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FULL/LONG TITLE OF THE STUDY

Orienting Policy Towards Inequality Minimising Actions (OPTIMA): A systems science approach to 20-minute neighbourhood policy and evaluation

SHORT STUDY TITLE / ACRONYM

OPTIMA

PROTOCOL VERSION NUMBER AND DATE

Version	Date	Changes from previous version
0.1	29/07/2024	
0.2	30/10/2024	Added to description of study steering committee and study management group in response to sponsor comment (p. vi/Appendix 1); Added sponsor number and research registry number (p. i)
0.3	10/02/2025	Minor amendments carried out in response to NIHR comments. 'Funded by' logo updated (header); updated signature page (p. ii); updated NIHR contact details (p. iv/v); deleted non-financial support column (p. v); Added timing unpredictable risk (p. 23); Added data management plan reference to section 7.2 (p. 24)

RESEARCH REFERENCE NUMBERS

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SIGNATURE PAGE

The undersigned confirm that the following protocol has been agreed and accepted and that the Chief Investigator agrees to conduct the study in compliance with the approved protocol and will adhere to the principles outlined in the Declaration of Helsinki, the Sponsor's SOPs, and other regulatory requirement.

I agree to ensure that the confidential information contained in this study will not be used for any other purpose other than the evaluation or conduct of the investigation without the prior written consent of the Sponsor

I also confirm that I will make the findings of the study publically available through publication or other dissemination tools without any unnecessary delay and that an honest accurate and transparent account of the study will be given; and that any discrepancies from the study as planned in this protocol will be explained.

For and on behalf of the Study Sponsor:

Signature: Date:

..../...../.....

Name (please print):

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Position:

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Chief Investigator:

Signature: Date:

..../...../.....

Name: (please print):

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LIST of CONTENTS

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Funder(s)	National Institute of Health Research Public Health Research Programme Contact: Ms Cheryl Baker, cheryl.baker@nihr.ac.uk
Committees	See Appendix 10.1

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STUDY SUMMARY

Study Title	Orienting Policy Towards Inequality Minimising Actions (OPTIMA): A systems science approach to 20-minute neighbourhood policy and evaluation
Internal ref. no. (or short title)	OPTIMA
Study Design	Mixed methods systems science study. Combines qualitative (realist review and stakeholder workshops) and quantitative (synthetic population and geographical service-related) data and methods into an agent-based model to allow differential policy comparison. Finally, we identify opportunities and develop plans for further natural experimental evaluation with integrated economic evaluation.
Study Participants	Simulated population of people living within local authorities in Scotland for the quantitative work. Community and policy stakeholders will contribute to the qualitative work
Planned Size of Sample (if applicable)	We will draw on a range of survey and routinely collected data with varying samples, plus a synthetic population. The qualitative workshops will each aim for up to 12 participants per workshop.
Follow up duration (if applicable)	The simulated nature of the model allows flexible follow-up time according to stakeholder need.
Planned Study Period	01/09/2024-31/08/2027
Research Question/Aim(s)	1. How can we synthesise the current evidence-base and stakeholders' lived experience to inform 20MN policy planning and simulation model building, making current uncertainties explicit? (WP1); 2. What do measures of quality of services and the overlaying of a synthetic population add to our baseline understanding of 20MNs and health (inequalities)? (WP2); 3. What can a simulation model of complex interactions of individuals accessing services, and services responding to their access, add to our understanding of which 20MN interventions might maximise health inequality benefits (and minimise harms)? (WP3); 4. What real-world evaluation design would best meet stakeholders needs for 20MN evidence to guide continuing future policy and investment? (WP4)

FUNDING AND SUPPORT IN KIND

FUNDER(S)
National Institute of Health Research Public Health Research Programme Contact: Ms Cheryl Baker, cheryl.baker@nihr.ac.uk

ROLE OF STUDY SPONSOR AND FUNDER

The study is sponsored by the University of Glasgow. The University holds insurance providing cover for the design of the research study protocol. Otherwise, the sponsor has no role in study design, conduct, data analysis and interpretation, manuscript writing, and dissemination of results.

The funder has no role in study design, conduct, data analysis and interpretation, or manuscript writing. Dissemination will be subject to NIHR's requirements for Publication and notification: https://www.nihr.ac.uk/documents/nihr-research-outputs-and-publications-guidance/12250#Notifying_NIHR_of_upcoming_research_outputs

ROLES AND RESPONSIBILITIES OF STUDY MANAGEMENT COMMITEES/GROUPS & INDIVIDUALS

The Study Steering Committee (SSC) will meet annually for study governance. It will be independently chaired by a senior academic and comprise of five additional senior researchers who are independent of the study team, and a representative of the public (Appendix 10.1). The SSC will include stakeholders with experience of managing large research projects, those with expertise in the ethics, data management, analysis and reporting of the major qualitative and quantitative methods and data used (including qualitative systems work (work package, WP1); the combination and analysis of geographical and health data and applied statistics (WP2); agent-based modelling (WP3); natural experiment and economic evaluation), and public representation. We will ask the SSC to formally review progress at each meeting based on a set of pre-specified criteria. The criteria will be discussed and agreed at the first meeting of the SSC, but are likely to include study progress, financial reports, risks and mitigations, amendments and approvals, ethics and data management compliance, publication and dissemination, and stakeholder collaborations.

We will additionally set up a Stakeholder Advisory Group (SAG) to provide practical on-going advice to keep research relevant, timely and actionable for broader policy stakeholders. The group will meet twice yearly and be chaired by one of our policy partners who had early input to our application, Public Health Scotland (PHS) and Scotland's Regeneration Forum (SURF). Additional members will be invited with knowledge of key features of the 20-minute neighbourhood, such as retail, housing, walkability/active travel. The group will focus on criteria such as stakeholder feedback and insights, review of strategic objectives, engagement and communication strategies, risks and mitigations, and further partnership opportunities.

Our Patient and Public Involvement and Engagement (PPIE) group and public co-investigator (see section 7.4) will provide regular public scrutiny and input to the entire research process. They will meet monthly, and provide additional input as required on an ad hoc basis.

Our Study Management Group (SMG) will be comprised of both co-PIs, all WP co-leads, and our public co-investigator. They will meet monthly to discuss strategy, ensure collaboration and co-ordinated work across all WPs, review budget and risks, progress against objectives and deliverables, and overall that the project is delivered on time and to a high standard.

PROTOCOL CONTRIBUTORS

This protocol was developed by the study investigators.

The protocol was also informed by early engagement activity.

In May 2023, the 'Places team' at the University of Glasgow's MRC/CSO Social and Public Health Sciences Unit organised a large 'Places and children's health' workshop. 70 stakeholders from research, policy, planning, and practice across Scotland participated. Olsen and Stokes led a breakout

room discussing 20-minute neighbourhood policy, specifically. In it, concerns about how to implement it in a way to ensure health and health inequalities were prioritised were raised. For example, potential difficulties in making sure the business sector's services provided healthy things, and that their need to make a profit might have unintended negative consequences on prices and rents (which we incorporate into WP3). They didn't feel like current evidence was sufficient to make these decisions, which was part of the motivation for this project.

In June 2023, Olsen and (co-PI) Stokes set up an interactive activity as part of the Glasgow Science festival, where the public could rate their own neighbourhood, and view interactive baseline data on the services within their current '20-minute neighbourhood' (within a 10-minute walk from their home). The feedback we received was that people recognised the importance of having services local, but also pointed to the importance of the quality of those services if they were to choose to use them and to provide a potential health benefit. From this we chose to include service quality (and a marker of affordability) as a key element to add to the neighbourhood evidence for future research (which we incorporate into WP2). It was also clear from discussing with people at this event that different circumstances people faced also meant they focused on different types of services as important (e.g., school if they had children, GP service if they were getting older). From this we set out to include more lived experience in informing key services, and how these might differ for different groups of people (which we incorporate into WP1).

At the above event we also met the local MP, Patrick Grady, who represents at Westminster the area where the University of Glasgow is located. He was keen on the project idea, and we arranged to meet again and presented the project proposal in more detail. From this, he offered to write a letter of support for the project, and also arranged for us to attend an event in Westminster in February 2024 to discuss the baseline analysis and project ideas with other MPs.

We also presented our initial plans to the MVLS PPIE panel in July 2023. We were provided with detailed feedback, including that we should also focus on mental health as a potential impact of the policy, and the need to consider the different needs of people within a place. For example, elderly and disabled people's mobility. We now incorporate these elements of population variation throughout. We subsequently recruited a public co-investigator who had previously engaged with us through the MVLS PPIE panel, Geoff Mohamed (see next section). Geoff provided us with additional input for, (i) our plans to respond to stage 1 feedback, (ii) the proposed PPI activity moving forward, and (iii) for improving the Plain English abstract and Flow Diagram.

This varied and continued involvement and engagement has strengthened the project proposal to now, and we plan to continue with stakeholder input throughout.

