

Presented by

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West

Mapping the relationship between Green-Blue-Grey Infrastructure (GBGI) and Quality of Life

Reclaim Conference

Bristol Natural History Consortium

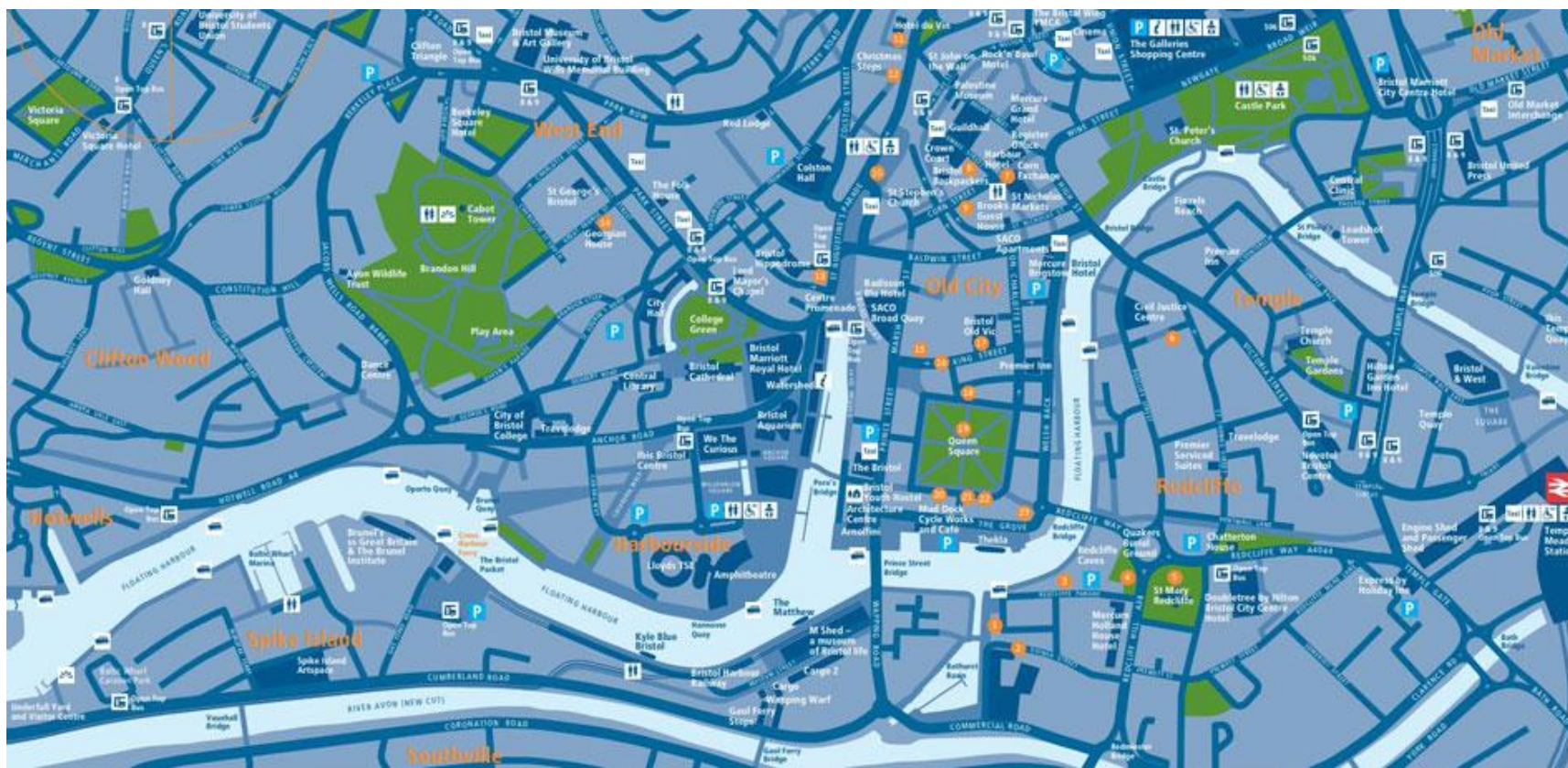
14/06/2023

Background

- Mental health, particularly for urban populations, is a growing public health concern.
- Understanding how people relate to and feel a sense of belonging in the urban environment is an important research agenda.
- There is mounting evidence about the importance of green (e.g. parks, trees) and blue (e.g. rivers, lakes) infrastructure for the health and wellbeing of urban residents.
- There is also emerging evidence about the benefits of certain 'grey' features (e.g. historic buildings, active travel routes).

Our Project

- Our Reclaim project “**The role of GBGI in levelling up across Bristol**” seeks to explore relationships between Green-Blue-Grey Infrastructure (GBGI) and a range of health and social outcomes in neighbourhoods across Bristol.



Bristol Quality of Life Survey

- The Quality of Life (QoL) survey provides an annual snapshot of the quality of life across Bristol.
- This is administered by Bristol City Council.
- The survey has run since 2001 (although our project will only explore data from 2011-2022).
- The survey includes up to 190 indicators of QoL and wellbeing of residents.
- Data for this project is being supplied by BCC at the postcode level with demographic characteristics aggregated to preserve anonymity of respondents.

