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Implementation of decarbonisation actions in general practice – a systematic review and narrative synthesis

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Implementation of decarbonisation actions in general practice – a systematic review and narrative synthesis

ABSTRACT

Objectives: To summarise existing literature on the implementation of decarbonisation actions in general practice, to outline the actions being implemented, factors influencing decarbonisation, identify evidence gaps and questions for future research.

Design: A systematic review and narrative synthesis.

Data sources: MEDLINE, Embase, CINAHL, Web of Science, and ProQuest (grey literature) were searched for literature published up to 29th March 2024.

Eligibility criteria for selecting studies: Studies of any design investigating the implementation of decarbonisation actions in general practice.

Data extraction and synthesis: Two reviewers extracted data and conducted quality assessments using a mixed methods appraisal tool. Narrative synthesis was used to analyse findings.

Results: Fifteen studies were included. Studies were primarily from the UK (n=5), followed by Australia (n=3), USA (n=2), Germany (n=2), and one each from France, Switzerland, and Israel. Study designs were qualitative (n=7), quantitative (n=7), and one mixed methods. Participants included healthcare staff (n=7), patients (n=5), health stakeholders (n=2), and the general public (n=1). General practices are adopting decarbonisation actions such as resource reuse, improved waste management, energy-efficient systems, and preventive care to reduce overmedication, with strong leadership and institutional support being crucial for their success. Barriers such as high costs, resource constraints, and limited awareness among clinicians and patients highlight the need for enhanced communication, education, and a structured promotion of initiatives such as Green Social Prescribing (GSP) to improve patient and community engagement.

Conclusions: There is limited evidence on the implementation of decarbonisation actions in general practice. A range of factors appear to impact on the extent to which implementation occurs, and addressing these will be crucial for effectively promoting and scaling decarbonisation actions in general practice. Future research should focus on understanding the role of institutional context, evaluating the real-world impact of interventions on greenhouse gas emissions, and exploring patient and community involvement.

Strengths and limitations of this study

- This review underscores the urgent need for integrating decarbonisation actions into general practice and represents the first systematic review on this topic.
- It provides a comprehensive and up-to-date analysis of the implementation of decarbonisation actions in general practice, drawing from a diverse range of international literature.
- The focus on studies from 2007 onwards ensures relevance, coinciding with the start of negotiations for a successor to the Kyoto Protocol.
- A limitation is the restriction to studies published in English, which may affect the generalisability of the findings.

- The exclusion of non-English studies could result in missing valuable evidence from research published in other languages.

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Keywords: climate change; sustainable healthcare; net zero; decarbonisation; general practice; family practice

BACKGROUND

"Tackling climate change could be the greatest global health opportunity of the 21st century." [1] Through comprehensive mitigation efforts aimed at reducing greenhouse gas (GHG) emissions, coupled with robust adaptation strategies to address the unavoidable impacts of climate change, there is the potential to transform healthcare systems and improve health outcomes worldwide [2-7]. Mitigation efforts, such as promoting decarbonisation actions, reducing carbon emissions, and adopting low carbon technologies, may also improve air quality, reduce the burden of chronic diseases, and enhance overall wellbeing [8]. Furthermore, adaptation measures, including strengthening healthcare infrastructure, enhancing disaster preparedness, and implementing resilience-building initiatives, can help healthcare systems better cope with the changing climate and mitigate the health risks associated with extreme weather events, infectious diseases, climate anxiety, and other climate-related challenges [9-11]. By embracing both mitigation and adaptation strategies within the healthcare sector, there is an opportunity to protect health, build resilient communities, and create a sustainable future [12,13].