KEY WORDS: 20-minute neighbourhoods; health inequalities; left-behind neighbourhoods; systems science; agent-based modelling; real-world evaluation

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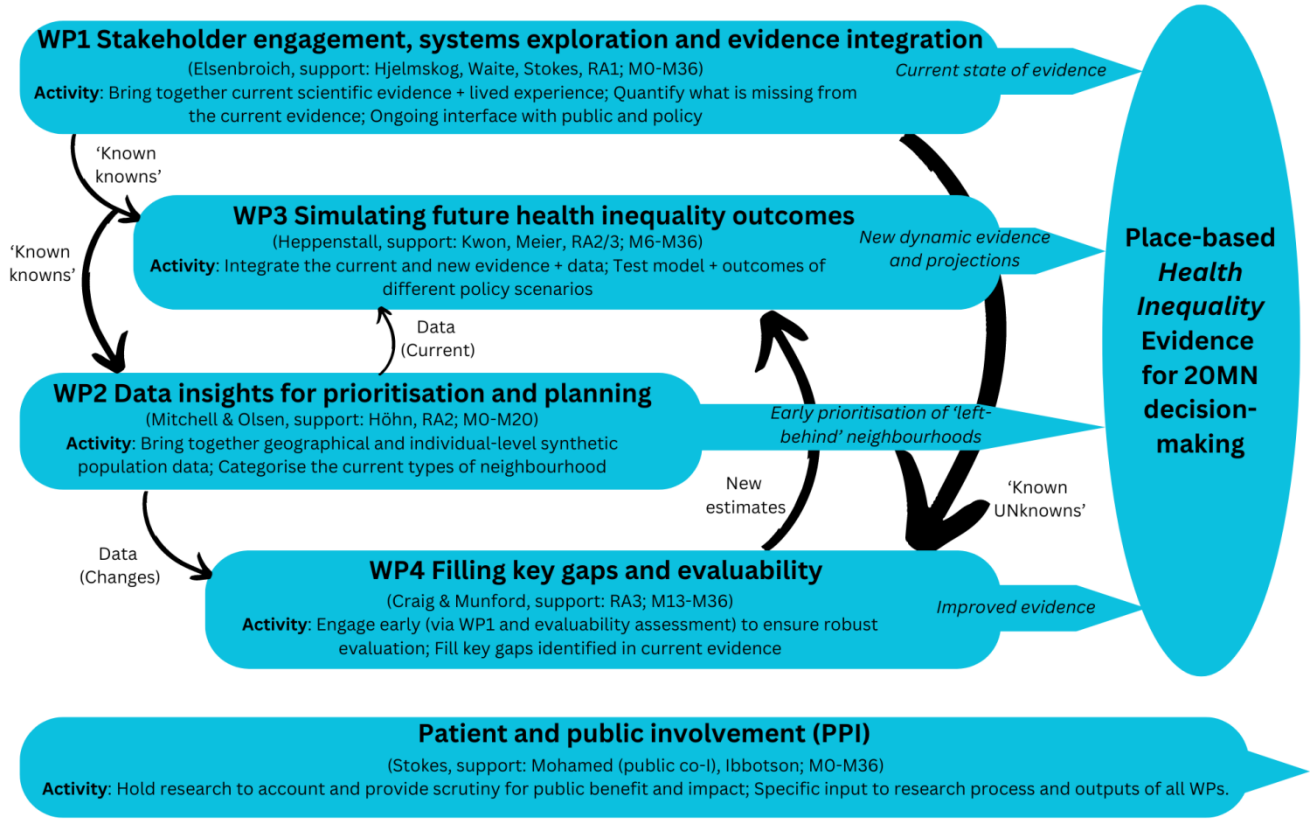
STUDY FLOW CHART

Orienting Policy Towards Inequality Minimising Actions (OPTIMA): A systems science approach to 20-minute neighbourhood policy and evaluation



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STUDY PROTOCOL

Orienting Policy Towards Inequality Minimising Actions (OPTIMA): A systems science approach to 20-minute neighbourhood policy and evaluation

1 BACKGROUND

Policymakers are giving priority to place-based interventions — geographically-targeted enhancements to our living environments. They are attempting to 'Level Up' and bridge the gap in persistent and growing health disparities across places (1). Yet, the evidence base for these interventions to improve health inequalities is insufficient, due partly to numerous methodological challenges in public health (2). This project will:

- Examine a large place-based intervention, the 20-minute neighbourhood concept (20MN) set to impact on populations at scale, *before* costs have been fully sunk;
- Use cutting-edge data and dynamic, future-oriented system simulation methods to build on the current evidence, and draw on consistent and close stakeholder and public engagement to align evidence generation to evolving policy needs;
- Produce and communicate to stakeholders new health inequality-specific evidence for place-based interventions, and modelling and data assets that can be further built-upon as our understanding of the mechanisms and impacts continues to grow.

1.1 'Places' as a priority for health inequalities research and policy

It is well known that our local environments can, positively or negatively, influence our health-related choices and behaviours (3). Health outcomes can be directly influenced by environmental exposures (such as pollution), and our local environments also influence other significant social determinants of health (e.g., income, diet, education) (4). There are large discrepancies in health across regions, and neighbourhoods. For example, there is a gap of nearly 20 years for average life expectancy across Glasgow (2019) (5). Poor health outcomes (and health inequalities, when comparing places) can also become ingrained in a place. For instance, a recent report by the British Academy (BA) and the Academy of Medical Sciences (AMS) drew attention to "notable similarities between maps of COVID-19 mortality…and maps showing mortality rates in the 19th century" (6), suggesting that little has changed in the past nearly 200 years (7). This has emphasised that it might be a place itself that needs to be improved to address health inequalities. Geographical 'levelling up' of health is therefore a priority for Scottish and UK Governments (1,8). Yet, there is no clear recipe for what makes a 'healthy place' and how to transition to this state. Policymakers commonly face the situation where they must pull ahead of the evidence-base to try to solve problems (9). This pulling ahead requires iterative policy development and dynamic evidence to avoid suboptimal choices becoming ingrained, through sunk political capital and costs (2).

1.2 Living locally – the 20-minute neighbourhood (20MN) as a public health policy

A particular type of place-based intervention, creating accessible neighbourhoods that encourage local living, has become especially popular in recent policy. These neighbourhoods have been conceptualised since the early twentieth century, to address issues such as sustainability and community social capital building (10,11). They have also been increasingly planned in recent decades on a global scale, commonly termed variations of 'X-minute cities' or neighbourhoods (12). Scotland has recently committed to rolling out this large place-based intervention nationally, the "20-

minute neighbourhood" (20MN). This vision is also planned elsewhere in the UK (13,14). The concept has been gaining further popularity post-COVID-19 in particular, and has now been pitched as a wider "framework for sustainability, liveability, and health" (15), i.e., a multi-solving policy. In Scotland, moreover, the 20MN specifically aims to reduce health inequalities (16).

The 20MN, then, is typical of many place-based planning concepts that have similar underlying design features, such as promoting walkable neighbourhoods with access to services at short distances from home, affordable housing, and pedestrian/cycling priorities. Therefore, evidence from their examination is also likely to have policy significance for a broader range of place-based interventions. The 20MN concept itself, though, is uniquely defined on the basis of a measurable policy implementation outcome, i.e., the ability to active travel to services that meet daily needs within a 20-minute locality (a 10-minute return journey, or within an 800-metre radius of home (17)).

The concept has two important elements, therefore: (1) the individuals (and where they live); (2) the daily services they use, and their proximity. In previous work, co-I Olsen and colleagues worked to define the services considered relevant for 20MNs in Scotland. They co-produced these using Scottish Government policy documents, and consultation with a group of representatives from Architecture and Design Scotland (an executive Non-Departmental Public Body), government, public health, and third-sector organisations (18). They arrived at ten service domains considered relevant, with mappable service locations to be measured within each domain: 1) healthy food retail; 2) public transport (including frequent public transport); 3) primary health care facilities; 4) education; 5) financial services; 6) community health resources; 7) accessible public open space; 8) recreational, sports pitches and facilities; 9) social and cultural services; and 10) eating establishments.

While the overall 20MN policy vision is clear, then, to date the concrete steps to implement the policy have been less so. This is common for health (and wider) policy at scale, commonly framed around a goal rather than how it will be achieved in practice. Rollout and implementation of the policy at national scale tends to be locally driven, so will be somewhat heterogeneous and responsive to local context (e.g., which services are currently lacking in a specific area, their budget, and local population preferences). There are also additional implementation barriers. Some of the 20MN domains (e.g., healthcare or education) are primarily delivered by public services in the UK, so relatively controllable by policymakers. Others, though, for instance, food retail or recreation services, are predominantly provided by the private sector. Consequently, there is much less direct policy control over these services, and dynamic markets can influence location. This includes rental and housing markets, also mostly private, determining where people are located relative to any services.

To give an overview of what implementation can look like, however, our recent scoping review categorised concrete interventions in three main groupings (14,19). To increase proximity of services for people, you can: 1) bring services closer to where people live - such as converting ground floors of buildings, or targeting specific local service locations to existing or new developments; 2) bring housing (i.e., people) closer to services - again, new developments or new use of old spaces; 3) reduce the active travel time between housing and services - e.g., via pedestrianisation or cycle paths. Additionally, some interventions might blur this categorisation slightly, such as an intervention where public school grounds are opened to the public as green space out-of-hours, effectively turning one service domain into two within the same location.

There are very few examples of concept implementation to date, and no robust evaluations for policymakers to learn from, particularly when examining health inequalities (14).

1.3 National roll-out of 20MN place-based policy in Scotland at scale

Significant initial spend has already been committed to roll out the 20MN (although, 'committed' is different from 'spent'). The headline figure in Scotland is £325M through the Place Based Investment Programme (2021/22-2025/26) (20). However, our baseline analysis shows how far away Scotland currently is from full implementation of the 20MN concept. Just over one in five of all Scottish residential locations had access to all 20MN domains in 2022 (18). To implement the concept requires large infrastructural interventions with high costs. As far as we are aware, there has been no full costing exercise undertaken for Scotland. However, there are significant costs from initial design through to implementation stages. For instance, Local Place Plans, which constitute one vehicle for planning implementation of these at community level (i.e., many of these across Scotland) are estimated to cost between £10,000-£30,000 each (21). The cost of implementing 1.5miles of walk/cycle path in Orkney, as one example, was £1.5M (22). This suggests the total cost via public expenditure alone will be many multiples of the current commitment.

An important aspect of continued rollout, however, is that the 20MN "must" also be considered in any future local planning (23). This local rollout of the concept is a cornerstone of the place-based intervention. This local planning will make a substantial, and ongoing, contribution to implementation and costs since many of the developments will be private investments (approved for planning by the public sector, and/or co-funded by public investments), such as housing and retail developments. For example, the "City Plan 2030…Local Development Plan for Edinburgh for the period 2022- 2032" is already planned for rollout five years beyond our proposed study end date. The implementation strategy includes a planning approval mechanism (for private investment), "Housing development will be supported where key community facilities are walkable within a 20-minute return trip. Applicants must demonstrate this through an assessment of walking distances to key services and infrastructure. Proposals for housing in areas that do not currently meet this walking distance will be considered only where these services can be delivered, relative to the scale of development, and managed as an integral component of a mixed-use development." To give an idea of the scale, one project, the Granton Waterfront regeneration in Edinburgh, specified in the Scottish draft 20MN guidance, is "a new coastal town with an ambitious 20-minute neighbourhood vision over the next 10-15 years" (16). This single project is estimated at £1.3B overall (24), with an initial £16M public funding to kickstart the regeneration (25).

It is now up to local policymakers to allocate the initial, and future, funding to various projects. They require evidence to do this effectively and efficiently, to minimise health inequalities.