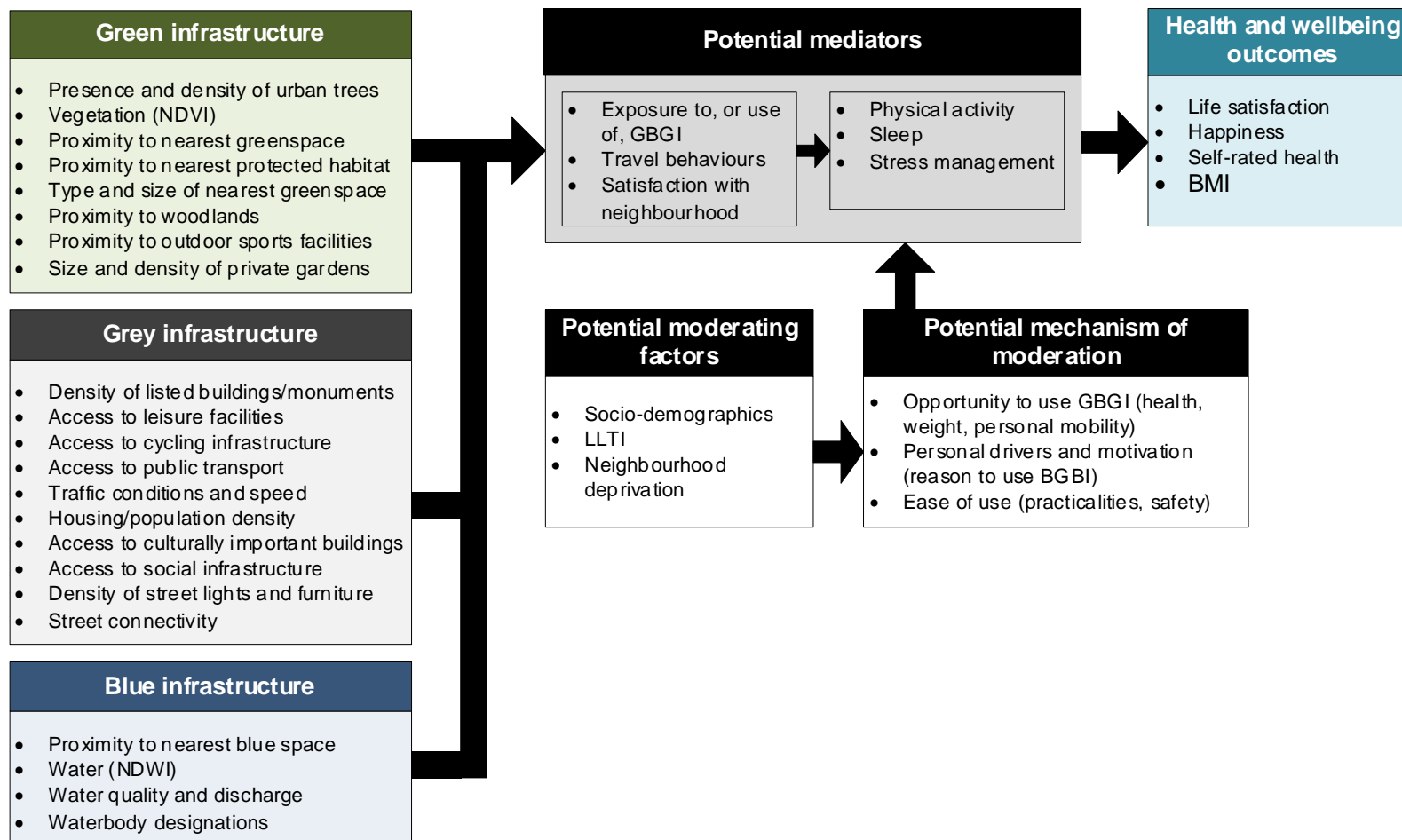
Methodology

- Using GIS and statistical analyses we aim to link various GBGI features to self-reported health, social interaction and neighbourhood satisfaction from the Bristol Quality of Life Survey.
- We aim to explore a broad range of GBGI features in this way, and draw on a large number of secondary spatial datasets in our analysis to measure exposure. These are all sourced from openly available data such as the OS, Bristol Open Data, Census and Natural England.
- We are currently piloting multiple GIS methods to quantify exposure to determine the most useful indicators for GBGI (for example, identifying the number of trees within a 10 minute walk of a postcode, or distance to the nearest bus stop, river or green space).

GBGI Exposures

Green	Blue	Grey
Presence and density of urban trees	Water bodies such rivers, lakes, ponds (including accessibility)	Listed and historic buildings and monuments
NDVI (Normalised Difference Vegetation Index)	NDWI (Normalised Differenced Water Index)	Bus stops/routes
Open green space (including accessibility)	Waterbody designations (e.g. RAMSAR, SPA)	Cycle network
Conservation areas		Urban density
Woodlands		Culturally important buildings
Nature reserves		Social infrastructure
Outdoor sports facilities		Streetlights and furniture
Size and density of private gardens		Traffic conditions
		Road speed limits
		Road network
		Ferry and rail network

GBGI Exposures & QoL



Our Project Aim

- By exploring the relationship between different GBGI and self-reported quality of life we aim to be able to better understand the importance of these features for improving people's lives and reducing inequalities within neighbourhoods and across the city.
- The evidence we produce will further our understanding of how citizens relate to their urban environment, and will help more inclusive decisions to be made by local councils about investment to ensure that all residents, wherever they live, benefit from GBGI which enhance quality of life for urban communities.



Measures of **Greenspace Exposure** and Their Association to **Health-Related Outcomes** for the Periods before and during the 2020 Lockdown: A Cross-Sectional Study in the West of England

Fouad, A.T.Z. et al. (2023) Measures of Greenspace Exposure and Their Association to Health-Related Outcomes for the Periods before and during the 2020 Lockdown: A Cross-Sectional Study in the West of England. *Land*. [online]. 12 (4), MDPI AG, p.728. Available from: <http://dx.doi.org/10.3390/land12040728>.

Part of an on-going research on greenspaces by:

