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Decarbonising general practice: identifying system-level conditions for sustained change

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Title: Decarbonising general practice: identifying system-level conditions for sustained change

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ABSTRACT

BACKGROUND

Decarbonisation of healthcare is a strategic priority in the UK, yet little is known about the system-level mechanisms that enable sustainability initiatives to become embedded within non-hospital settings. This paper reports the integrative synthesis from the GPNET-0 study, explaining how decarbonisation actions are mobilised, sustained, or displaced in general practice.

METHODS

We conducted a theory-informed synthesis across qualitative, survey, and economic strands of a multi-level mixed-methods study. A structured analytic matrix was used to integrate 174 discrete findings. Realist logic guided development of explanatory configurations linking institutional conditions, organisational processes, and implementation outcomes. Configurations were refined into programme theory testable statements.

RESULTS

Across 17 explanatory configurations, decarbonisation was shaped less by individual attitudes than by interacting structural mechanisms. Three mechanisms consistently underpinned implementation: legitimacy (clear policy signals and leadership endorsement), system-level alignment (coherence between national, regional, and practice-level governance), and workability (integration under constrained capacity). Actions framed as discretionary, champion-led, or additive to existing workload were repeatedly displaced. By contrast, initiatives embedded within governance expectations and aligned with routine practice processes were more likely to be sustained and normalised.

CONCLUSION

Decarbonisation in general practice is not primarily a behavioural challenge, but a structural implementation problem. Sustained change depends on institutional embedding, governance, coherence, and operational feasibility within everyday practice environments. The programme theory presented here provides a system-level explanatory framework to inform future implementation strategies and empirical testing in general practice.

KEYWORDS: Implementation science; Decarbonisation; General Practice; Primary Care; Programme Theory; National Health Service.

BACKGROUND

Healthcare systems are increasingly recognised as both contributors and responders to the climate crisis. The World Health Organization has emphasised the need for health systems that are both climate-resilient and low carbon, highlighting the dual responsibility to respond to climate-related health risks while reducing the environmental impact of healthcare delivery.[1] These ambitions reflect a growing global expectation that healthcare systems mitigate their contribution to climate change while maintaining high-quality, equitable care. Globally, healthcare contributes approximately 4-5% of greenhouse gas emissions,[2] underscoring the scale of its environmental footprint and the urgency of system-level transformation. Within this context, national health systems are increasingly expected to translate high-level commitments into operational change across diverse care settings.

In the UK, the National Health Service (NHS) accounts for around 4–5% of national greenhouse gas emissions.[3] As the country's largest employer,[4] and one of the largest employers globally,[5] its scale inevitably contributes to this footprint. In 2020, the NHS committed to achieving directly controlled net zero emissions by 2040,[3] with meso-level health system structures (local/regional healthcare integration and commissioning bodies) required to develop Green Plans to support decarbonisation.[6]

General practice (family medicine delivered by a general practice model) is central to the NHS net-zero ambition and is similarly important in an international context. It contributes to the NHS carbon footprint through direct care delivery, supply chains, prescribing, and staff and patient travel.[7,8] Each of the 270 million consultations delivered annually in general practice generates 66 kg CO_2e (compared to 125 kg CO_2e per inpatient bed-day) (8). The UK's Royal College of General Practitioners (RCGP) and international college counterparts have identified climate action as a strategic priority, recognising that general practice teams are well positioned to act as role models, educators, and agents of system-wide change while continuing to deliver person-centred care.[9]

Trust in general practice remains high.[10] This positions general practice as an important setting for examining how sustainability initiatives are communicated, negotiated and implemented in routine care. While frameworks for climate-related communication exist,[11] these often do not account for the organisational and relational realities of general practice which operates as small, independently contracted organisations. This organisational autonomy may enable local innovation, but also contributes to variation in capacity, infrastructure, and leadership, shaping what is feasible. Although the sector has demonstrated an ability to adapt rapidly in response to crisis (e.g., COVID-19), such agility does not remove the structural constraints shaping everyday work.

A growing body of research identifies practical clinical and non-clinical actions to reduce emissions in general practice including energy and waste reduction, sustainable procurement, low-carbon prescribing (e.g., dry powder asthma inhalers[12]), alongside changes to clinical pathways such as: alternative screening approaches; climate-sensitive health counselling, and social and nature prescribing. Many of these actions align with broader healthcare quality strategies such as 'Choosing Wisely',[13] while others involve optimising care to reduce carbon intensity (e.g., improved diabetes control.[14] Policy initiatives to relocate care from secondary to primary care settings, for example, at the end of life,[15] may also influence the carbon profile of care pathways. Practical tools to support sustainability in general practice have emerged e.g.[16,17] but there remains limited evidence on the system-level conditions under which such initiatives become embedded, sustained, or displaced. NHS general practices operate under sustained workload pressure, limited funding, and frequent top-down reorganisation. Individual sustainability "champions"[18] have been proposed to achieve sustained system transformation, but sustained implementation is likely to also depend on the alignment of institutional mandates, organisational capacity, professional engagement, and patient and community participation.