1.4 Literature review

Place and health outcomes

The current evidence-base does illustrate that neighbourhood exposures clearly *can* improve health outcomes (26–31). Most of the current causal evidence, though, comes from studying 'movers' *to* better neighbourhoods (32), i.e., those gaining a substantial 'dose' change. The impacts of improving neighbourhoods themselves, however, are less well understood, especially what happens to existing

(not new) residents through gradual improvements (32,33). Evidence is especially lacking on the full mechanisms of neighbourhood effects (32). There is, though, emerging evidence that many of the services involved in the 20MN, for instance, “improving the public realm, parks and playgrounds, supermarkets, transport, cycle lanes, walking routes, and outdoor gyms” (3), can have positive impacts on mental and physical health outcomes, particularly through active travel (3,34).

Envisioned pathways to health and overcoming health inequalities

While evidence on mechanisms is lacking, we conducted a scoping review examining those *envisioned* for health and health inequalities in current international 20MN (and similar concept) plans (14,19). We identified that pathways to outcomes are poorly outlined. HEALTH PATHWAYS envisioned were mostly via increased active travel directly, e.g., physical activity decreasing obesity and stress, or the assumption that closer services will lead to direct benefits of service use, e.g., increased access to and consumption of healthy food. Other pathways outlined were mostly knock-on impacts of these mechanisms, e.g., via decreased car pollution with increased active travel. HEALTH INEQUALITY PATHWAYS were much less clear, often simply prioritising deprived areas first. Evidence regarding the geographical health inequality impacts of place-based interventions is most lacking in the broader literature, currently, as evidenced by a recent systematic review (3).

Potential for place-based interventions to unintentionally increase health inequalities

Our review also identified, importantly, that there were concerns about unintended health inequality impacts raised in some policy plans. For example, the possibility of increasing access to unhealthy services (e.g., alcohol, gambling) as well as healthy ones. Also, the possibility of increased local prices forcing out the poorest residents from any benefits (14).

For health inequalities, the dynamics as well as the potential for different impacts in the short- and longer-term, are especially important when thinking about place-based interventions. For example, the recent BA and AMS national report exploring the historic and geographic patterns of health inequalities emphasised this issue specifically that, “understanding geographic inequalities in morbidity and mortality requires good data collection and appropriate analysis on population movement… Improved health in an area may result from wealthier individuals with better overall health moving into areas that previously had poorer health outcomes, pricing local populations out. This scenario results in a change in health outcomes for the local area, but not for the people who once resided there. How, then, can we distinguish between ‘levelling up’ and gentrification? – the former indicating real, long-term, positive impact, the latter an artificial outcome which may actually exacerbate inequalities” (6).

Another possibility is that in the long-term the local population, even if not forced out, is unable to support the healthy new services that are put in place, and there is therefore deterioration of quality or service provision (21,35). In other words, that the 20MN dissipates naturally over time, wasting investment that could have otherwise been put towards reducing health inequalities. People, and services, are not fixed in place, so dynamic study requires longitudinal linked intersectional administrative datasets, uncommon in most countries. Tracking who exactly might benefit, and which areas’ aggregate health measure they contribute to at a particular point in time (to examine geographical inequalities), has therefore proven extremely difficult (32,33).

Proximity not sufficient for health (inequalities)?

The assumption of the policy that proximity to services alone is a sufficient condition for health benefits is also questionable. Again, the baseline analysis by Olsen and colleagues identified that more (32.6%) of the most deprived quintile of locations analysed in the Scottish baseline analysis, where health is *poorest*, met the criteria for a 20MN than the least deprived (17.6%) (18). A recent cross-sectional analysis comparing those living in to those not living in 20MNs in Melbourne found no consistent patterns, failing to support one of the frequently assumed beliefs that 20MNs could support healthier behaviour (diet, physical activity or self-rated health), and that these relationships might vary by socio-economic status (36). We know from healthcare services that it is not just proximity that contributes to access and use, but aspects such as quality and affordability too (37,38). This emphasises that we really need to understand in more depth the mechanisms for what DOES contribute to a healthy place.

Conventional methods lacking to provide this evidence

Public health has previously relied on trials (if even feasible to randomise) or natural experiments of piloted interventions (ex-post) to inform this early stage of policy from a quantitative point of view. These provide robust evidence, but retrospectively, with a long time-lag, and/or high up-front costs of piloting of the implementation. Other areas of public policy and private sector, however, are increasingly capitalising on advances in computing power and systems science methods such as computer simulation. This can allow understanding of a system and interactions within it, and it also permits simulated experimentation at a much lower cost and shorter timescales, than real-world piloting (2). These models are particularly suited to understanding the dynamics of the system, crucial to health inequality evidence for place-based interventions, as described above. The linked data necessary to track people over time and space, in the UK, is not currently available at the individual level necessary for this evidence generation. What IS able to approximate it currently, however, are synthetic population data in combination with dynamic spatial modelling.

Calls for systems science methods to address current methods challenges

To address these evidence gaps, the UK Government, WHO, and MRC, among others, recently highlighted the need for incorporation of systems science methods to better inform policy (39–41). Agent-based models (ABMs), for example, can simulate heterogenous agents interacting with each other and their environment over time, and can perform an evidence integration function to bring together qualitative and quantitative current evidence-bases. The ex-ante policy simulation and stakeholder engagement that modelling allows could also aid data collection and prime future rigorous evaluation (2).

2 RATIONALE

This project can offer new and valuable evidence relating to investment in place-based interventions and health. In particular, the methods we plan to use were chosen to address the scarcity of research related to health inequalities, due to the challenges detailed above. We will leverage:

The timing of sustained rollout of a major population scale place-based intervention

Local governments in Scotland now need to implement 20MNs (16). They need to prioritise interventions, with costly infrastructural investments. There is little to no EVIDENCE on what health inequality outcomes might be achieved. We will provide iterative evidence over the course of the project as well as a platform to build on this evidence further in the future.

Public health and computational methods advancements

As a COMPLEX SYSTEM of individuals and services interacting dynamically, there is potential for implementation of 20MNs to have large unintended consequences. We will employ methods that can: i) bring together the diverse evidence-base that currently exists; ii) complement it with systems mapping workshops and stakeholder knowledge; iii) allow modelling and simulation of the dynamics; iv) improve the opportunity for robust evaluation to feed back into this process.

Tying of these advanced methods to robust existing methods

We will combine the above with already strong methods and data, through: realist review, geographical data, synthetic population data, cluster analysis, natural experiments, and using established ways to grade the evidence that exists, so we can capture uncertainty.

Stakeholder engagement and adaptive response

Continuous engagement and co-production with policy and public stakeholders will inform the research. Strong PPIE input will guide the project from conception to finish.

Assets and platform for future place-based intervention research

We will package what we produce for others to freely use with their own data and for future place-based health inequality research.

3 THEORETICAL FRAMEWORK

We draw on guidance for complex system interventions (41), and combine multiple methods, including: Realist review of the current scientific literature; Systems mapping workshops for real-world nuance and to fill gaps; Synthetic population and geographical data analysis; Natural experiments and economic analyses. We then bring all of this together in a simulation model to examine the accumulation of mechanisms and forecast health inequality outcomes of different intervention approaches.

4 RESEARCH QUESTION/AIM(S)

We aim to produce timely, effective, actionable evidence on 20MNs and their health inequality implications, as investment decisions are being made. For feasibility, and in line with policy assumptions, we will initially focus on active travel pathways to health.

4.1 Objectives

The project aims to answer four over-arching research questions to achieve this aim:

1. How can we synthesise the current evidence-base and stakeholders' lived experience to inform 20MN policy planning and simulation model building, making current uncertainties explicit? (WP1)
2. What do measures of quality of services and the overlaying of a synthetic population add to our baseline understanding of 20MNs and health (inequalities)? (WP2)
3. What can a simulation model of complex interactions of individuals accessing services, and services responding to their access, add to our understanding of which 20MN interventions might maximise health inequality benefits (and minimise harms)? (WP3)
4. What real-world evaluation design would best meet stakeholders needs for 20MN evidence to guide continuing future policy and investment? (WP4)

4.2 Outcome

Our main outcomes of interest are health inequalities, the health part which we propose to measure based on the Short-Form Health Survey (SF-12), a frequently used self-reported health-related quality of life measure – including in the UK's Understanding Society survey that our synthetic population is built from. The SF-12 captures both physical and mental health separately, and we will use both of these as outcomes. In addition to this, a mapping of SF-12 mental and physical health component scores to the well-established metric of health state utility scores and quality-adjusted life years is possible. The simulated nature of the data will allow flexible comparison of within- and between-modelled areas (capturing gentrification), as well as absolute and relative health inequality. Variables such as the resident agent's demographic characteristics will allow further examination of alternative axes of inequality.

Via the agent-based model we will also simulate intermediate mechanisms between neighbourhood service changes and health outcomes. For example, active travel is one proposed mechanism we identified in our preliminary scoping review for how proximity to services might actually impact these mental and physical health outcomes (the predominantly proposed mechanism within current global 20-minute neighbourhood related plans). It is the full pathway, changes to the built environment > impacting proposed (/evidenced, as above) mechanisms (e.g., active travel) > impacting these health outcomes (e.g., SF-12 physical and mental health), that we will model. Final estimates will be focused on the downstream health measures.

5 STUDY DESIGN and METHODS of DATA COLLECTION AND DATA ANALYIS

The intervention

The National Planning Framework 4 (NPF4) is the statutory framework for implementation of 20MNs in Scotland (23). As outlined above, the £325M Place Based Investment Programme is being used in practice to kickstart local implementation (part of the Scottish Infrastructure Investment Plan (42)).

This ‘capital expenditure’ money is then allocated by the 32 Scottish local authorities to community-led projects via various processes, usually by inviting bids and allocating to local applications (e.g., (43–47)). The 2023 Scottish 20MN draft planning guidance makes clear that much of the implementation is expected to be locally led, through preparation of Local Development Plans, Local Place Plans, and through the decision-making of local planning authorities approving (or not) infrastructure developments (16). This is likely to result in varied activities implemented, but all designed to achieve measurable service proximity gains. Using data, we will be able to say whether previous (or future envisioned plans) have measurably changed the 20MN maps. We will be able to model what dynamic impacts these proximity gains are likely to have on health inequalities, based on current evidence and data. And we will be able to set up further rigorous evaluations of these implementations.