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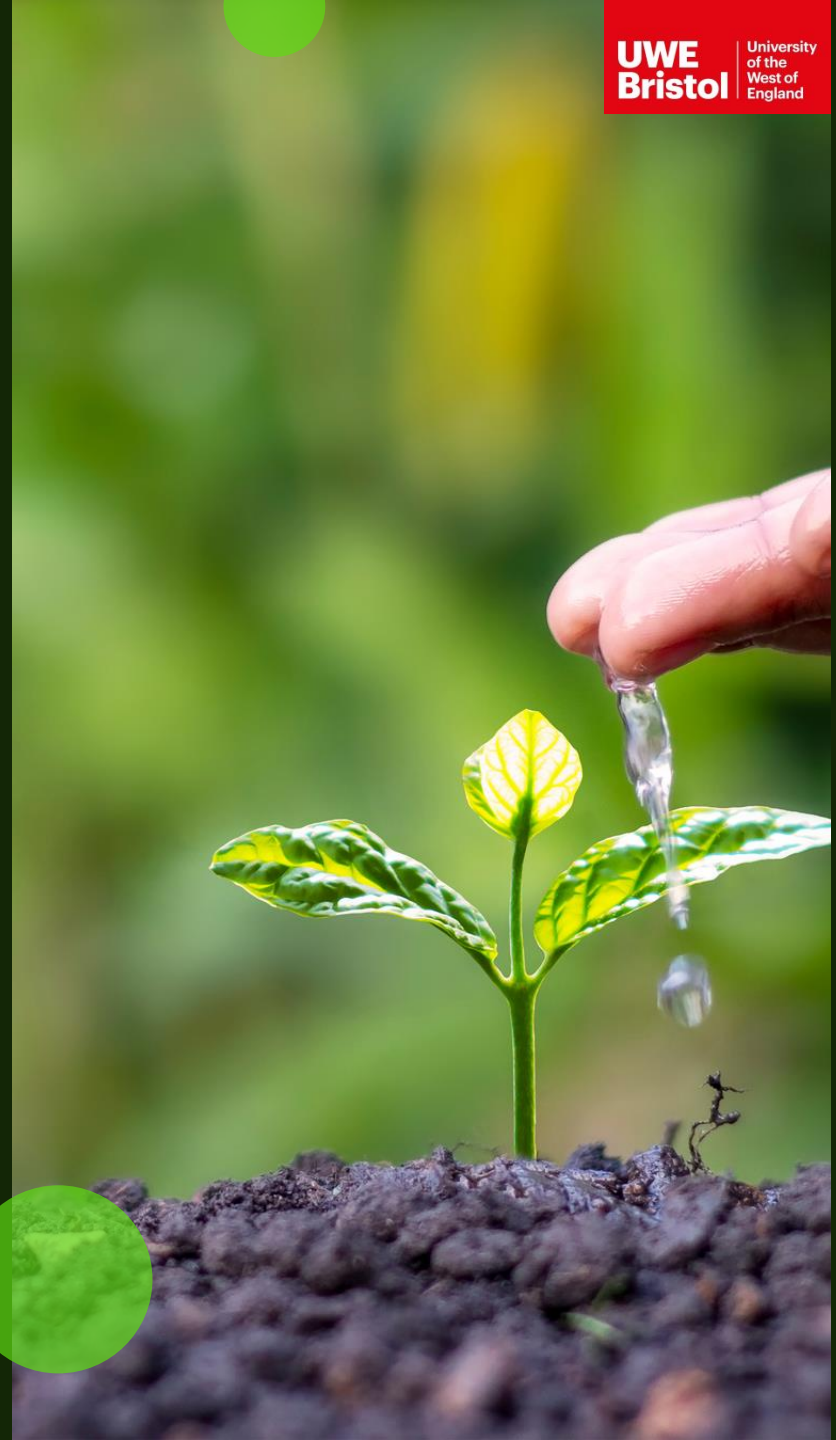
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Overview

- Background
- Objectives
- Methodology
 - Data Collection and Analysis
 - Scope Definition
 - Baseline Characteristics
- Findings
- Discussion
- Conclusion
- Next steps

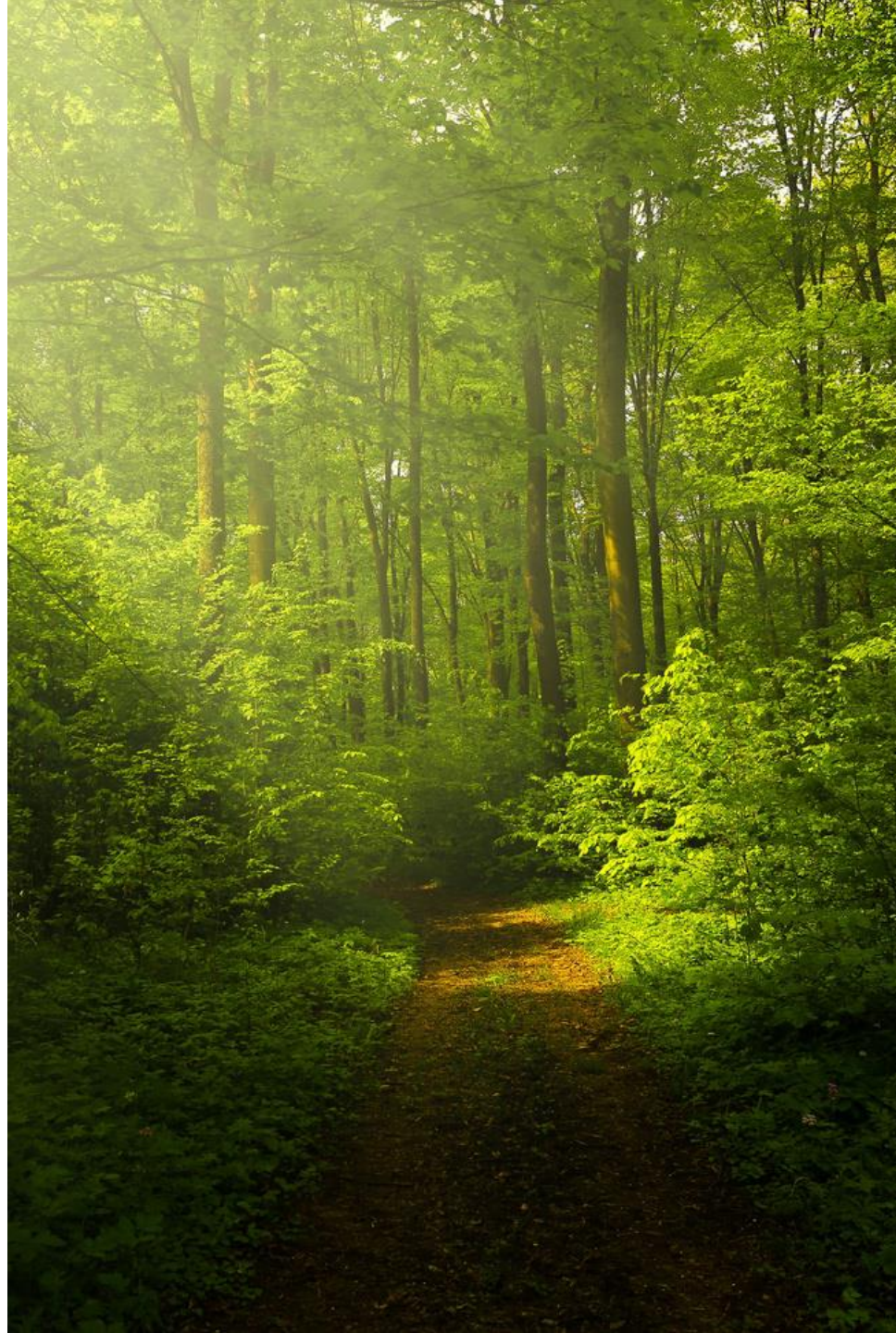


Background

- How did **Covid-19 lockdowns** change greenspace use, and what impact did this have on health and wellbeing?
- Systematic reviews have shown that in urban areas there are beneficial associations between greenspace and health.
But this relationship is often inconsistent.
- **Measures of greenspace** exposure are inconsistent across studies and understanding which measure best predicts health outcomes needs development.

Objectives

1. Explore quantitative spatial **measures** of evaluating **greenspace exposure**.
2. Explore which measures of greenspace exposure **connects to health outcomes**.
3. Understand the mechanisms which explain the association between green space and health by **including confounding factors** in a single analysis.