The GPNET-0 Study (Box 1) is the first large-scale mixed-methods programme examining decarbonisation in English General Practice. The study was designed to understand how institutional, organisational, professional, and patient factors influence the implementation and sustainability of actions to reduce healthcare-related emissions. In contrast to previous research, which has largely focused on identifying discrete decarbonisation actions, the programme takes a system – level perspective on implementation. This paper presents a programme theory-led

integrative synthesis of findings from GPNET-0 to identify and explain the conditions that shape the implementation and sustainability of decarbonisation in general practice.

Box 1. Overview of the GPNET-0 Study

The GPNET-0 Study

The GPNET-0 Study is an NIHR-funded mixed-methods programme examining how decarbonisation can be implemented and sustained within English general practice, in the context of NHS net zero commitments.

Aim

To examine how institutional, organisational, professional, and patient factors influence the implementation and sustainability of actions to mitigate greenhouse gas emissions associated with general practice, and to generate actionable recommendations to support this transition.

Research Programme

The study generated multi-level evidence across multiple geographic areas, covering 473 general practices. Work included:

WP 1 - A systematic review of decarbonisation actions in general practice

WP 2 - A survey (additional file 1 of current activity and attitudes towards sustainability in general practice AND

Longitudinal case studies of 12 practices implementing decarbonisation actions over 12 months

WP 3 - Patient survey/interviews to understand views on sustainability actions in general practice

WP 4 – Economics analysis of costs of adopting carbon-reducing changes in general practices

WP 5 - Stakeholder interviews with policymakers, NHS commissioners and representatives from general practice and healthcare organisations and professional bodies.

WP 6 - Knowledge mobilisation workshops

See reference list in Additional file 1, WP = Work Package

METHODS

Study design

This study is a theory-informed synthesis of findings from the GPNET-0 Study (Box 1, Additional file 1). The analysis drew together findings from across the study (Additional file 1) to examine the factors shaping the implementation and sustainability of decarbonisation actions within general practice. As per our study protocol,[19] we used realist approaches to draw on our constantly updated programme theory[20] and thereby create explanatory programme theory configurations (EPTCs).

Data integration

The synthesis drew on qualitative, quantitative, and economic outputs, including data from general practice teams, patients, and system stakeholders (Box 1; Additional file 1). Data integration was initiated through a whole research team meeting, including patient and public contributors, at which high-level findings from across the work packages were presented to establish a shared understanding of the evidence base and inform the approach to synthesis. A discrete finding was defined as a single, conceptually distinct observation [a] about a factor influencing implementation (e.g., a barrier, enabler, or action), expressed at a level that enabled meaningful comparison across data sources.

Each finding was characterised according to:

- the level of the system at which it operated (institutional [b], organisational [c], professional [d], patient [e])
- its function (barriers [f], enablers [g], or actions [h])
- its alignment with Normalisation Process Theory (NPT) constructs and Theoretical Domains Framework (TDF) domains
- its evidentiary strength (high, medium, low [i]) and supporting data sources

Definitions for a-i can be found in Additional file 1

Findings were subsequently extracted from study outputs, including published and unpublished analyses, (by NK and quality checked by RS and FD) and reported within a structured data extraction table (Microsoft Excel). Qualitative work packages had been analysed using a shared coding framework informed by NPT and the TDF.

Where findings were not explicitly reported in published output, they were interpreted from original analyses to ensure consistency in the level and format of data included. This process resulted in 174 discrete findings. Integration and comparison of findings across data sources were undertaken iteratively, with regular discussions across the research team to review emerging interpretations and ensure consistency. An example is shown in Additional material files 2 and 3 for the specific topic “financial incentives”. Interpretive notes and traceable references were recorded alongside each entry.

Analysis and Interpretation

The analysis was informed by implementation theory.[19] NPT and TDF, applied in earlier strands of the GPNET-0 study, were retained as interpretive lenses to support understanding of implementation processes across the dataset. Context-mechanism-outcome (CMO) logic was applied as an analytic device to examine how contextual conditions shaped behavioural processes and implementation outcomes across system levels to create explanatory configurations.