WP1: Stakeholder Engagement, Systems Exploration and Evidence Integration
(Elsenbroich, support: Hjelmskog, Waite, Stokes, RA1; M0-M36)

Aims: WP1 will bring together the evidence-base through stakeholder engagement, review and synthesis of literature, and integration of existing evidence to estimate effect sizes and sub-group differences. It will work iteratively across evidence sources to complement and fill gaps with lived experience on hidden pathways, identify uncertainties, provide ongoing engagements with policy decision-makers, and feed co-produced evidence and insights in a timely manner to the work packages that follow.

Rationale:

Place has been identified as intimately connected to health outcomes in the scientific literature (see background section). A recent review of the literature has, however, shown that much remains unknown, particularly regarding health inequalities and the mechanisms of how place translates into health outcomes (3). WP1 will (1) synthesise the current scientific evidence base, focusing on differentiating any known heterogeneous sub-group impacts, (2) capture the level of uncertainty in this evidence and key gaps that remain, (3) co-produce and supplement the missing mechanisms and behavioural rules for individual and service actors within the system with evidence from lived experience and policy stakeholders.

Methods:

We will use three primary methods:

(1) Initially we will conduct a REALIST REVIEW (M0-18, with the option to revisit or iterate this review as the evidence base grows via stakeholder collaboration and the outputs of other work packages) to map the current knowns (and unknowns) about what works, for whom, in what circumstances, and how (48). Quantitative and qualitative evidence will be collated to inform nuances in terms of proximity of services and health (inequality) pathways, and population heterogeneity. Our methods will draw on Pawson et al.’s framework ((49), adapted from, (48)) and take the following steps: 1) clarify and define the scope of the review to determine the question, purpose, and theoretical evaluative framework; 2) search for and appraise the evidence through background searching, purposive sampling, and testing

for relevance and rigour; 3) extract the data to populate the evaluative framework and synthesise findings; 4) develop a narrative in collaboration with stakeholders, in preparation for dissemination. From this review of the literature, we want to primarily capture two things: (i) agents' decision-making behaviour rules within the system; (ii) the impacts of this behaviour on health (and impact estimates for other feedback loops within the system, e.g. the extent to which proximity to certain service domains enhances or mediates related health outcomes, such as the relationship between access to public open spaces and use of sports/recreational facilities). We will include grey literature and evaluations of real-world interventions in this review, and we will limit the inclusion criteria to both the initial ten 20MN service domains (outlined on page 2), and in the first instance to studies conducted within the UK so as to demonstrate shared institutional parameters (with international studies brought in where UK evidence is lacking).

For (i), we expect to be informed primarily by relatively weak causal evidence, such as descriptive surveys and non-causal qualitative data. Here, we separate the two types of agents we are interested in within the policy: the individuals, and the services themselves. For example, for individuals:

-Which in-person services do which people consider essential, at what frequency (i.e., what is actually a 'daily service need', for whom, e.g., with increasing online/delivery options)?

-To what extent is proximity to each service the limiting factor for access (versus quality, cost, or other decision-making factors)?

-What does a 20MN look like for different sub-groups (e.g., old or disabled), and what determines active travel choice versus other means of transport for different sub-groups?

For services, for example:

-How do private sector services decide where to locate, and to sell (un)healthy goods?

-How and to what extent can public sector services influence the private sector's service locations?

-Which service requires what density of population (or level of demand) to support it?

For (ii), we expect to be informed primarily by quantitative evidence, with varying degrees of robustness, statistical uncertainty, and causal inference. Here, we are interested in capturing the estimated health impacts of the pathways of interest (e.g., what are the plausible physical and mental health payoffs of proximity to services?), as well as quantifying estimates along other relevant behavioural decision-making pathways from (i) (e.g., do the potential physical and mental health payoffs of proximity to services differ across population sub-groups?; or, e.g., what is the average time to service closure by density of surrounding population?).

The realist approach, with its emphasis on context and enabling factors, will allow us to understand the relative effectiveness of different component parts of interventions, to identify the most effective elements and/or those elements that will be appropriate for different Scottish contexts. The decision-making behaviour rules and estimates will feed into later work packages.

(2) We are aware that there are likely to be missing context-specific decision criteria and explicit gaps in the current evidence-base regarding these mechanisms and estimates, particularly for parts of the causal chains previously of lesser direct interest to health researchers. Following the realist paradigm of context specificity, we will recruit two stakeholder groups to inform and fill gaps via real-world lived

and policy experience and expertise. We will recruit two groups, one consisting of community stakeholders and one of policy stakeholders.

Both groups will consist of 8-12 people and will have two/three workshops over the project, respectively. We will use the networks of our PPIE group and policy partners, Public Health Scotland (PHS) and Scotland's Regeneration Forum (SURF), to attract willing and engaged participants. PHS is Scotland's public health body, jointly accountable to Scottish Government and local authorities. PHS is responsible for bringing together and sharing data and intelligence to shape decisions affecting health, including a localised working programme with a network of stakeholders, national and local policymakers. SURF is a registered charity whose objective is to enhance disadvantaged communities by providing a platform for all sectors involved in Scottish community regeneration to exchange knowledge and experiences. SURF holds regular online network meetings (50), including small community groups, private companies, the Scottish Government, local authorities, housing associations, health boards, academic institutions, professional bodies, voluntary organisations, and charities. The workshops will enable us to understand the evolving policy context, evidence needs, and disseminate findings in accessible formats.

The workshops with both groups will use participatory methods to provide structured ways to enable detailed understanding, consensus and analysis of the system to evolve throughout the project's lifetime. This will include Participatory Systems Mapping and a participatory, iterative Theory of Change, underpinned by a Soft Systems Methodology approach that accommodates and values a broad range of knowledge and stakeholder perspectives (51). Early workshops will work on understanding the system and pathways/decision points (also informing additional questions for the evidence review in (1), above). Then, focus will be on bringing together missing evidence and filling key gaps in the current literature and informing timely policy interventions of interest for the modelling. Finally, there will be more of a dissemination focus, and a focus on achieving further iteration and improvements to the evidence we present.

(3) The quality of the above evidence will also vary. We will evaluate parameter and structural UNCERTAINTY of the evidence by adapting the GRADE guidelines (52). For example, there might be specific pathways and groups for which there is robust causal evidence, where mechanisms are well studied and understood, where much less assumption needs to be made about what the impact of a given policy is likely to result in for a given health outcome measure. More likely, though, there will be gaps in evidence, or weak causal evidence along some parts of the pathway(s). This final piece of evidence grading work will make the strength of assumptions based on the current evidence explicit for what we later encode in the model. We will make this assessment (in plain-English) available alongside our model and alongside results from any simulations using it. For the estimates of impacts we identify (1/ii, above), we will also have a range (confidence interval) to inform sensitivity analyses in the WP3 modelling. Any evidence gaps that need to be filled by stakeholders (2, above) will also be identified as highly uncertain, and prioritised as key gaps for WP4 to try and improve the evidence base.

Outputs and deliverables:

1. *Discrete WP outputs*:

- Ongoing/iterative co-produced Theory of Change.

2. *Inputs to other WPs*:

- WP2: Details of any useful additional data to source.
- WP3: Behavioural assumptions and current estimates detailed in the scientific literature (with gaps filled by stakeholders).
- WP3: (Un)certainty estimates of the current evidence and behavioural assumptions (for sensitivity analysis).
- WP4: Details of key gaps in the current evidence base.

3. *Publications*:

- Proximity to services and health: A realist review
- Using participatory systems methods to inform real-time policy rollout: transdisciplinary insights for health inequalities from Scotland's 20MNs.
- Working with uncertainty in public health policy evaluation: using 'hard' and 'soft' systems approaches to support 'learning by doing' in 20MNs.

Summary of extant evidence will aid decision-making under uncertainty, identify key policy levers, and provide an initial understanding of potential (un)intended consequences. For modelling, we will have the 'rules' people and services use when interacting with each other in our system. Engagement in the policy process will enable accessible evidence responding to needs.

WP2: Data insights for prioritisation and planning
(Mitchell & Olsen, support: Höhn, RA2; M0-M20)

Aims: WP2 will collate, create, share (with WP3), and analyse novel data linkages which capture the baseline conditions for the 20MN policy, and geographical changes over time. WP2 extends existing work spatially (from Scotland to the whole of GB), and by adding measures of service quality (where available) and sociodemographic profile to highlight area-level health needs. The linked dataset created will underpin WP3's simulation models. Utilising this dataset, we will apply clustering methodology to establish a typology of areas which perform similar with respect to outlined 20MN characteristics (e.g., areas meeting key targets already vs. different types of 'left behind' areas). This will facilitate a baseline-level assessment for Scottish areas and will allow us to capture other areas in GB currently not covered by 20MN policy interventions. To achieve these aims, WP2 will have four phases:

1. Create a thorough spatial dataset of local services (informed by WP1) in which the key innovation is the addition of measuring service quality.
2. Link this dataset describing provision and quality of services with a survey-based full-scale synthetic population dataset to allow for local health and service needs to be measured.
3. Use the linked dataset to identify communities which are 'left behind', defined by having a combination of high health or service needs (high demand), but poor provision of services to meet these needs (low supply) using clustering methodology.
4. Share and disseminate the linked dataset and insights on clusters widely and in an accessible way, allowing communities, policymakers, and WP3 researchers to utilise these as resources.

Rationale*:*

So far, appraisals of 20MNs at a national scale have focused on proximity to services. Within the UK, only Scotland has a comprehensive and consistent assessment. At the same time, elements of the

20MN concept are increasingly considered across the UK, and more specifically for several English cities. Our previous stakeholder engagement revealed there are substantial problems with assessments of 20MNs based solely on proximity. The initial 20MN approach assessed which services were available, without considering the needs and (e.g., financial) resources of the local population, or the quality of available services. This resulted in some affluent areas with a low population density being identified as lacking proximal services – while it is likely that their needs were already met. In turn, some deprived communities in dense urban areas were characterised as having excellent access to services, despite these being of known poor quality, distributing unhealthy commodities, or inadequate for locally high levels of need. At the same time, local need can only be assessed with knowledge of the sociodemographic and health characteristics of local populations. The development of novel synthetic full-scale population datasets for GB has enabled for such detailed information at the level of individuals, and a granular geographical resolution to become available in quasi-open data settings. To enable more rigorous evaluation of the 20MN policy, it is necessary to have standardised measures of service provision, quality and community need outside current intervention areas (i.e., beyond Scotland). We will extend existing measures of 20MN amenities and services provision in Scotland to all of GB, on a consistent and comparable basis, developing and adding measures of quality for services. In England, there has been research to define left-behind areas which are rated as being highly deprived, having higher community need but also poor infrastructure (53). Considering these results, we will use our linked dataset to identify places with the greatest unmet needs since these are likely to be priorities for 20MN-style interventions and could make greatest impacts on health inequality. As outlined above, the predominant approach to tackling health inequalities with the 20MN currently is by targeting the most deprived areas first. We will add nuance to this, categorising which specific needs (versus current supply) local neighbourhoods currently have.