Methodology



An online survey

To collect health outcomes - **Physical Activity, Quality of Life and Nature Connectedness + visits to green spaces.**

Two time points – during the lockdown, and before the lockdown.



Postcodes

Participants shared their **postcodes** to link their health outcomes to spatial data



GIS Spatial data

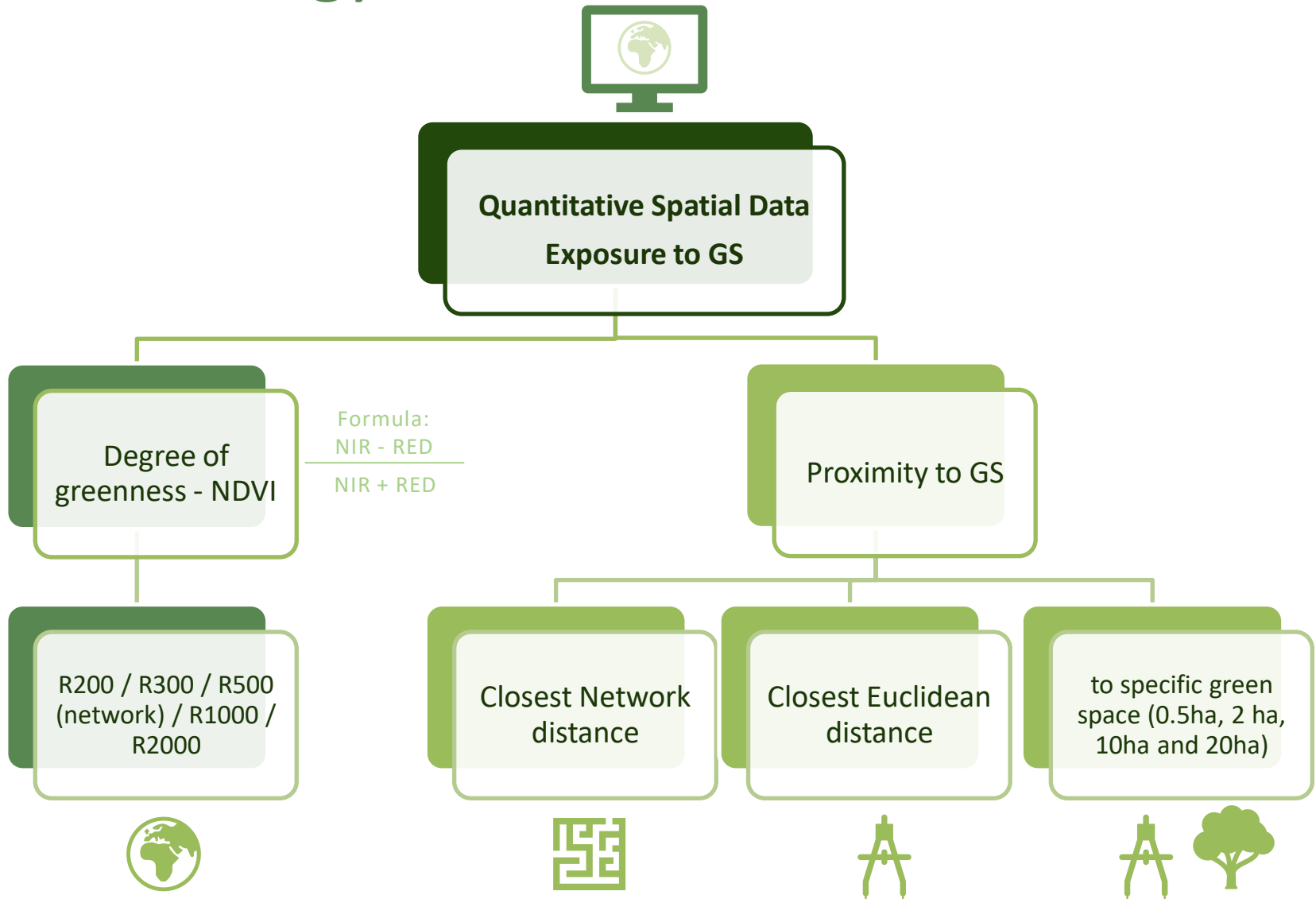
Calculate exposure to GS as:

Degree of greenness:
Normalised Difference Vegetation Index

Proximity measures to GS



Methodology



Scope



Area of study

Resident in West of England within local authorities of:

- North Somerset
- City of Bristol
- Bath and North East Somerset
- South Gloucestershire






Baseline Characteristics

- 617 participants
- Over-representation:
 - White residents
 - Females
 - Higher levels of education
 - Own their homes outright
 - Access to a private outdoor space

CHARACTERISTICS	CATEGORY	N (%)
SEX	Female	383 (62)
	Male	224 (36)
	Prefer not to say	10 (2)
AGE IN YEARS	65-74	142 (23)
	55-64	141 (23)
	35-44	109 (18)
	45-54	103 (17)
	25-34	64 (10)
	75-84	33 (5)
	18-24	16 (3)
	Prefer not to say	9 (1)
ETHNICITY	White	578 (94)
	Mixed	13 (2)
	Other	12 (2)
	Black/African/Caribbean	10 (2)
	Asian	4 (0)
EDUCATION	Degree or Higher	450 (73)
	GCSE only	85 (14)
	A-levels or equivalent	68 (11)
	No qualifications	14 (2)
HOUSING TENURE	Owner	522 (85)
	Rented	63 (10)
	Socially Rented	30 (5)
	Other	2 (0)
CAR OWNERSHIP	No	90 (15)
	Yes	524 (85)
DOG OWNERSHIP	No	490 (79)
	Yes	127 (21)
PRIVATE/SHARED OUTDOOR SPACE	No	33 (5)
	Yes	584 (95)
HAVING CHILDREN	No	452 (73)
	Yes	165 (27)
HAVING <u>LIMITING</u> LONG-TERM ILLNESS	No	489 (79)
	Yes	127 (21)
EMPLOYMENT	Employed	376 (61)
	Retired	142 (23)
	Other	68 (11)
	Unemployed	19 (3)
	Student	11 (2)