Analysis proceeded iteratively using the structured integration matrix. Discrete findings were triangulated across sources to identify areas of convergence (consistent patterns across sources), divergence (conflicting or contradictory findings), and absence (where anticipated relationships were not supported by available data). Related findings were grouped into higher-order explanatory themes based on shared underlying mechanisms or system conditions (e.g., financial incentives). Grouping was informed by similarities in NPT constructs, TDF domains, and the function of findings (barriers, enablers, action), and was refined through iterative comparison within the matrix.

For each theme, EPTCs were developed to explain how specific contextual conditions triggered or inhibited mechanisms, resulting in implementation outcomes. EPTCs were constructed by:

- Identifying recurring patterns across grouped findings
- Specifying the contextual conditions under which these patterns occurred
- Articulating the underlying mechanisms (e.g., coherence, cognitive participation, resource constraints)

- Linking these to observed or inferred outcomes

Where findings spanned multiple system levels, interactions between levels were explicitly considered in constructing configurations. EPTCs were iteratively refined through comparison with the underlying data and through discussion with the wider research team to ensure plausibility, internal coherence, and alignment with findings across work packages. Refined EPTCs were then synthesised into higher-order programme theory testable propositions (PTTS), which describe the conditions under which decarbonisation efforts in general practice were mobilised, sustained, deprioritised, or displaced. All authors contributed to reviewing and refining the analytical outputs at key stages of the synthesis process.

RESULTS

Seventeen explanatory configurations were generated through iterative synthesis of 174 findings across the wider study strands (Table 1; Additional file 4). These configurations describe the conditions under which decarbonisation actions in general practice are mobilised, embedded within routine care, deprioritised, or sustained. Configurations span early mobilisation, routine integration, and longer-term sustainability phases. Several illustrate “decay” (the weakening or displacement of initially enabling mechanisms under competing organisational or institutional pressures).

TABLE 1 SHOULD APPEAR HERE

Mapping configurations against dominant actor level provided a descriptive overview of where responsibility for action most commonly resided (Table 2).

Table 2. Distribution of Explanatory Programme Theory Configurations (EPTCs) by Dominant Actor Level

Cluster theme	Dominant Actor Level	Contributing EPTCs
Patient-facing engagement and equity	Patient	9 – patient communication 13 – structural inequities
Practice-level leadership	Organisational (Practice)	3 – leadership mobilisation 4 – symbolic leadership
Team-based implementation	Organisational (Practice)	7 – embedded feedback cycles 10 - peer learning 14 – team reinforcement rituals 17 – emotional processing
Organisational workability	Organisational (Practice)	5 – "quick wins" 6 – workload pressure 12 – integration into routine 13 – structural inequities
Meso-level governance and coordination	Institutional (Local GP/NHS management)	2 – inconsistent local guidance 8 – monitoring as generative/extractive 10 – peer learning 16 – cross organisational alignment
National drivers and disruptors	Institutional (National)	1 – national policy coherence 11 – short-term incentives 15 – system shocks

Decarbonisation depended on whether actions were institutionally supported, coherently governed, and practically feasible within routine workflows. Across the 17 configurations, three interacting mechanisms consistently shaped implementation: (1) legitimacy (e.g., through regulation, contract or funding); (2) system-level alignment across national, meso, and general practice levels; and (3) practical workability within resource-constrained environments (feasibility). These mechanisms operate in combination across domains of implementation, rather than as discrete or bounded categories.

Legitimacy, mandate, and system-level alignment

Clear national policy direction (EPTC 1), consistent local guidance and governance alignment (EPTCs 2, 16), and active practice-level leadership (EPTC 3) reduced uncertainty and signalled that decarbonisation was legitimate core work. Where policy and leadership signals were absent or inconsistent, engagement was fragile. Short-term incentives could stimulate initial activity (EPTC 11) but did not secure durability in the absence of consistent policy direction and organisational embedding. Showing practices their personalised economic modelling evidence reinforced these dynamics by shaping perceptions of feasibility and organisational risk. In contrast, where leadership was symbolic or unsupported (EPTC 4), or policy signals were inconsistent, initiatives were vulnerable to drift.

Workability under constraint and the risk of displacement

Workability was a central determinant of whether decarbonisation actions persisted. Small, feasible, "quick wins" (EPTC 5) supported early progress and built confidence. Integration into everyday workflows (EPTC 12) facilitated normalisation, particularly when teams had space to reflect on uncertainty and workload implications (EPTC 17). However, where workload and staffing pressures were high (EPTC 6), sustainability actions that remained additive rather than integrated were readily deprioritised by competing immediate clinical demands. Even strong moral commitment could not compensate for limited operational capacity.

