	0.794	12.210
Threshold 2	0.875	22.828	1.121	13.627
Number of observations	1397		1397	
Log-likelihood constant only, LL(c)	-1658.22		-1658.22	
Log-likelihood at convergence, LL( $\beta$ )	-1621.70		-1609.06	
Akaike Information Criterion (AIC), constant only	3328.44		3328.44	
AIC at convergence	3265.40		3251.32	

LRT(A) = >99.97% l.o.c. RPOPHM > FPOP; LRT(B) = >95.66% l.o.c. RPOPHM > RPOP

Table 3 can be interpreted such that an independent variable with a  $t$ -stat > 1.65 is statistically significant (at 90% level of confidence (l.o.c.)),  $t$ -stats > 1.96 indicate significance at 95% l.o.c. and  $t$ -stats > 2.33 indicate statistical significance at 99% l.o.c. The sign of the model parameter estimates (coefficients) can be interpreted as follows: a positive parameter significantly increases the likelihood of the highest ordered response ( $[y=4]$ , six or more weekly outdoor exercise trips) and a negative parameter significantly increases the likelihood of the lowest response ( $[y=1]$ , no weekly outdoor exercise trips). Instances of heterogeneity in the means of random parameters are denoted by grey fill.

The Likelihood Ratio Tests (LRTs) succeeding Table 3 provide a means of evaluating competing model frameworks (Washington, et al., 2020). LRT(A) shows that, with >99% l.o.c., the RPOPHM framework has significantly improved explanatory power compared to the fixed parameters (FPOP) counterpart. Furthermore, LRT(B) shows that with >95% l.o.c., the RPOPHM framework has significantly greater explanatory power than the RPOP counterpart. Both LRTs reinforce the merits of accounting for both, unobserved heterogeneity within independent variables and heterogeneity in the means of random parameters. The Akaike Information Criterion (AIC), which is a goodness-of-fit (GOF) metric, also shows that the RPOPHM has superior GOF compared to the FPOP counterpart, as lower AIC is consistent with superior GOF (Washington, et al., 2020).

Four independent variables were significant as random parameters suggesting highly heterogeneous effects on outdoor exercise trips within these variables. For the random parameters, model coefficients cannot reveal the nuances of unobserved heterogeneity they capture, therefore, the distributional effects of the random parameters are also given in Table 4. The distributional effects can be interpreted as follows: for the health problem or disability random parameter, 20.48% of the relevant observations (i.e., responses of individuals with a health problem or disability) increase the likelihood of a responses to  $[y=4]$  – six or more exercise trips, while the remaining 79.52% increase the likelihood of  $[y=1]$  – no outdoor exercise trips. The positive and negative distributional effects of the random parameters are displayed in Table 4, and Figure 2 is an example of how this distributional effect can be visualised.

Table 4. Distributional effects of random parameter variables

Variable as random parameter	Negative effect (%)	Positive effect (%)
Gender (1 if male, 0 if female)	42.50%	57.50%
Health problem or disability (1 if yes, 0 if no)	79.52%	20.48%
Age (1 if over 65, 0 otherwise)	47.82%	52.18%
Directly affected by COVID-19 (1 if yes, 0 if no)	47.08%	52.92%

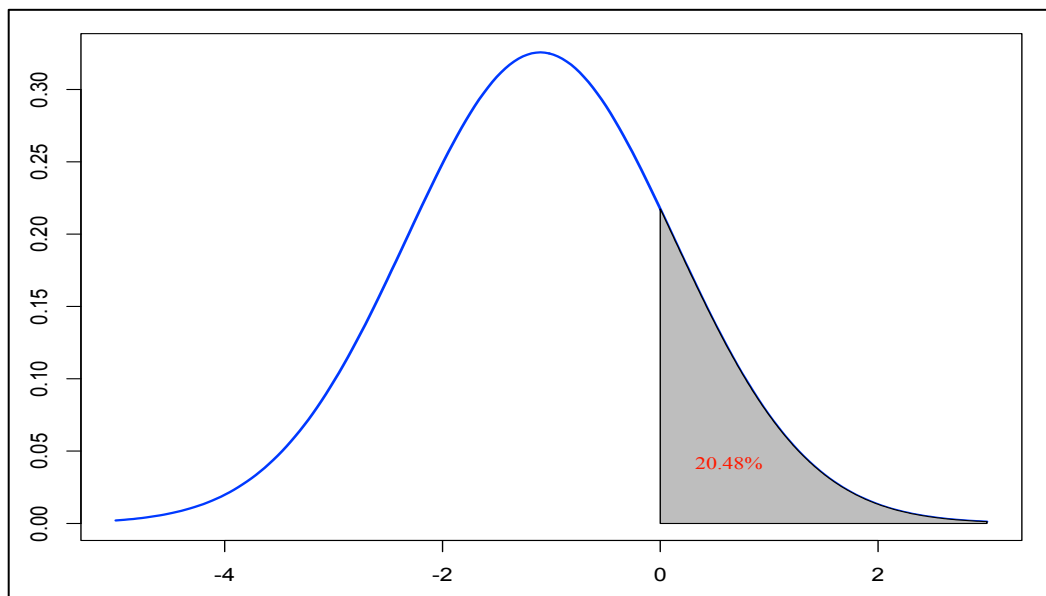


Fig. 2. Visualising the distributional effect of the 'health problem or disability' variable as a random parameter