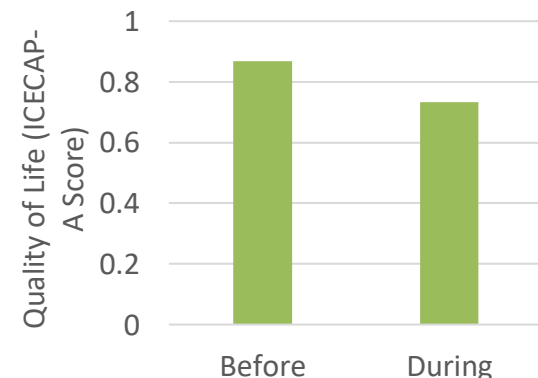
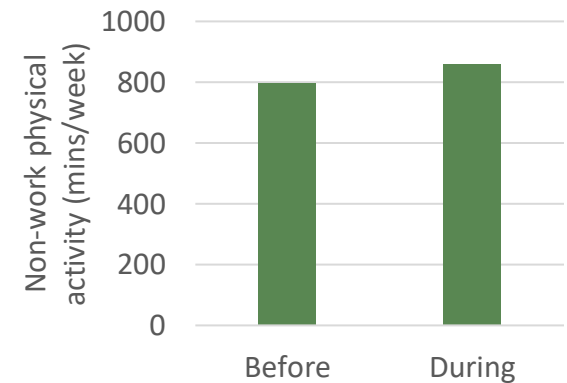
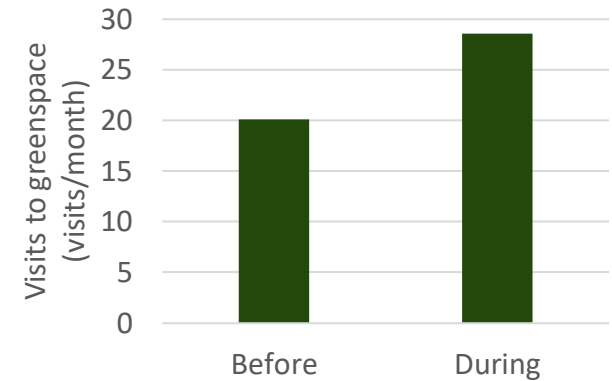


Findings - Descriptive Stats

- NDVI increases as the radius increases. 
- The mean network distance to the nearest greenspace is 333
The mean Euclidean distance is 190 m. 
- The mean distance to the nearest greenspace increases as the size of the greenspace increases 
- The mean distances to GS are **further than the AGS** for the doorstep greenspace (275 m mean > 200 m standard) and the local greenspace (374 m mean > 300 m standard).
- The mean distances to GS are **within the AGS** for neighbourhood greenspace (774 m mean < 1000 m standard) and the wider neighbourhood greenspace (1100 m mean < 2000 m standard).

Findings - Descriptive Stats

- Visit to GS (per month) **increased by 38%** to a mean of 29 visits per month during lockdown. A Paired Sample T-test shows that the difference in means (8.14 visits/month) is statistically significant ($t=10.19$, $p<0.001$).
- Physical activity has also **increase by 9%**. The difference in means (90.76 minutes/week) is statistically significant ($t=2.02$, $p=0.04$).
- Wellbeing was **lower during lockdown** than before (difference in mean ICE-CAP score -0.13), and this difference is also statistically significant ($t=-20.13$, $p<0.001$).



Findings – Overall Model Significance

	Visits to Greenspaces/month		Physical Activity in Minutes		ICE-CAP Score		Connectedness to Nature ¹	
	Before Lockdown	During Lockdown	Before Lockdown	During Lockdown	Before Lockdown	During Lockdown	Before Lockdown	Before Lockdown
	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²	Overall fit R ² Adjust R ²
NDVI radius 200m (Euclidean)	<0.001***	<0.001***	0.071	0.592	<0.001***	<0.001***	0.002**	0.056
	0.168	0.125	0.071	0.047	0.137	0.154	0.091	0.071
	0.122	0.074	0.021	-0.004	0.092	0.110	0.044	0.022
NDVI radius 300m (Euclidean)	<0.001***	<0.001***	0.071	0.592	<0.001***	<0.001***	0.002**	0.072
	0.168	0.129	0.071	0.047	0.136	0.154	0.092	0.069
	0.122	0.079	0.021	-0.004	0.091	0.109	0.045	0.020
NDVI radius 1000m (Euclidean)	<0.001***	<0.001***	0.048*	0.587	<0.001***	<0.001***	0.003**	0.098
	0.169	0.117	0.074	0.047	0.136	0.154	0.09	0.066
	0.123	0.066	0.024	-0.004	0.090	0.109	0.043	0.018
NDVI radius 2000m (Euclidean)	<0.001***	<0.001***	0.041*	0.577	<0.001***	<0.001***	0.003**	0.090
	0.17	0.116	0.075	0.048	0.136	0.154	0.089	0.067
	0.124	0.065	0.026	-0.004	0.090	0.109	0.042	0.018
NDVI radius 500m (Network)	<0.001***	<0.001***	0.074	0.592	<0.001***	<0.001***	0.002**	0.078
	0.168	0.12	0.070	0.047	0.138	0.156	0.091	0.068
	0.122	0.069	0.021	-0.004	0.092	0.111	0.044	0.020
Network Distance (m) to nearest greenspace access	<0.001***	<0.001***	0.068	0.564	<0.001***	<0.001***	0.004**	0.111
	0.172	0.117	0.071	0.048	0.136	0.158	0.088	0.065
	0.126	0.066	0.021	-0.003	0.09	0.114	0.041	0.016
Euclidean Distance (m) to nearest greenspace access	<0.001***	<0.001***	0.065	0.535	<0.001***	<0.001***	0.003**	0.105
	0.071	0.117	0.071	0.049	0.136	0.157	0.089	0.066
	0.126	0.066	0.022	-0.002	0.09	0.112	0.042	0.017
Euclidean Distance (m) to nearest 0.5ha doorstep greenspace access	<0.001***	<0.001***	0.07	0.46	<0.001***	<0.001***	0.001**	0.110
	0.168	0.119	0.071	0.051	0.136	0.154	0.095	0.065
	0.122	0.068	0.021	0.00	0.09	0.11	0.048	0.016
Euclidean Distance (m) to nearest 2ha local greenspace access	<0.001***	<0.001***	0.078	0.502	<0.001***	<0.001***	0.003**	0.110
	0.167	0.114	0.07	0.05	0.136	0.154	0.089	0.065
	0.121	0.063	0.020	-0.001	0.09	0.109	0.042	0.016
Euclidean Distance (m) to nearest 10ha neighbourhood greenspace access	<0.001***	<0.001***	0.077	0.376	<0.001***	<0.001***	0.003**	0.08
	0.167	0.114	0.07	0.054	0.136	0.157	0.089	0.068
	0.121	0.063	0.02	0.003	0.09	0.113	0.042	0.019
Euclidean Distance (m) to nearest 20ha wider neighbourhood greenspace access	<0.001***	<0.001***	0.055	0.566	<0.001***	<0.001***	0.004**	0.108
	0.167	0.113	0.073	0.048	0.137	0.158	0.087	0.065
	0.121	0.062	0.023	-0.033	0.091	0.114	0.04	0.017