Monitoring, peer exchange, and reinforcement

Local governance structures shaped whether sustainability was reinforced or eroded. Monitoring operated in two distinct ways. Where measures were locally interpreted and aligned with clinical priorities (EPTC 7, 8), they supported reflection, reinforcement, and visible recognition (EPTC 14). Where monitoring was experienced as externally imposed compliance, it increased administrative burden and weakened engagement. Peer exchange through local networks (EPTC 10), particularly when supported by meso-level alignment (EPTC 16), facilitated diffusion of tested, low-friction interventions. Practices were more willing to adopt approaches demonstrated by peers than to implement generic directives that were not perceived as workable within their local context.

Patient-facing legitimacy and structural constraint

Patient engagement (though often scant) was shaped by visible action and credible communication (EPTC 9), alongside structural inequalities affecting access and participation (EPTC 13). Within this context sustainability initiatives were more readily accepted by all where they were framed as compatible with high-quality care. Conversely, where sustainability was perceived to compromise care quality or exacerbate inequity, general practice staff anticipated reputational/relational risk and patients were reluctant to engage. This reduced willingness to implement change, even when policy and leadership signals were supportive.

Shock, fragility, and resilience

'System shocks' such as leadership turnover, organisational restructuring, or funding withdrawal (EPTC 15) exposed the fragility of initiatives reliant on individual champions or temporary incentives. Where sustainability practices had been embedded into routine workflows and reinforced socially (EPTCs 14, 7, 8), they were more resilient to disruption. Where embedding was partial, initiatives decayed rapidly under pressure.

Programme theory testable statements

The 17 EPTCs were consolidated into eight programme theory testable statements (PTTS) (Box 2). Figure 1 illustrates the analytical process by which configurations were grouped and integrated to generate these higher-order explanatory propositions. Collectively, the PTTS articulate the system conditions under which decarbonisation in general practice is mobilised, sustained, deprioritised, or reinforced. Across propositions, three interacting mechanisms were recurrent: legitimacy, system-level alignment, and practical workability. Indicating that voluntary decarbonisation actions in general practice are structurally unstable unless embedded within governance, funding and workflow structures.

Figure 1 - EPTC 9 and 13 form a Programme Theory Testable Statement (PTTS) relating to patients