## 5. Discussion of Results

The results of the RPOPHM model showed that various respondent characteristics significantly affected the rate of outdoor exercise trips made during the March 2020 lockdown. Influential variables include socioeconomic factors, such as: self-employment, which significantly increased the likelihood of no outdoor exercise trips, in comparison to other forms of employment (full/part-time employment, furloughed, student or retired); social AB households (whose main income earner is employed in a professional/managerial occupation) were significantly more likely to exercise frequently (six or more times per week) than other social grades; and social DE households (whose main income earner is employed in a manual occupation or is unemployed) were significantly more likely to complete no outdoor exercise. A possible explanation for the low outdoor exercise of self-employed individuals may be related to the nature of their working commitments during the pandemic. A recent study by Lee et al. (2021) found that self-employed English residents travelled more frequently than those in full/part-time occupations for work-related purposes during the pandemic. As a result, self-employed individuals may not have had the same freedom as others (e.g. furloughed individuals) to complete outdoor exercise trips. The frequent outdoor exercise of social AB households may also be related to COVID-19 working situations, as those in higher income, professional occupations were possibly more able to telecommute than those in other occupations. It is likely that the low exercise of social DE households is the result of a combination of occupational and broader socioeconomic factors. For example, a recent report in England showed that lower income groups, who are more likely to reside in social DE households, have poorer access to local green space and are less likely to own equipment (e.g. bicycles), which facilitate outdoor exercise (Sport England, 2015). This is also likely to be a contributing factor in Scottish social DE households. Policymakers may mitigate this effect by ensuring that those living in lower income neighbourhoods have access to high quality, local green space within walking distance.

Those who reported a health problem or disability were significantly more likely to complete no outdoor exercise trips than those with no stated disability. This could be the result of an initial cautiousness among those with a health problem or disability to travel for any purpose during lockdown, however, this effect may also be explained by accessibility issues. The 'health problem or disability' variable was significant as a random parameter, suggesting heterogeneous outdoor exercise behaviour among this group during lockdown. The mean of the health problem or disability parameter was found to be significantly influenced by the variable indicating personal vehicle as a mode of travel used frequently prior to lockdown. This suggests that those who have a health problem or disability, and access to a personal vehicle, were more likely to exercise during lockdown. Intuitively this makes sense, as those who took extra precautions to minimize infection risk may have chosen to drive to a more secluded area for outdoor exercise, but would have been less able to exercise in a perceived safe manner if they lacked personal vehicle access. In addition, those who travelled frequently by active modes prior to lockdown were significantly more likely than those who travelled by other modes to complete frequent weekly outdoor exercise trips. This may be explained by the fact that those who frequently travelled by active modes are likely to live in areas, and have access to equipment, that facilitated this behaviour pre-lockdown, and therefore, these individuals were able to continue travelling actively despite the pandemic.

The following independent variables produced statistically significant random parameters: those who are male, those with a health problem or disability, those over the age of 65 and those who have been directly affected by COVID-19. These groups are found to be associated with highly heterogeneous effects on the rate of outdoor exercise trips made during lockdown. The heterogeneous outdoor exercise trips of males may be related to occupational factors, for example, key workers are more likely to be male, hence these individuals are less likely to have freedom to exercise frequently, however, higher income earners are also predominantly male, and this subgroup may be more likely to have telecommuted during the pandemic. As previously discussed, the heterogeneous behaviour of those with a health problem or disability was at least partially explained by personal vehicle access, showing the merits of testing for heterogeneity in the means of random parameters.

## 6. Conclusions

We show that various sociodemographic variables significantly influenced the frequency at which Scottish residents made outdoor exercise trips during the COVID-19 lockdown. Influential variables were dominated by socioeconomic factors, such as, employment status and household social grade. These influences emphasise the pandemic's disproportionate effect on lower income subgroups of the population (i.e. social DE households), while

those in more affluent households (social AB) had lockdown working situations that allowed them to exercise frequently. We suggest that policymakers take action to ensure low exercise groups – social DE households, those who are self-employed and those who have a health problem or disability – do not suffer from increased incidence of the associated mental and physical illnesses in the near future. Public information campaigns may be utilised to inform these groups of the health benefits of frequent exercise, while local authorities should also investigate whether infrastructural impediments, such as a lack of local green space, prevent lower income groups from achieving frequent outdoor exercise. Further research may investigate issues of transport inequity raised in this study, for example, targeted studies may analyse the effect of personal vehicle access on the physical activity and general mobility levels of disabled individuals, providing crucial information to resolve inequities in the transport system.

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