- 57 significant models (p-value <0.05) of 88 possible models
- R² ranges from 0.071 to 0.172
- Adjusted R² from 0.026 to 0.126

■ * P-value <0.05;
 ■ ** P-value <0.01;
 ■ *** P-value <0.001

Findings – Specific to Spatial measures

Measure of exposure to greenspace	Health-related outcome							
	Visits to Greenspaces/month		Physical Activity in Minutes		ICE-CAP Score		Connectedness to Nature ¹	
	Before Lockdown	During Lockdown	Before Lockdown	During Lockdown	Before Lockdown	During Lockdown	Before Lockdown	During Lockdown
B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	
NDVI radius 200m (Euclidean)	5.5 (6.07), 0.37	18 (6.83), 0.009***	-231 (328), 0.48	13 (433), 0.98	0.046 (0.043), 0.284	0.05 (0.065), 0.442	13.5 (7.9), 0.088*	1.57 (0.84), 0.063*
NDVI radius 300m (Euclidean)	4.75 (6.20), 0.44	21.5 (6.95), 0.002***	-238 (335), 0.48	38.5 (442), 0.931	0.033 (0.044), 0.45	0.038 (0.066), 0.57	14.2 (8.06), 0.079*	1.28 (0.86), 0.14
NVDI radius 1000m (Euclidean)	11.6 (7.74), 0.134	0.006 (0.048), 0.909	-570 (369), 0.12	-155 (487), 0.75	-7.91 (6.80), 0.25	0.028 (0.073), 0.70	12.4 (8.92), 0.17	0.79 (0.95), 0.41
NDVI radius 2000m (Euclidean)	-11.2 (7.78), 0.15	11.9 (8.87), 0.18	-751 (423), 0.076	290 (558), 0.60	-0.002 (0.055), 0.97	0.033 (0.083), 0.70	13.1 (10.2), 0.20	1.14 (1.08), 0.30
NDVI radius 500m (Network)	5.03 (7.16), 0.48	16.13 (8.06), 0.046**	-204 (387), 0.60	-14.6 (511), 0.977	0.060 (0.051), 0.233	0.096 (0.076), 0.21	15.5 (9.31), 0.097	1.36 (0.990), 0.17
Network Distance (m) to nearest greenspace access	-0.006 (0.003), 0.075*	-0.006 (0.004), 0.14	-0.15 (0.18), 0.40	0.17 (0.23), 0.47	1.46E-6 (2.32E-5), 0.95	6.26E-5 (3.48E-5), 0.072	0.004 (0.004), 0.309	-6.95E-5 (0.000), 0.88
Euclidean Distance (m) to nearest greenspace access	-0.009 (0.006), 0.088*	-0.009 (0.006), 0.144	-0.29 (0.30), 0.34	0.41 (0.39), 0.304	-1.64E-5 (3.96E-5), 0.68	8.54E-5 (5.93E-5), 0.150	0.009 (0.007), 0.21	0.00 (0.001), 0.59
Euclidean Distance (m) to nearest 0.5ha doorstep greenspace access	-0.003 (0.004), 0.402	-0.007 (0.004), 0.068*	0.14 (0.19), 0.46	0.38 (0.26), 0.14	-3.6E-6 (2.5E-5), 0.885	2.51E-5 (3.75E-5), 0.505	0.011 (0.005), 0.021**	0.00 (0.000), 0.81
Euclidean Distance (m) to nearest 2ha local greenspace access	-0.001 (0.003), 0.747	-0.002 (0.003), 0.412	-0.016 (0.14), 0.91	0.24 (0.18), 0.20	-3.78E-6 (1.82E-5), 0.835	7.82E-6 (2.73E-5), 0.77	0.004 (0.003), 0.193	-8.3E-5 (0.000), 0.81
Euclidean Distance (m) to nearest 10ha neighbourhood greenspace access	0.00 (0.001), 0.714	0.001 (0.001), 0.404	-0.014 (0.057), 0.8	0.154 (0.076), 0.042	3.38E-6 (7.43E-6), 0.649	1.80E-5 (1.11E-5), 0.11	0.002 (0.001), 0.209	0.00 (0.000), -1.32
Euclidean Distance (m) to nearest 20ha wider neighbourhood greenspace access	0.00 (0.001), 0.64	0.00 (0.001), 0.68	-0.056 (0.043), -1.31	0.040 (0.057), 0.485	5.28E-6 (5.65E-6), 0.35	1.53E-5 (8.47E-6), 0.072	0.001 (0.001), 0.603	-4.55E-5 (0.000), 0.684

- **10** significant for the measure of greenspace exposure.
- **6** GS exposure measures (NDVI R200m; NDVI R300m; NDVI R500m in Network; Network Distance to nearest greenspace access; Euclidean Distance to nearest greenspace access; and Euclidean Distance to nearest 0.5 ha doorstep greenspace access) have a significant association with at least one of the **4** health-related outcomes.

■ * P-value <0.1;
 ■ ** P-value <0.05;
 ■ *** P-value <0.01

Findings

	Physical Activity in Minutes		ICE-CAP Score		Connectedness to Nature ¹	
	Before lockdown	During lockdown	Before lockdown	During lockdown	Before lockdown	During lockdown
	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value	B (SE), p-value
Visits to greenspace	5.41 2.26 0.017*	14.6 2.76 <0.001***	0.0 0.0 0.164	0.0 0.0 0.78	0.155 0.057 0.007**	0.12 0.005 0.026*

■ * P-value < 0.05

■ ** P-value < 0.01

■ *** P-value < 0.001

- All 6 relationships are significant in their overall goodness-of-fit (R^2 0.078-0.183 and adjusted R^2 0.025-0.135)
- 4 associations (of the six tested relationships) are significant for the particular health-related outcome of interest.