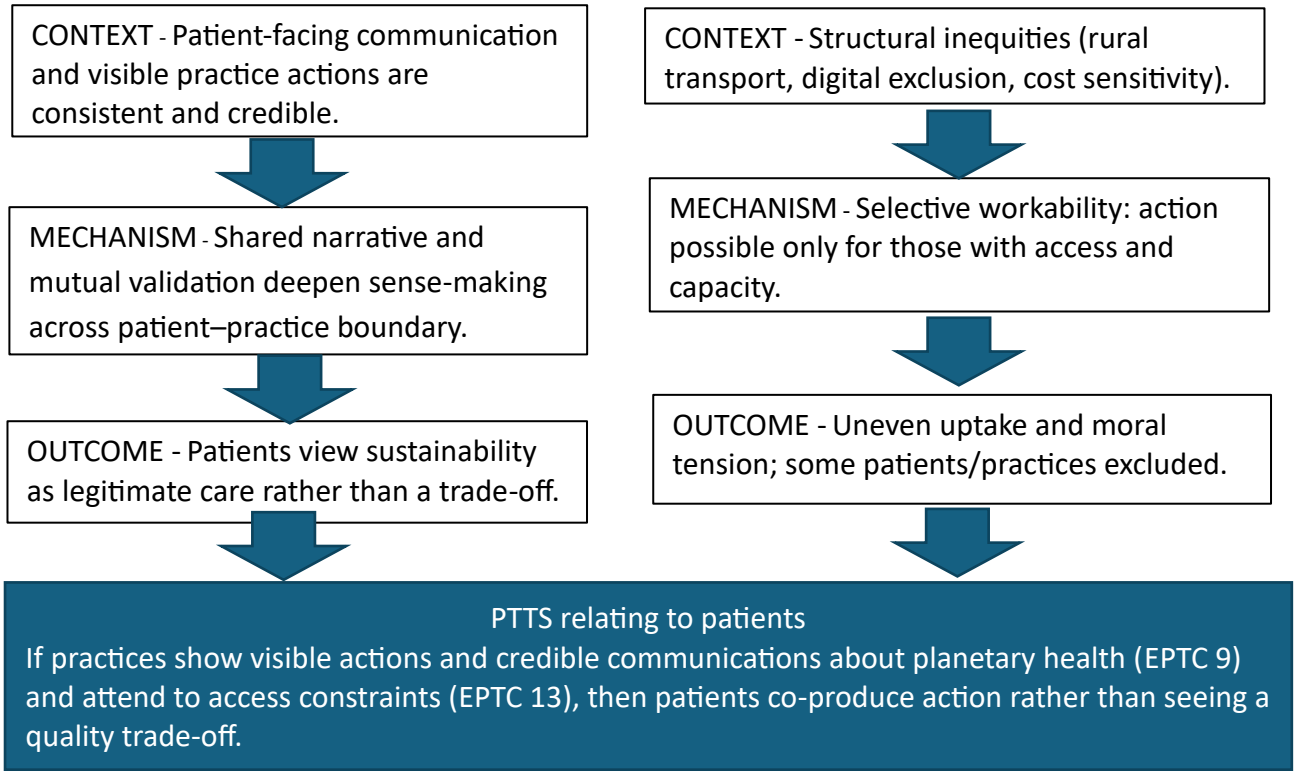


Figure 1 provides an illustrative patient-level configuration which forms a narrative glue for their engagement; equivalent configurations were developed across other actor levels but are not presented here.

Box 2. Programme Theory Testable Statements

1. **Clear national direction and aligned local leadership**
   If national policy is clear (EPTC 1), local guidance and meso-level governance structures are aligned (EPTCs 2, 16), and practice leaders actively support change (EPTC 3), then teams are more likely to prioritise decarbonisation because expectations are consistent and the work feels legitimate and supported.

2. **Making the link between good clinical care and sustainable care explicit**
   If decarbonisation is seen as part of delivering high-quality care and does not add unnecessary workload (EPTC 12), participation is more likely to continue because it makes practical as well as moral sense.

3. **Supporting teams**
   If teams have space to discuss concerns (EPTC 17) and can start with small achievable actions ("quick wins"; EPTC 5), early uncertainty is more likely to turn into confidence, reducing the risk of superficial or symbolic engagement (EPTCs 4, 6).

4. **Addressing workload and capacity**
   If workload and staffing pressures are not addressed (EPTC 6), decarbonisation efforts are likely to be deprioritised even when funding or policy support exists (EPTC 11), because immediate clinical demands take precedence.

5. **Learning rather than compliance**
   If sustainability measures are interpreted locally and linked to everyday clinical priorities (EPTCs 7, 8), monitoring supports learning and improvement; if they are imposed as compliance task, engagement weakens.

6. **Spreading through peer exchange**
   If practices can share experiences and practical examples through local networks (EPTCs 10, 16), adoption spreads because teams prefer approaches that reduce perceived risk and coordination burden.

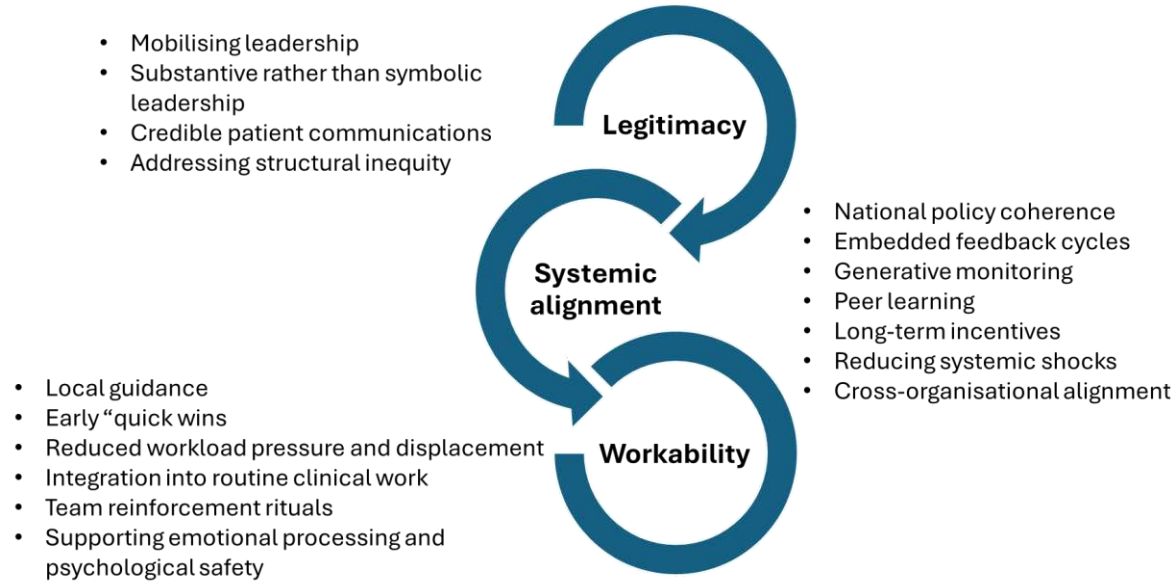
7. **Patient trust**
   If practices communicate clearly about sustainability actions (EPTC 9) and consider access barriers (EPTC 13), patients are more likely to support changes without feeling the quality of care is compromised.