Methods:

There will be 4 steps:

(1*) Identification of candidate services and priority health (inequality) outcomes to assess 20MNs for which suitable area-level data is available*. The Scottish Government's policy does not specify the exact services for a 20MN. Given our overall aims, we will need to create an agreed set of indicators to work with, building on our initial ten domains used in baseline analysis (18). We will apply two methods. Firstly, through WP1, we will add community lived experience understanding of which services, which people deem local 'daily needs' which support the health promoting potential of 20MNs. Secondly, again in iterative collaboration with WP1 stakeholders, we will select the priority indicators available from the synthetic population dataset (described in more detail below).

(2) *Obtaining spatial service and amenity data and developing and assigning measures of quality*. The UK has comprehensive spatial data describing the built and natural environment, from sources such as Ordnance Survey. These data are freely available for academic research. Olsen and Mitchell have extensive experience of using them for socio-spatial analyses at local and national level, including producing the existing tool for Scotland, drawn upon by the Scottish Government to develop their initial policy. We will base the assessment on previous work conducted by Olsen and Mitchell which identified the presence of ten service domains within an 800m vicinity of each residential location in Scotland (18). Here we will also consider local services which may be both health harming (i.e. busy roads, unhealthy

commodity retailers) and health benefiting, and which have been shown to cluster within socioeconomically deprived areas (54). To create a linked dataset, these will be geographically linked to residents' 20-minute neighbourhoods or summarised within small geographical areas (Data Zones, DZ, in Scotland, Lower-Super-Output Areas, LSOA, in England and Wales) to quantify the number of facilities (count; area covered; length of roads) and their quality. These geographical quantity measures are also readily available over time, quarterly since 2014, so we will loop over the datasets to extract longitudinal changes in 20MNs by small geographical areas over time to create a 'policy map', a grid of changes in relevant service provision by area, by year, to inform WP3 rate of service change and WP4 evaluability.

The incorporation of quality measures for amenities and services in combination with individual-level characteristics and resources for assessing of 20MNs is an important innovation. Measuring quality can be complicated, with alternative indicators available, so we will draw on WP1 consultation with communities and stakeholders to build a quality indicator set. Since the concept of 20MNs is primarily based on local access to proximal services, we will suggest quality measures need to reflect the demand for accessing/using these services. (A notable exception to this is likely to be for food shopping, however, where demand might be based on criteria which actually run counter to health, e.g., high-sugar/salt flavours. Here, we suggested that services might be classified into 'healthy' or 'not healthy' based on the service type itself to begin with, e.g., a supermarket sells fresh produce which can provide healthy food, whereas a fast-food shop is likely to lead to a less healthy, potentially health-harming, purchase.) Services predominantly provided (or, at least heavily subsidised/offered for free) by public sector are also likely to require different indicators than those more predominantly privately privately provided (i.e., reflecting the variable impacts of market forces, and 'customer satisfaction', for service selection quality criteria).

Example indicators for our previous ten domains used in baseline 20MN assessment include:

Service domain	**Potential Quality Indicators**
Predominantly provided (or, at least heavily subsidised/offered for free) by public sector	
Primary Health Care Facilities	e.g., Scotland's Health and Care Experience Survey (55); or, workforce indicators such as practice list size/GP headcount (56,57)
Education	e.g., Scotland's school-level data dashboard, for instance, pupil-teacher ratio, attendance, attainment profile (adjusted for school sociodemographic profile) (58)
Accessible Public Open Space	e.g., based on the UKRI project 'Better Parks, Healthier for All?' (Mitchell is co-PI; Olsen is a co-I) - park-level quality measures for GB are in development and will be available for inclusion in this project (59)
Public Transport	e.g., frequency of public transport, five or more departures an hour (considered high-quality since passengers tend not to look at a timetable before arriving and are suggested as one factor for encouraging modal shift in transport methods (60)) (61)
Community Health	e.g., General Pharmaceutical Council pharmacy inspections (62); or,

Resources (Pharmacies)	pharmacies that provide additional services (63)
More mixed or predominantly privately provided	
Healthy Food Retail	e.g., Food Standards Agency food hygiene rating (64); or, quality rating based on categorised type of outlet (e.g., (65))
Eating Establishments	e.g., Food Standards Agency food hygiene rating (64); or, quality rating based on categorised type of outlet (e.g., (65))
Recreational, Sports Pitches and Facilities	e.g., user reviews (for instance, Google/Yell (66,67)); or, quality rating based on categorised type of facility/chain name (or, public/private provider) or other categorisation proxy preferred by stakeholders (such as diversity of leisure provision; opening hours)
Social and Cultural Services	e.g., user reviews (for instance, Google/Yell (66,67)); or, quality rating based on categorised type of facility/chain name or other categorisation proxy preferred by stakeholders
Financial Services	e.g., user reviews (for instance, Google/Yell (66,67)); or, quality rating based on categorised type of facility/chain name or other categorisation proxy preferred by stakeholders

We will consult with stakeholders (via WP1) on the merit of the indicators available, and potential alternative open-access sources to capture the quality/affordability dimensions. Service quality assessments will allow us to consider three aspects of local neighbourhoods and characterise these for WP3, these include areas of high health need / high service quantity / low service quality. Data on area internet availability will allow proxying of digital service substitution (combined with population's engagement ability, below) (68). This will allow us to consider what is the best configuration of 20MNs, which is an evidence gap.

(3) *Obtaining synthetic population dataset reflecting individual-level characteristics and performing spatial linkage.* We will utilise a synthetic full-scale population dataset, reflective of the population in GB. This dataset will allow us to incorporate detailed individual-level information on a variety of sociodemographic factors, health status, as well as household-level resources for all residents within small areas. Our synthetic population dataset is created via a spatial microsimulation approach, which combines publicly available census and population statistics data for small geographical areas (DZ/LSOA) with individual-level information from the UK Household Longitudinal Study (Understanding Society) (69). Reflecting the characteristics of more than 50 million adult individuals in GB, the dataset is representative with respect to key sociodemographic characteristics such as age, sex, employment status, health, or household composition at the most granular non-disclosive geographical resolution in census reporting. Details of the spatial microsimulation approach as well as the underlying combinatorial optimisation algorithm have previously been described in detail elsewhere (70). An updated version of this dataset will soon become part of the UK Data Service's curated data collection (co-led by Co-I Höhn, Data Set ID 14238, DOI pending). This dataset is currently reflective of the period 2019-2021, while drawing in parts on information from the UK census 2011. Once small-area information from the UK

census 2021 will becomes available for all GB nations (expected first half 2024), we will update and re-validate this dataset. Utilising this unique attribute-rich dataset will allow us to derive estimates for individuals, assigned to small geographical areas, variables such as their physical and mental health status (e.g., via 12-Item Short Form Survey (SF-12), a frequently used self-reported health-related quality of life measure capturing mental and physical health separately, and with ability to map to further well-established metrics of health state utility scores and quality-adjusted life years), perception of neighbourhood safety, income, service needs, digital engagement ability, or means of transport available. If required to fill additional data needs identified in WP1, this dataset can also be linked probabilistically with other full-scale synthetic population datasets which are based on other surveys (e.g., Labour Force Survey).

A shared granular geographical resolution will enable us to spatially link our synthetic population dataset with the geographical data described earlier. This linkage will provide a strong foundation for utilising Bayesian multiple imputation methods (e.g., Amelia II) to fill missing data with reliable estimates in a small number of cases where information on sociodemographic or geographical features may be missing (71). A particular advantage emerges as Bayesian approaches allow for all available information to be considered alongside supporting external information when imputing missing values.

(4) Develop typology of areas using data-driven clustering approaches within the developed linked WP2 dataset; We will utilise a data-driven clustering approach (e.g., k-means) to detect similarities across multiple thousands of small areas in Scotland and GB. The resulting typology will provide insights on areas performing similarly with respect to 20MN policy characteristics and sociodemographic profile. This will help us to determine a baseline-level assessment before the full rollout of 20MN policies - as areas can meet key targets of the policy already or can currently be considered left-behind. A similar methodological approach has previously proven effective for establishing typologies of local authorities with respect to factors enabling economic inclusion and economic outcomes and the association of clusters with population health and health inequality outcomes, (co-led by Co-I Höhn) (72).

Outputs and deliverables:

1. Discrete WP outputs:

- Creating linked dataset, rendered to DZ/LSOA level, capturing relevant amenities and services, their quality, alongside the sociodemographic and health profile of areas to establish baseline-level situation and informing parameters of modelling proposed in WP3. Share linked dataset publicly (e.g., via Open Science Framework).
- Data-driven identification of typologies: Similarity of areas with respect to meeting 20MN characteristics will allow identification of different types of forerunners and left-behind areas.
- Provide spatial visualisations via interactive small-area data dashboard (e.g., Shiny), allowing policymakers and stakeholders to gain a deeper understanding of the state of the art in terms of key variables defining 20MN and to prioritise places with the widest gap between need and supply.

2. Inputs to other WPs:

- WP1: details of stakeholder engagement need to incorporate into workshops.
- WP3: Baseline geographical and population data.
- WP4: Longitudinal (annual) ‘policy map’ of what service changes occur where.

3. Publications: At least three publications in high-impact, high-reach journals:

- Operationalising a 20-minute neighbourhood concept using novel data linkages across GB.

- A data-driven approach establishing a typology of areas with respect to meeting key 20MN policy targets.
- Identification of left-behind neighbourhoods across GB characterised by local health need, service quantity and quality.

WP3: Simulating future health inequality outcomes
(Heppenstall & Kwon, Meier, support: RA2/3; M6-M36)

Aim: This work package will use spatially explicit agent-based models (ABMs) (73,74) to bring foresight into (i) which interventions might maximise individual health benefits and (ii) the anticipated impacts of these changes on the local areas (or population groups) for health inequality. For feasibility, we will initially focus on health impacts via active travel, as the predominant pathway determined through our previous review, and develop the model for a single Scottish local authority. Iteratively, we aim to respond to stakeholder input to further develop the model and to allow expansion incorporating data from other local authorities. We will use the dynamic insights from the modelling to flexibly examine projected health inequality impacts, to inform and help mitigate unintended consequences.