Discussion

- NDVI changes with changing the catchment area
→ Future research needs to be critically aware of defining the catchment areas of the study
- Precise distances from the residents' addresses to the greenspace access points
→ improves the previous research that uses service area/population weighted centroid
- Significant change in residents' visits to GS, physical activity and wellbeing before and during covid
→ Covid changed our lifestyles

Discussion

- Increase in visits to GS + decrease in Euclidean or network distance to the nearest GS
=increase in physical activity
→ Spatial measure of GS exposure is positively related to a health-related outcome.
- NDVI of smaller radii (200 m and 300 m) has been significantly and positively related to the residents' connectedness to nature before lockdown
→ Greener the immediate context of the home, more residents feel connected to nature.
- Larger radii NDVI (1 km and 2 km – larger context) do not relate to connectedness to nature nor with frequency of visits to GS.
→ Residents are more aware of their immediate smaller context and how green it is, which impacts their connection to nature and their use of close-by GS.

Discussion

During Lockdown

- Positive association between visits to GS and the greenness of the local area around the participants address (smaller NDVIs 200 m, 300 m and 500 m).
Positive association between visits to GS and decreasing the distance to the doorstep green space (0.5 ha)
→ Residents were more likely to leave home, visit local GS and do physical activity
- Quality of life showed no positive association to greenspace exposure.
→ Maybe the Covid-19 pandemic severely affected quality of life that greenspace exposure did not have a positive impact

Conclusion

- The studied health-related outcomes are mostly associated to measures of greenspace exposure that capture the immediate context
 - (1) the smaller NDVI radii (200 m, 300 m and 500 m)
 - (2) the proximity to smaller GS (0.5 ha) which are commonly close-by
 - (3) the nearest GS (which are commonly of smaller areas).
- Health-related outcomes in this study do not relate to the larger context in terms of
 - the larger NDVI radii (1000 m and 2000 m)
 - the proximity to larger GS (10 ha and 20 ha).

This happens despite the mean distance to the smaller GS not meeting Natural England's AGS, i.e. being farther away than where they are expected to be.
- The reason some studies have found no relationship between greenspace and health may be because of chosen greenspace measure.

Next Step

- Structural equation modeling of the pathways informed by these relationship

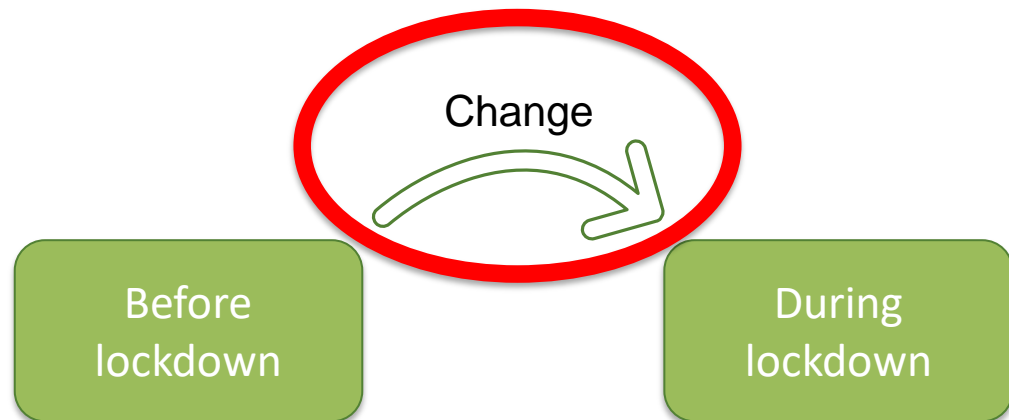
Background

- There is extensive evidence demonstrating the importance of greenspace as a wider determinant of health.
- The COVID-19 pandemic affected how people visited and experienced greenspace. But research during the pandemic highlighted the need for greenspace given their importance for health benefits.
- Understanding the mechanism is **complex** as there are many interdependent elements.
- Despite numerous theoretical explanations for the relationship between greenspace and health, little research has included potential confounding, modifying and mediating factors in a single analysis. There is a need for greater focus on what works and **unpicking causal pathways**.



Aims

- To assess whether provision and exposure to greenspace is associated with better health outcomes in the West of England, and to explore what factors might explain the relationship.
- This study tests the pathways, as **changes** from before to during the COVID-19 pandemic, a unique point in time with implications for how people interacted with greenspace.



Structural Equation Modeling

“a statistical method that examines the relationships among numerous variables in a simultaneous way”

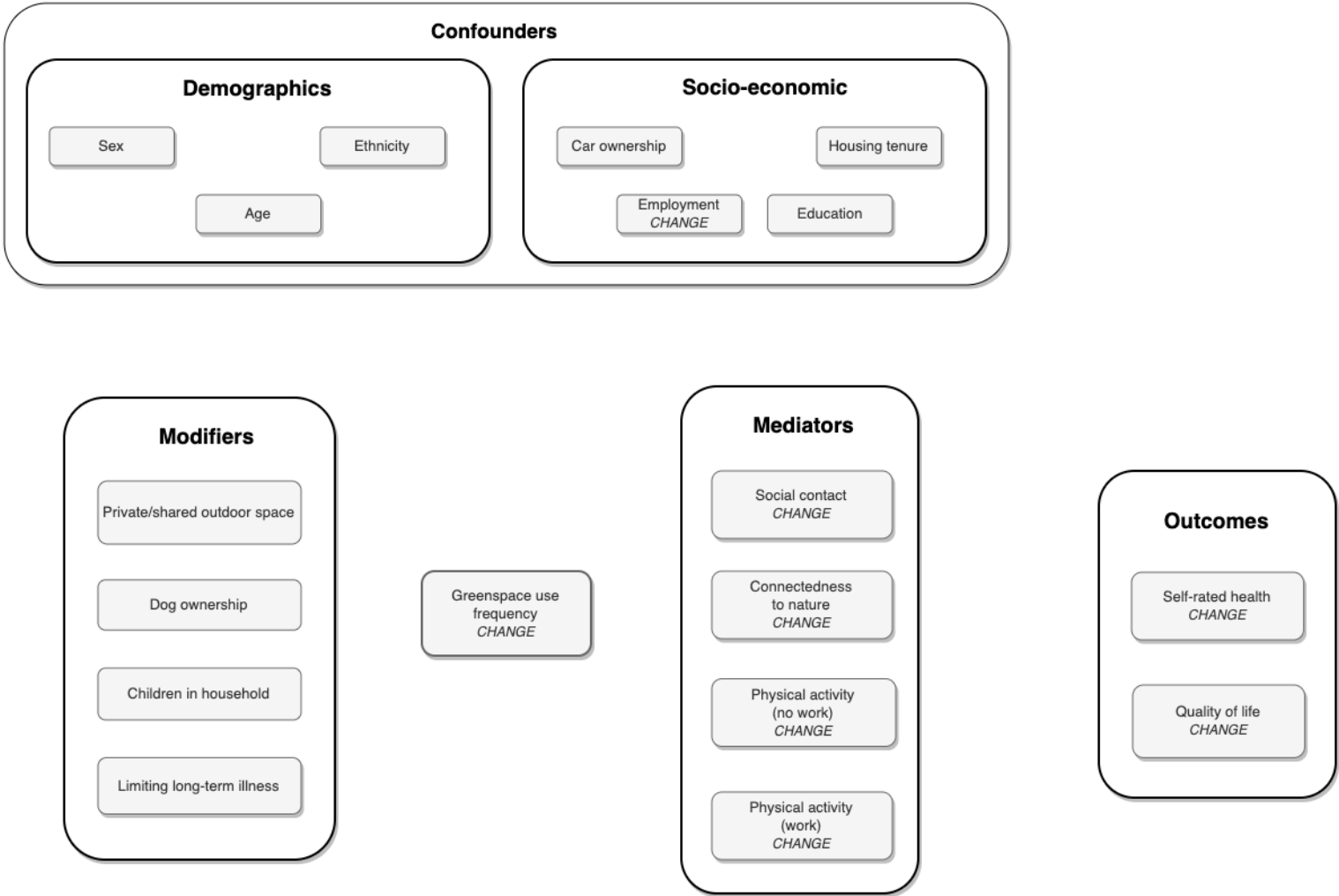
- A confirmatory approach.
- A model is proposed and SEM examines whether the observed data will provide evidence of directionality and significance of the relationships.
- Conducted in SPSS Amos.
- Can analyse multiple exposures, mediators, moderators, confounders, and outcomes.