8. **Building resilience to disruption**
   If sustainability practices are embedded into routine work and reinforced socially (EPTCs 14, 7, 8), they are more likely to withstand system shocks (EPTC 15).

DISCUSSION

This paper reports the integrative synthesis from the GPNET-0 Study's findings, providing a system-level explanation of how decarbonisation actions are enabled, constrained or displaced in general practice. We developed 17 explanatory programme theory configurations (EPTCs) to articulate recurring implementation patterns across system levels. All the EPTCs are shaped by three commonly occurring structural mechanisms: legitimacy, system-level alignment, and workability (figure 2). Where decarbonisation actions were treated as legitimate core work and integrated into routine workflows, implementation was more likely to be sustained and embedded. Where actions relied on voluntary effort, informal champions, or additional tasks that increased workload burden, they were vulnerable to displacement under competing clinical pressures. These conditions were shaped by wider system-level factors rather than individual practice choice alone. Overall, these findings indicate that decarbonisation in general practice is primarily a structural implementation challenge, depending on alignment between policy, organisational systems, and routine practice work. We discuss our findings working from the patient at the centre outwards to the national health agenda. Patient and community engagement emerged as a central theme for the GPNET-0 Study through our PPIE work and will be fully reported elsewhere.

Figure 2 – Diagrammatic representation of the three structural mechanisms and relationship to EPTCs



Relationship to existing literature

Consistent with prior research, awareness of decarbonisation in general practice was variable even among clinicians[21] and limited among non-clinical staff and patients.[22] While previous studies have emphasised patient-centred communication strategies that link climate change to individual health outcomes or prescribing decisions,[23] our findings suggest that patient-facing legitimacy operates differently in general practice. Patients prioritised reassurance that decarbonisation actions would not compromise quality of care and Health Care Professionals (HCPs) felt they needed to align with best practice initiatives when communicating the importance of decarbonisation.

At the organisational level, leadership has been widely recognised as a facilitator of change in healthcare. However, consistent with other NHS change initiatives,[24] our findings indicate that designating a sustainability or "climate" lead is insufficient without authority, time, and integration into organisational processes. While practices with identified sustainability leads reported higher levels of activity, these roles were frequently informal and voluntary, as found in other paradigms.[25] This aligns with critiques of professional declarations that emphasise individual responsibility without addressing necessary organisational infrastructure.[26] Our findings also reinforce established organisational science principles regarding team-based implementation and the value of early "quick wins" in embedding change.[27] However, we extend this literature by demonstrating how resource scarcity and structural inequalities constrain organisational capacity. Practices are not equally positioned to implement decarbonisation actions, and deprivation-related factors may influence feasibility. Existing NHS general practice remuneration mechanisms attempt to account for contextual variation, suggesting potential parallels for decarbonisation policy design.

At meso-level governance (e.g., regional and system-level organisations), local guidance, compliance monitoring, and peer learning networks were central to translation of national ambition into practice-level action. Similar governance dynamics have been observed in other system reforms, including workforce and demand management.[28] However, the creation and mobilisation of sustainability knowledge at meso-level remains under-

explored in the literature. Competing priority pressures[29] may limit the capacity of these structures to support de novo decarbonisation initiatives unless they are institutionally mandated.

National policy support, finance incentives, and legislative change have been shown to accelerate uptake of targeted initiatives, such as environmentally focused prescribing. Our findings reinforce this by demonstrating that policy coherence and alignment across levels influence implementation trajectories. However, incentives alone did not secure durability without integration into routine work. This echoes broader evidence that externally driven initiatives require structural embedding to achieve sustained change[30] and suggests that decarbonisation efforts in health systems more widely depend on alignment between policy, organisational systems, and everyday clinical practice.

Strengths and Limitations

A key strength of this multi-method longitudinal study is the breadth of evidence integrated across qualitative, survey, and economic strands, enabling a multi-level understanding of implementation dynamics and readiness for knowledge implementation. Engagement of stakeholders from devolved UK nations and inclusion of academic GPs and patient representatives enhanced the relevance and credibility of the findings. Extensive patient and public involvement strengthened the relevance and interpretive validity of findings. The use of structured matrices to develop and refine EPTCs enabled traceability from source to explanatory propositions. Incorporating NPT, TDF and CMO logic provided conceptual coherence and supported the development of transferable explanatory propositions.