Rationale:

There has been a shift in geographical thinking over the last decade to recognise that individual decision-making drives the processes that shape urban areas (75,76). This recognition goes hand-in-hand with increases in the diversity and richness of data (e.g. synthetic populations) and increased computational power that allow the construction and running of well-parameterised individual-based models (76). This WP will build ABMs that are based on the real-world geography (using various GIS data) and synthetic population (using Census individual microdata reflecting the main characteristics of the real populations that live in these areas) (both from WP2). It will embed the important behaviours/pathways identified in WP1 for how different agents move around these geographies (and interact with services), and the health impacts of doing so (also from WP4). Through robust representation of individuals, WP3 will create new understanding and foresight into the impact of potential policy scenarios on health impacts and allow a flexible exploration of health inequalities. The latter, health inequalities, are where the dynamics and long-term effects are critical and particularly difficult to examine with other existing non-dynamic methods. For example, as health inequality is a comparative measure, it matters where an individual resides at a specific time point, to (i) calculate an area's aggregate health, and to then, (ii) to compare that health to another area.

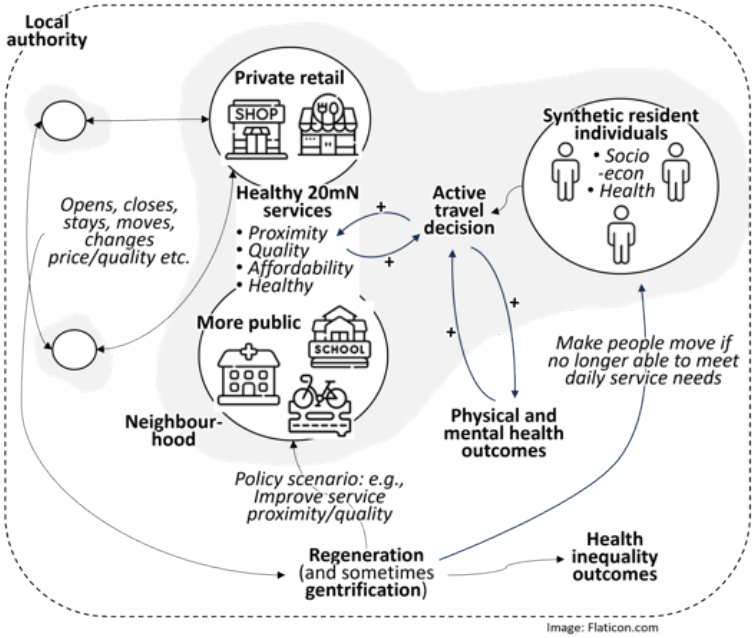
Methods:

We will extend the prototype ABM developed by Co-I Kwon for the 20MN concept in Greater Manchester, examining active travel behaviours and its impacts on local services using geographic, population and health data (77–79). This ABM has been designed in a modular fashion and can therefore be readily adapted to Scotland and the unique pathways and behaviours that a 20MN captures (informed by WP1 and 2). The specific modelling priorities have initially been informed by our scoping review (14) and an existing systematic literature review (3). These are: a focus on health via active travel; ability to model access constraints other than proximity alone (e.g. quality and cost);

and ability to capture the possible unintended (mental and physical) health inequality effects of population and service movement over time, and co-location of healthy and unhealthy services (e.g., positive/negative effects of gentrification). Agents will represent both individual residents and services (e.g., using the framework of the ten 20MN service domains (18)) (see Figure for outline of the modelling components, expanded on below).

For illustration, and responsive to WPs1/2:

Individual resident agents are located across the local authority, have distinct service needs (e.g. taking children to school, frequent visits to GP) based on their heterogeneous characteristics (e.g., age, sex, health, digital engagement ability), and make decisions on whether to undertake active travel to those services (or obtain digitally, if possible) based on the behavioural rules/pathways from WP1 and their own and area attributes, leading to accumulated impacts on physical and mental health. Here we initially focus on the daily service needs other than work, with the aim of capturing the types of behaviour that take place in the locality, with the possibility of extending to work travel needs, as appropriate through stakeholder co-production in the project. Therefore, service agents represent a variety of private retail and public services, such as food outlets, GPs, and schools, drawn from the real data supplied by WP2, with characteristics such as proximity to residential areas, quality, affordability, and healthiness (e.g., fast food stores would be classified as unhealthy). The policy scenarios of 20MN investments (e.g., improving public services' proximity and quality) will have an impact on the private retailers' decision to open, close, stay, move to another neighbourhood and/or change price/quality. This can lead to regeneration of certain neighbourhoods in the model and makes the synthetic resident individuals move if no longer able to meet their daily service needs due to affordability. The relocation of resident individuals further affects the private retailers' decisions on location and price etc., reflecting the changing client base in the neighbourhoods.



The ethos behind the model building is to start simple, thoroughly check the model outputs, and gradually increase the complexity. For feasibility, we will initially build the model using data for one local authority in Scotland, composed of many neighbourhoods (local authority to be chosen based on engagement and interest via stakeholder workshops in WP1, as well as ability to represent several different neighbourhood types based on WP2 clusters). We will set land parcels as patches and set patch attributes based on real GIS data, such as land/building use. The agent characteristics reflecting the real population will inhabit these simulated geographies. One 'tick' in the model will represent one month, running for five years or more (i.e., 60+ ticks) to be able to test effects of possible gentrification. Each synthetic resident will make active travel and location decisions for one random day of a month every month (since we assume these decisions will be lifestyle-based, and repetitive if representing 'daily needs'). Each private retail service will make location decisions every month (since

we assume these services to be dynamic at this frequency, e.g., via monthly shop-front leases). Other public services are likely to be more fixed to place, but might make price or quality adjustments, for instance (again, behaviours based on WP1 findings). While we will start with the focus on active travel, we will later consider adding other pathways to health such as healthy food consumption, access to healthy infrastructure and air quality, depending on the feasibility and informed by stakeholder priorities (from other work packages).

Once the model is built, we will validate, informed by other WPs. The uncertainty of the evidence base (from WP1) will identify key parameters and rules for additional sensitivity analyses. This will allow, effectively, a bootstrapping approach to quantifying the uncertainty. For example, we will have from the literature a central estimate and confidence interval for the various impacts of active travel (or direct impacts of specific services), and other parameters in the model (a narrower/wider range of estimates depending on the strength of the current evidence base). Likewise, behavioural rules we have built into the model will be based on varying levels of certainty of the evidence-base. We will run the model multiple (e.g., 1000) times, varying the parameters within the range for each (range of variation reflecting the inverse of strength of evidence, i.e., less certain evidence varied over a larger range), to get a statistical estimate of the uncertainty. As well as this statistical approach, we will sense check the model findings (and dynamic outputs) with stakeholders (WP1). Historical data (WP2) will allow parameterisation and a check of whether the model is able to mimic observed patterns. Ultimately, real-world evaluation findings (WP4) will feed back in to further improve the model assumptions and inputs.

After validation, we will run various policy scenarios (based on WP1 co-produced stakeholder priorities): For example, introducing new services or upgrading existing; targeting some neighbourhoods of a local authority and (not yet) others. This will help simulate, for instance, whether more deprived residents would eventually have to relocate from the improved area(s) to other neighbourhoods in the local authority, or alternatively whether the services themselves introduced or upgraded to improve the area would shut down or move out because local residents cannot sustain the ‘healthy 20MN’. We will enable loading of baseline geographical and population data from other local authorities (based on WP2 GB data) too. This will allow policy simulation of forecasted impacts of (combinations of) 20MN interventions on health (inequalities).

The simulated nature of the data will allow flexible comparison of within- and between-modelled areas (capturing gentrification), as well as absolute and relative health inequality. Variables such as the resident agent’s demographic characteristics, initial/current location, and initial/current health status, can be exported in a spreadsheet for each tick (i.e., time point within the model) to conduct various calculations regarding gentrification, population movement and health inequality. For example, we can compare at a specific point in time within the model, such as at t20 (20 months from baseline), the sum (or average) of health of all agents currently in neighbourhood X minus (for absolute inequality; or divided by for relative inequality) the sum (or average) of health of all agents currently in neighbourhood Y. Or, to track the gentrification/population movement element: At t20, average of health of all agents who were in neighbourhood X at t0 (the ‘current’ residents, who might be the intended policy targets) minus average of health of all agents who were in neighbourhood Y at t0. These health inequality calculations could similarly be done flexibly stratified by various demographic characteristics we have in our agents too (e.g., economic status, age, gender, etc.).

Outputs and deliverables:

1. Discrete WP outputs:

- Dynamic modelling platform for health inequality insights from place-based interventions.

2. Inputs to other WPs:

- WP1: details of stakeholder engagement needs to incorporate into workshops.
- WP1: details of any specific evidence needs for incorporation into model.

3. Publications:

- Using ABM for simulating future health inequality outcomes.
- Comparing health inequality outcomes across multiple scales.
- From neighbourhood to city: scaling up a public health ABM

Code output: Transferable, open-access simulation model (adaptable for future, and incorporation of other pathways to health); model outputs to aid policymaker understanding of the dynamics, and comparison of forecasted policies with uncertainty explicit. All model code will be documented and made available via Github.

WP4: Filling key gaps and evaluability
(Craig & Munford, support: RA3; M13-36)

Aim: To identify opportunities and develop plans for natural experimental evaluation with integrated economic evaluation***.***

Rationale:

Evidence of the effectiveness and cost-effectiveness of 20MN investments is needed for iterating the modelling work in WP3 and to inform future investment in the policy. For the modelling work, we would like, as far as possible, to replace assumptions with effect estimates, and to replace estimates based on evidence from other populations and places with evidence specific to Scotland and the kinds of interventions that are being implemented here. The best way to obtain these estimates will depend on the detail of how investment is allocated and what kinds of changes are being made to neighbourhoods. It is unlikely that allocation will be random, so an in-depth understanding of the process will be needed to deal with selective exposure to 20MN investments (for example, a situation where less or more deprived neighbourhoods are disproportionately likely to experience investment) (80). We will work with national and local stakeholders to understand this allocation process and to develop evaluation plans that, as far as possible, take account of departures from randomness.