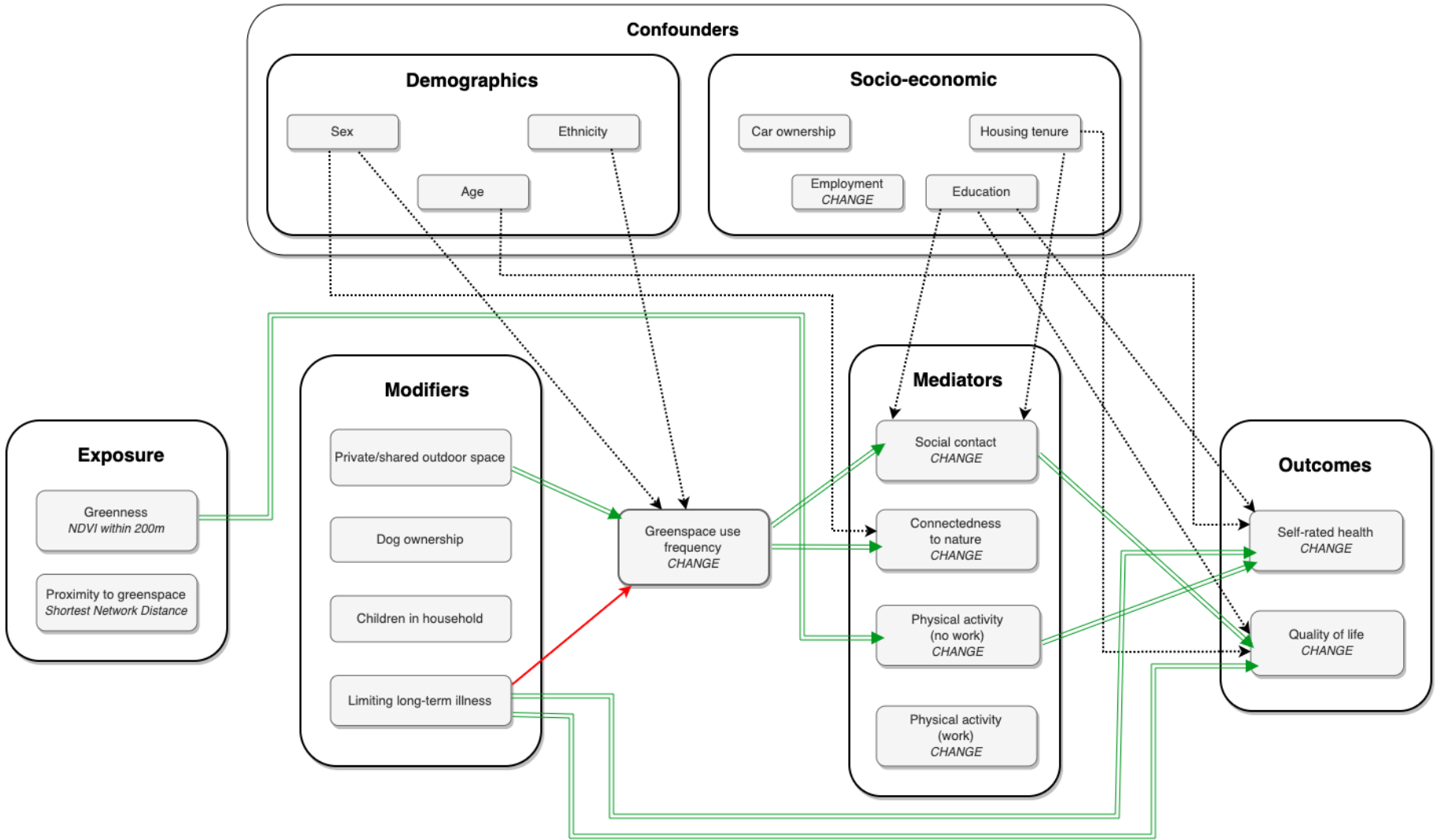
Variables in model

Exposures	Outcomes	Mediators	Moderators	Confounders
Greenness	Quality of life	Social contact	Long-term limiting illness	Sex
Proximity to greenspace	Self-rated health	Connectedness to nature	Dog ownership	Age
Greenspace use frequency		Physical activity	Children in household	Ethnicity
		Physical activity commuting	Access to private/shared outdoor space	Education
				Occupation
				Change in employment
				Car ownership
				Housing tenure

Modeling so far

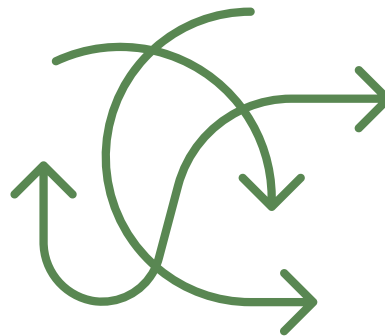


Modeling so far



Going forward

- A complex statistical method with some technicalities still to overcome.
- Create and refine a final model identifying changes.
- Even if no moderated mediating relationships are identified, the analysis can still uncover individual pathways between variables.



Thank you

Any questions?