This synthesis depended on the quality and completeness of findings generated in earlier study strands, which varied across work packages, data generation was more challenging by some methods and with some participant groups. We acknowledge that volunteer case study practices may have been more engaged than the average general practice, but this is common to most ethnographic research. As with all theory informed synthesis, the resulting programme theory reflects interpretive judgement, although this was mitigated through traceability, documentation of analytic decisions, and examination of convergence across data sources.

Implications and future research

The findings highlight that decarbonisation in general practice requires structural rather than solely behavioural solutions. Policy design should prioritise clear national direction, aligned meso-level governance, and integration into routine practice workflows. Without these conditions, sustainability actions remain discretionary and vulnerable to displacement.

For national bodies, this means embedding decarbonisation within regulatory frameworks, contractual expectations, and long-term funding mechanisms. For meso-level organisations, it requires consistent guidance, supportive monitoring, and facilitation of peer learning networks that reduce coordination burden. For general practices, the priority is to integrate sustainability into existing processes, create space for team reflection, and ensure visible communication with patients that reinforces trust and avoids exacerbating inequities.

The programme theory developed here offers a system-level framework that can inform future implementation strategies, guide the design of supportive governance structures, and shape empirical testing of decarbonisation interventions in primary care and comparable health systems internationally. Future research should test the programme theory propositions developed here, examine comparative implementation across different health systems, and evaluate incentive and governance models that support sustainable integration.

CONCLUSION

This synthesis identifies that decarbonisation in general practice is shaped by structural conditions rather than individual motivation. Sustained change depends on legitimacy, system-level alignment, and workability within routine practice. When these conditions are present, decarbonisation can be embedded and normalised; when absent, initiatives remain fragile and prone to displacement. The programme theory provides a system-level explanation of these dynamics and offers a foundation for designing, implementing, and evaluating future sustainability strategies in general practice.

395 **Table 1**. **Explanatory Programme Theory Configurations (EPTCs)**

EPTC	Configuration
EPTC 1 – National policy coherence	(C) National frameworks, policies, and incentive structures establish GP decarbonisation as a priority. (M) clear and consistent policy signals align professional identity and clarify expectations across system levels. (O) GP decarbonisation is perceived as legitimate core work rather than discretionary activity.
EPTC 2 – Inconsistent local guidance	(C) Guidance and expectations vary across meso-level* healthcare organisations or are poorly coordinated. (M) GP teams must locally interpret fragmented signals, diverting efforts into sense-making rather than action. (O) Participation stalls and implementation is delayed.
EPTC 3 – Leadership mobilisation	(C) General practices have visible, values-based leadership and named sustainability/decarbonisation roles. (M) GP Leaders legitimise the work and actively enrol team members. (O) GP decarbonisation becomes a socially endorsed team norm.
EPTC 4 – Symbolic leadership	(C) GP leadership is nominal, unsupported, or lacks time and authority. (M) Activation is fragile; legitimacy is asserted but not operationalised. (O) GP decarbonisation remains peripheral or tokenistic, and vulnerable to decay.
EPTC 5 – Early “quick wins”	(C) General practices implement small, visible decarbonisation actions. (M) Achievable tasks demonstrate feasibility and reinforce belief in progress. (O) Momentum builds and practical routines begin to stabilise.
EPTC 6 – Workload pressure and displacement	(C) General practices operate within overloaded systems with competing clinical demands and limited resources. (M) Decarbonisation tasks are displaced when acute priorities dominate workflow. (O) Decarbonisation activity is deferred or deprioritised despite professional commitment.