Methods:

(1) Evaluability assessment: We will conduct an evaluability assessment (EA) (81,82) of the Scottish Government's 20MN investments. EA is a systematic, collaborative approach to designing and planning evaluations, which is recommended by the Scottish Government for all evaluations of complex interventions (83). An EA comprises of a structured series of workshops with researchers and intervention stakeholders. Participants work together to develop an agreed conceptual model of how

the intervention works, what kinds of impacts can be expected and what are the priorities for evaluation. These priorities can then be used to inform the search for relevant datasets and/or to decide what primary data needs to be gathered, and to develop detailed evaluation plans. The advantage of working collaboratively is that stakeholders gain an in-depth understanding of what an evaluation can and cannot deliver, and the researchers gain a deeper understanding of how the intervention works and which outcomes matter most. We will also use the workshops to discuss with stakeholders the possibility of adapting the allocation process (for example, if localities are invited to bid for 20MN funds, the possibility of using lotteries to distribute awards among eligible bidders).

We will recruit EA workshop participants initially via the stakeholder mapping work in WP1, supplemented by people with specific expertise (e.g., those directly involved in investment decisions and 'experts by experience'), either recommended by WP1 stakeholders such as PHS or SURF, or recruited directly via our own contacts in local and central government and relevant third sector organisations. We will aim to recruit 15-20 participants and aim, as far as possible, to retain participants through the series of workshops so that we can develop a shared understanding of the constraints on and resources available for evaluation as we go along. Three workshops are standard for an EA, but we will allow for an additional 1-2 workshops if we encounter issues that take longer to resolve.

We will adapt the standard EA process to produce, in addition to a summary report for stakeholders, (1) options for evaluation work that will produce evidence that can be used by other work packages within the lifetime of the project; and (2) options for longer-term evaluation as the 20MN policy evolves. For the preferred short-term evaluation options, we shall write up a study protocol for publication (e.g., via the Open Science Framework) before beginning the evaluation. Completed evaluations will be reported in an accessible format for the stakeholder group, with an accompanying technical report, plus a paper in an open access journal. For the longer-term outcomes, we will produce evaluation plans to capture effects at the extensive ('clean' 20MN effect) and intensive margins (20MN + 'dose' of modelling engagement in policy process). Plans will include a short-term economic evaluation, with data on costs prioritised for collection. It will also include information on how to conduct a longer-term economic evaluation, allowing positive and negative consequences to mature.

(2) Economic evaluation: The 20MN is a policy whose primary outcome may not always be public health, but where impacts on health, either positive or negative, are unintended or downstream consequences. An economic assessment must therefore consider the *complete system* effects of the implementation of 20MNs. We will do so using Cost-Consequence Analysis (CCA; (84)). CCA has been recommended for complex interventions that have multiple effects and for public health interventions which have an array of health and non-health benefits that are difficult to measure in a common unit (85). Unlike cost-effectiveness and cost-benefit analyses, CCA does not require the researcher to impose a perspective (e.g. health, or healthcare-focussed) on the analysis, and instead allows decision-makers to examine the impact of different perspectives. Results tend to be presented in a disaggregated format and provide a comprehensive overview of a full range of relevant costs and consequences for each stakeholder/decision-maker to apply their own perspective (preferences and priorities, or formal weighting of outcomes) to make subsequent informed actions.

To ensure relevance for decision-makers, it is important to co-develop the full range of outcomes they would be interested in. Building on the connections established though the EA, we will work with stakeholders to identify outcomes to be included in the CCA. We will do this in an iterative and holistic way, aiming to capture a wide range of possible positive and negative consequences associated with 20MN implementation. The CCA approach does not attempt to combine the range of costs and outcomes into a single aggregate measure, rather its strength is in presenting a range of useful information in the measure's natural units that different stakeholder perspectives will value differently. The full range of outcome effects and the full range of costs are therefore usually reported separately in table format (e.g., (86,87)). CCAs do also nest within them cost-effectiveness analyses (CEAs) and cost-benefit analyses (CBAs) by only considering a subset of outcomes. For example, considering only health related quality of life within a CCA allows for estimation of a CEA. If this is of interest to stakeholders, we will advise them of the necessary assumptions.

We will work with policymakers to gain an understanding of the costs associated with 20MNs. The Green Book (H.M. Treasury) provides guidance on the relevant consequences to be included in evaluations of government policies (88). These will include health and well-being, income (at both individual, household, and area- level), employment, economic productivity (i.e., Gross Value Added; or GVA), and use of health and care services. Stakeholders will also be consulted on other relevant consequences to be included. Income and employment (and other labour market outcomes (89)) are consequences that can be readily translated into monetary values using The Green Book methods (88). Heath and care utilisation can also be assigned a monetary value by applying NHS Reference Costs and the Personal Social Services Research Unit (PSSRU) unit costs (90). Health-related quality of life, mortality, and well-being are also outputs that can be monetarised if appropriate. These can include calculating healthy life expectancies, quality-adjusted life expectancy, and disability free life years (91).

To monetarise health-related quality of life outcomes we will use responses to the Short-form 12 (SF12) questionnaire available in Understanding Society data (see e.g. WP2) using the societal value of a quality-adjusted life year (QALY) approach. Specifically, we will map from SF-12 to SF-6D using published algorithms to generate QALYs (92). We will monetarise, where appropriate, other health outcomes and present them alongside the main QALY outcome. For example, Understanding Society also contains information on Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) and the Recovering Quality of Life (ReQoL-10; in certain waves) instruments which can be used to measure QALYs. Additionally, the life satisfaction measures enable the calculation of wellbeing years (WELLBYs) (92,93).

Depending on the manner in which 20MN investments are rolled out, we will also consider distributional CCAs to consider how costs and consequences vary by, e.g., levels of household income, education, ethnicity, region/location, and markers of disadvantage.

Outputs and deliverables:

1. Discrete WP outputs:

- We will produce an overall report of the EA for the WP1 stakeholder group. The report will include a detailed summary of the process of conducting the assessment and an appraisal of the evaluation options, ranked according to expected value of evidence in relation to cost.

2. Inputs to other WPs:

- Estimates of behavioural and health effects of 20MN investments to feed into WP3.

3. Publications:

- Paper on short-term health economic evaluation.
- Protocol(s) for longer-term evaluations.

Integrating simulation modelling and public health evaluation planning: combining methods to inform early and iterative policy development.

6 STUDY SETTING

As these are large-scale, population-level, place-based interventions being considered globally, we will make the population scope of each of our methods as generalisable as possible. Overall, we examine the national rollout of the 20MN policy in Scotland, primarily. However:

- Our review of the scientific literature will also draw on international best evidence (with nuances checked with stakeholders when non-UK evidence is used – see WP1).
- Since we have geographical and synthetic population data at the Great Britain (GB)-level, we will generate the linked data and examine clusters at this broader level (particularly since many devolved English local authorities are likewise considering implementation and would benefit from a baseline assessment – see WP2).
- Our evaluability work will similarly look broadly at where comparators can be found with necessary data (see WP4).
- The co-production through qualitative stakeholder workshops will be Scottish-based. These will be sought through our policy contacts (see WP1) and informed by our PPIE group. From these, we are looking for reflections and filling gaps in the generalisable 'human' mechanisms and the types of contextual factors (e.g., cultural and political context) that matter to inform our health inequalities evidence base, and which can potentially be modelled, rather than focusing on recording the specific contextual factors present within any single place.
- The dynamic modelling, due to computational limitations, will be based on a smaller geographical level. Initially, we will build the model using a single Scottish local authority. The assumptions built into the model will be based on the broader evidence-base above, with heterogeneity, e.g., different behaviours or estimated impacts across population subgroups, also built in based on this evidence-base. Once the model is developed, we will also ensure baseline geographical and synthetic population data for each of the other Scottish local authorities (and across GB) can be loaded to explore bespoke intervention plans (and code available for local customisation – see WP3).

7 ETHICAL AND REGULATORY CONSIDERATIONS

The only part of the study that involves primary data gathering is the qualitative stakeholder workshops in WP1. These workshops will cover non-personal and non-sensitive subjects, interested in recovering more general system rules and behavioural considerations for how/why people choose to use which services within neighbourhoods. The analysis will not focus on the comments attributed to any individual taking part, but rather the collective summary of their combined expertise and discussions. Participant information sheets will be co-produced with our PPI group and discussed with potential participants to ensure informed consent.

The use of secondary data can also have ethical considerations, of course. This is particularly true for simulation modelling, perhaps, where assumptions built into the models can influence the model outputs and the resulting key messages reported to policymakers and the wider public. We are particularly aware of this issue from the outset and, as outlined in the planned work, build in significant uncertainty analysis to help frame this messaging. We will also make our modelling assumptions clear, in Plain English, alongside any model outputs and, where possible, ensure these assumptions are

editable by other users for our open access code and model dashboard. We will also regularly reflect on this process with our Study Steering Committee, Stakeholder Advisory Group and PPI group, as well as within our formal ethics application.

7.1 Assessment and management of risk

Due to the nature of local roll-out of national policy, implementation is likely to be varied and somewhat unpredictable. However, we know money is being invested and change is beginning. Rather than implementation being too quick for the project, the large extent of change needed and high costs mean this change is more likely to be too slow, which might limit the ability of WP4 to evaluate full implementation within the length of the project (although, we can potentially exploit historical changes and partial implementations, e.g., addition of a specific service). Our methods allow us to easily track the changes that do occur over time with updating geographical data. We also draw on adaptable and future-oriented methods, allowing projections to inform plans or decisions between alternative policy implementations being debated.

20MN roll-out timing unpredictable (Likely, low-risk)

Due to the nature of local roll-out of national policy, implementation is likely to be varied and somewhat unpredictable. However, we know money is being invested and change is beginning. Rather than implementation being too quick for the project, the large extent of change needed and high costs mean this change is more likely to be too slow, which might limit the ability of WP4 to evaluate full implementation within the length of the project (although, we can potentially exploit historical changes and partial implementations, e.g., addition of a specific service). Our methods allow us to easily track the changes that do occur over time with updating geographical data. We also draw on adaptable and future-oriented methods, allowing projections to inform plans or decisions between alternative policy implementations being debated.

Important data missing or unavailable (Very likely, low-risk)

The intervention involves the complex interactions of individuals and services, and dynamic impacts on health inequalities. We know that the current scientific evidence base is lacking, particularly on the mechanisms side. It is very likely, therefore, that there will be some important behavioural rules, and potentially impacts of these, that are not easily estimable. However, our WP1 is designed to try and fill these gaps with stakeholder engagement, as a placeholder for better evidence, and to record the levels of uncertainty across what we are able to model. WP3 is able to incorporate what is available in data within a novel synthetic, linked dataset. WP4, to fill (or plan to fill, where not yet rolled out) the prioritised and feasible gaps in the evidence with new robust evidence. Modelling can also function to examine *proposed* mechanisms and examine the plausible impacts of these iteratively too.