EPTC 7 – Embedded feedback cycles	(C) GP teams incorporate decarbonisation into routine meetings or audits. (M) Regular reflection supports collective learning and adjustments. (O) Decarbonisation practices become self-correcting and more durable.
EPTC 8 – Monitoring as generative or extractive	(C) Decarbonisation metrics are introduced at general practice and meso-levels. (M) When locally interpreted, monitoring supports meaningful learning; when externally imposed, it increases compliance burden. (O) GP engagement is sustained under local ownership but weakens under extractive oversight.
EPTC 9 – Credible patient communication	(C) General practices communicate clearly about decarbonisation actions and make changes visible. (M) Shared understanding develops across the patient-practice relationship. (O) Patients perceive decarbonisation as compatible with good care rather than a trade-off.
EPTC 10 – Peer learning	(C) General practices share experience and practical examples through local networks. (M) Peer exchange reduces perceived risk and coordination burden. (O) Workable interventions spread more rapidly across practices.
EPTC 11 – Short-term incentives	(C) Time-limited GP funding or incentives stimulate activity. (M) External reinforcement triggers activation without long-term embedding. (O) Early uptake is followed by drift when incentives end.
EPTC 12 – Integration into routine clinical work	(C) GP decarbonisation principles are incorporated into everyday clinical practice. (M) Moral framing combined with visible efficiency gains reinforces participation. (O) Decarbonisation becomes normalised as both ethical and practical clinical work.
EPTC 13 – Structural inequity	(C) Structural barriers such as transport, digital exclusion, or cost sensitivity affect patients. (M) GP decarbonisation actions are selectively workable depending on patient access and capacity. (O) Uptake is uneven, generating moral tension and differential benefit.

EPTC 14 – Team reinforcement rituals	(C) General Practices maintain visibility of decarbonisation through brief updates, recognition, or micro-audits. (M) Ongoing communal appraisal reinforces collective efficacy. (O) Sustainability routines become durable and self-reinforcing.
EPTC 15 – System shocks	(C) Leadership turnover, structural change, or funding withdrawal disrupt existing arrangements. (M) Loss of ownership and feedback capacity destabilise prior gains. (O) GP decarbonisation efforts unravel and slip down the agenda.
EPTC 16 – Cross-organisational alignment	(C) General practices, and meso-level organisations collaborate within shared governance and aligned incentives. (M) Relational trust and compatible systems enable coordination action (O) Decarbonisation activity diffuses and scales across organisational boundaries.
EPTC 17 – Emotional processing and psychological safety	(C) GP teams experience uncertainty or emotional burden related to sustainability work but have space for collective reflection. (M) Shared processing transforms anxiety into empowerment. (O) Engagement is sustained and confidence strengthened.

EPTCS all relate to the general practice setting. Throughout, the abbreviation GP is used for this setting (General Practice) to enhance readability by keeping statements short. CMO concepts are used from Context, Mechanism, Outcome Configuration theory (Pawson and Tilley 2013)

List of Abbreviations

CMO - Context-mechanism-outcome

EPTCs - Explanatory Programme Theory Configurations

NHS – National Health Service

NPT - Normalisation Process Theory

GP – General Practitioner (in table 1 we use GP for the setting of General Practice)

HCP – Health Care Professional

PTTS - programme theory testable propositions

RCGP - Royal College of General Practitioners

TDF - Theoretical Domains Framework

List of Additional Files

Additional File 1 - Wider GPNet0 project bibliography to date and study definitions AND Definitions of terms used in the methods section **Word file**

Additional File 2 - Meta-framework with examples of raw evidence from each of the study work-packages on the topic of financial incentives **Word file**

Additional File 3 –Triangulation of data relating to financial incentives according to NPT domain **Word file**

Additional File 4 - Explanatory Programme Theory Configurations (EPTCs) **Word file**

DECLARATIONS

Ethical approval

The study received ethical approval from the Health Research Authority and Health and Care Research Wales (IRAS ID 327991; REC reference 23/PR/1169). Informed consent was obtained from all study participants. NHS ethics operates in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials: Selected de-identified data are available on reasonable request from the corresponding author. Due to the multiple data flows across this complex study, it is not possible to make all data available especially where publications on other aspects of the study are pending.

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions: Lead author (corresponding) – Rachel Ann Spencer contributed to all stages of the study from design onwards (including co-leading WP6 on whole study synthesis) and is the original drafter of this paper.

Naomi Klepacz was senior research fellow for the GPNET-0 study, led the meta-synthesis and was second author of the content of this manuscript.

Frederik Dahlmann helped conceptualise the GPNET-0 study and was co-lead of WP6 of the GPNET-0 study and produced diagrams for/commented on this manuscript.

Olivia Geddes, Sophie Dahlmann and Nicky Thomas, were core research staff for the GPNET-0 study. They extracted the data at source, were involved in the synthesis and commented on this manuscript.

Patsy Barker was a medical student seconded to the GPNet-0 team and commented on this manuscript.

Helen Twohig and Helen Atherton conceptualised and led other work-packages of the GPNET-0 study. They were involved in the synthesis and commented on this manuscript.

Raquel Nunes and Jeremy Dale were study leads for the GPNET-0 study. They were involved in the synthesis and commented on this manuscript.

All authors confirm that they had full access to all the data in the study and accept responsibility to submit for publication. All authors read and approved the final manuscript.

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