Low stakeholder engagement (Unlikely, high-risk)

The research is outward-facing, co-produced and responsive to policymaker and other stakeholder needs. This makes the engagement key. We don't expect this to be an issue given the level of enthusiastic engagement we have had in bid preparation. For example, discussing the project with a

local MP, we were invited to put on an engagement event at Westminster, due to take place in early 2024. Neverthless, levels of stakeholder engagement will be continuously monitored via workshop and other meeting attendance. Alternative strategies for engagement will be discussed with our policy and public stakeholders, and, if necessary, alternative strategies devised.

Uncoordinated work packages (Unlikely, high-risk)

Our modelling work package relies on inputs from all other WPs. This requires continuous engagement and communication across researchers. Our WP0 approach to the research synthesis will mitigate this risk. We have a co-PI with lots of experience of co-ordinating large grants, and another co-PI with time costed to achieve this co-ordination in this grant on a day-to-day level, including coordination with PPIE, working closely with the public co-I.

Loss of staff (Unlikely, low-risk)

Our key staff members are employed either on baseline contracts, or co-funded by other projects that span this project's proposed timeline. We are all also based in larger teams with specialised skills in the methods we are using here.

7.2 Research Ethics Committee (REC) and other Regulatory review & reports

The University of Glasgow will be the study sponsor. We will seek ethical approval for the qualitative work from the MVLS Research Ethics Committee at the University of Glasgow, and also submit to this panel our data management plan. We will ask our public representatives (PPI group) to review all letters and information sheets used to recruit qualitative research participants to ensure they are clear and accessible.

7.3 Peer review

An outline and a full proposal for the study were reviewed by the NIHR Public Health Research Programme Funding Committee. Independent peer review was also sought to inform the Committee's decision.

This protocol will be reviewed by the research governance lead for the College of Medicine, Veterinary and Life Sciences at the University of Glasgow.

7.4 Patient & Public Involvement

The public perspective is key to the 20-minute neighbourhood, so we have chosen to closely involve a public co-I, Geoff Mohamed, as an embedded member of the research team. Geoff has a long-term involvement with PPIE through the University of Glasgow 'MVLS' and 'Primary Care' PPIE panels and has taken part in several PPIE workshops. He has an active caring role and is involved in promoting carers issues locally and nationally. Geoff will work closely alongside the co-PI and PPIE lead (Jonathan Stokes) to provide regular scrutiny and input to the entire research process. This will involve attendance of the monthly study management group, quarterly full team meetings, and PPIE group meetings (below).

Our specific focus, on health inequality impacts, means a diversity of people with lived experience of different places will be valuable for informing the work. Before project start-up, we will aim to recruit a further 3-4 PPIE members to a wider PPIE group. Geoff (supported by Stokes and Ibbotson) will chair this PPIE group to provide ongoing scrutiny and input to the project. The group will organise additional reflective sessions annually to take stock of the PPIE input and training to date, and to plan to address any issues. This PPIE group will also be invited to attend the bi-annual stakeholder advisory group meetings, alongside our policy partners. This group will monitor study progress, and aim to ensure maximisation of patient and public benefit and research impact.

The PPIE group will also contribute to every stage of the project through various activities, with initial examples described below (but also responsive to needs):

1. PPIE GROUP MEETINGS (monthly, face-to-face preferred but hybrid option): Initial PPIE group meetings to introduce the topic, discuss research aims and methods, identify any training needs, and gain preliminary PPIE input to the specific research plans. Later meetings through the project will reflect on initial findings and outputs from the research as they emerge and feed into next steps.

2. INFORMING RECRUITMENT OF WP1 COMMUNITY PANEL (this panel is separate from PPIE): Part of the research, in WP1, will involve a community panel to provide research data. This panel will inform how real people behave and make decisions about using services within their local place. We will draw on the experience of our PPIE members, and their knowledge of existing local community groups and best ways to reach them to help us recruit participants for this part of the research. We will also ask the PPIE members for their feedback on our workshop plans and the questions we plan to discuss.

3. DISSEMINATION OF IMPACTFUL RESEARCH MESSAGES: Many of the research methods we will use, such as the simulation models in WP3, are complex. We will draw on the expertise of our PPIE group to help us simplify our descriptions of what we are doing, and what our results show. Since we are using future-looking methods, we will particularly ask for advice on communicating uncertainty. We will look at possibilities to use visual explanations, and more accessible public-facing blogs and social media outputs, to accessibly communicate our evidence accurately.

To accomplish our PPIE plans, we have also costed an experienced PPIE co-I (Ibbotson, UoG MVLS PPIE panel lead) to work alongside Geoff and Jonathan. We will pay contributors at NIHR INVOLVE rates.

7.5 Protocol compliance

Compliance with the protocol will be monitored by the Study Steering Committee (SSC). Any revisions required to the protocol will be submitted to the SSC for approval, before being incorporated in a new version of the protocol that will be submitted to the funder.

7.6 Data protection and patient confidentiality

We will develop a data management plan according to MRC/CSO Social and Public Health Sciences Unit Standard Operating Procedures before primary data gathering or secondary data acquisition begins. WPs 2,3 and 4 utilise secondary data sources, and we will observe the data management rules of the primary data custodian. As above, WP1 will collect only deidentified data from workshops, with unattributed note-taking recording group discussions and outcomes of workshop activities. Co-PI Stokes will be the data custodian.

7.7 Indemnity

The study is sponsored by the University of Glasgow. The University holds insurance providing cover for the design and conduct of the research.

7.8 Access to the final study dataset

Work package leads will have full access to the datasets used in their respective work packages. Data will only be shared between work packages in a deidentified form, where licence arrangements allow, and where sharing is required to further the aims of the study (for example where data from work package 1 and 2 is needed as an input to the models used in work package 3).

8 DISSEMINIATION POLICY

8.1 Dissemination policy

We describe the project outputs within each work package section, above. There are several potential groups who could use and benefit from these outputs. Notably, the focus of the research on the Scottish national policy and rollout across all 32 local authorities in the country make the evidence directly relevant for national and local decision-makers. For example, a Senior Architect in the Scottish Government told us our project “seems very relevant to the policy agenda”. However, the UK Government’s expectations for Levelling Up via place-based interventions, and existing plans by, for instance, several English local authorities (13,14), means there will also be broader UK-wide local and national government interest. Other likely groups to benefit, include: (i) other public agencies (such as Public Health Scotland, who offer resource, data, and guidance on public health specifically, but also those more broadly focused on place and infrastructure, such as SURF, the Scottish Budget and Public Spending Directorate, and the UK National Infrastructure Commission); (ii) those writing community-led local place plans and working to develop proposals for their local areas from the bottom-up; (iii) other local members of the public (and local groups) campaigning for community redevelopment and eager to know how to bring about more equitable place change; (iv) international stakeholders, as these plans (and, unfortunately, growing health inequalities) are now global, with little evidence or implementation to date to learn from; (v) wider public health researchers and academics interested in place-based interventions and health inequalities, particularly as a key gap in the current evidence-base and with the addition of new models and data platforms for them to build on.

Our dissemination will utilise both: (i) our WP1 public and policy stakeholder groups; (ii) our broader project’s PPIE group and stakeholder advisory group. For (i), our later WP1 workshops will turn specifically towards dissemination, and iterative improvement of outputs and their communication, to maximise direct impact of the modelling on those more closely involved in the research project. For (ii), our stakeholder advisory group will be composed of 15-20 members, including our policy stakeholders (and their network members) who provided letters of support, public and community group representatives, as well as academics with relevant expertise. Both groups will provide opportunities for relevant beneficiaries to help shape the research as it progresses, provide links to their relevant broader dissemination networks, provide ongoing input opportunities to incorporate continuous developments in the policy, public, and research sectors, and help shape the dissemination outputs to specific audiences and maximise impact.

Our study management group will develop further formal dissemination plans to package and disseminate the specific outputs in relevant ways. This will include several formats to maximise reach

(and audiences), such as: (i) project reports, per work package; (ii) policy briefs, particularly scanning for ongoing evidence calls from government; (iii) bespoke presentations arranged via policy partners (and their practitioner/NGO events – we have budgeted for engagement events at Westminster and Holyrood); (iv) academic conferences and peer-reviewed publications; (v) press releases to accompany key findings and outputs; (vi) public facing blogs and social media posts; (vii) visualisations, maps, and play models to put across key concepts; (viii) a project website to bring the above together in a single point of contact. The research team have experience of creating this range of content and will concentrate on matching messaging to the optimum content type for the defined audience.

Since this project specifically utilises forward-looking methods, with plans to progressively output and refine evidence to align with the policy rollout timetable, we expect to be able to have a range of impacts. These impacts include: (i) informing local policy rollout in a timely way, as national visions gradually become concrete development and infrastructure plans; (ii) ability to allow more robust evaluation of what is ultimately rolled out for iterative improvement; (iii) ability for policymakers to anticipate potential unintended consequences, and to more quickly adapt rollout with earlier knowledge and engagement with the research process; (iv) more efficient use of invested public and private money, and ultimately benefits on health inequality outcomes; (v) the emergence of future research questions and projects which subsequently build on our findings and data and modelling outputs for the wider research community.

A final report of the study will be published in the NIHR's Journal Library, in line with NIHR's requirements for publication and notification: https://www.nihr.ac.uk/documents/nihr-research-outputs-and-publications-guidance/12250#Notifying_NIHR_of_upcoming_research_outputs.

8.2 Authorship eligibility guidelines and any intended use of professional writers

All researchers working on the study will be co-authors of the final report. Authorship of individual papers will depend on specific contributions. We will aim to pursue an inclusive authorship policy. When formulating a publication, we will flag to wider research team and give opportunity to contribute from as early as possible in the process. The final list of authors must, however, be able to define a *substantial* contribution to the manuscript and its underpinning research according to the CRediT taxonomy (https://www.elsevier.com/researcher/author/policies-and-guidelines/credit-author-statement). Joint first-authorship (e.g., lead of data analysis and lead of writing to maximise skillsets)/joint senior-authorship will be encouraged where it makes sense.

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10. APPENDICIES

10.1 Appendix 1- Study Steering Committee

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