As the initial point of contact in healthcare, primary care should take a leading role in tackling these challenges [14]. The healthcare sector is responsible for around 4-5% of the total GHG emissions in the UK, with primary care being responsible for around 23% through direct care delivery, staff and patient travel, and other related services [15-18]. Addressing the environmental impact of primary care is crucial for overall sustainability efforts within the healthcare sector, as highlighted by the 2020 National Health Service (NHS) report on delivering net zero [17]. Achieving net zero will require comprehensive leadership and behaviour change at all levels of healthcare [1,3,6,19]. Despite its importance, the British Medical Association has observed that primary care lacks detailed guidance on its role in achieving net zero carbon emissions within healthcare [20]. The distributed organisational structure of primary care also presents a significant challenge to implementing changes [21].

Through targeted interventions and the adoption of decarbonisation actions, primary care can not only reduce its carbon footprint but also improve patient outcomes, foster community resilience and inspire other healthcare sectors to follow suit [5,22,23]. In the UK, as the foundation of primary care and gateway to other healthcare services in the NHS, the role of general practice is therefore significant [24].

Scoping searches found no prior systematic reviews examining the implementation of decarbonisation actions in general practice. The aim of this study is to address this gap in knowledge by exploring the existing body of empirical research on the implementation of decarbonisation actions in general practice. The objective is to summarise existing literature on the implementation of decarbonisation actions in general practice, to outline the actions

being implemented, factors influencing decarbonisation, identify evidence gaps and questions for future research. This review aims to provide valuable insight to those commissioning and delivering GP services, by examining which factors influence the implementation of decarbonisations actions in general practice and to examine why this happens.

METHOD

This systematic review was conducted following a predefined protocol [25]. It uses a mixed-methods design and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework [26].

Patient and public involvement

Patient and public representatives were integral to the review. They were involved in the design, development and conduct of this review. A patient and public representative provided feedback on drafts and is a co-author.

Eligibility criteria

The inclusion criteria for the review were: any study design; studies that investigated the implementation of decarbonisation actions in general practice (or equivalent in non-UK studies); studies published in English from 2007 onwards. Studies were excluded if they were published as a poster, letter, conference abstract, and if based in community pharmacy, walk-in centres, dental, and optometry (eye health) services (or equivalent in non-UK studies).

Search strategy

Databases were searched from January 2007 to March 2024 and included MEDLINE, Embase, Web of Science, and CINAHL. Searches for grey literature were also conducted in ProQuest. The selected date coincides with the UN climate change conference where negotiations on a successor to the Kyoto Protocol began. Search strategies can be found in Supplementary Table 1. Forwards and backwards citation searches were undertaken on all included articles.

Study selection and data extraction

After duplicates were removed, two reviewers screened studies independently at title and abstract stage and at full text stage using Rayyan (systematic review management software) [27].

A data extraction form was developed where key elements of studies were captured independently by the two reviewers, and any discrepancies were resolved through discussion with a third reviewer.

Outcomes

The outcomes of interest were decarbonisation actions, and factors (institutional, organisational, professional and patient related) influencing the adoption, implementation and integration of decarbonisation actions.

Quality assessment

The Mixed Methods Appraisal Tool (MMAT), designed for reviews where study designs are mixed and individual studies use mixed methods, was used to assess the quality of included studies [28]. Two reviewers independently assessed the quality of the studies, and

discrepancies were addressed through discussion. Studies were categorised as high, medium or low quality, depending on how many MMAT criteria were met. An overall quality rating was determined for contextual information only and studies were not excluded on this basis.

Data synthesis

A narrative synthesis approach was used due to the diversity of designs of included studies, allowing for systematic analysis of studies with different designs by considering their similarities and differences [29]. An iterative approach was applied, initially describing the characteristics and key findings of included studies, which were then organised to identify patterns. Patterns were explored within and between studies.

RESULTS

The search strategy identified 188 peer-reviewed and grey literature studies, after duplicates were removed there were 168 studies to screen at title and abstract level; 48 studies were included for full-text screening, out of which 15 studies were included in this review [30-44]. There were no eligible articles identified from the grey literature database search. The screening process, numbers and reason for exclusions can be found in the PRISMA flowchart [26] (Supplementary Figure 1). The main characteristics of included studies can be found in Table 1.

Studies were from the UK (n=5) [33,39,40,42,44], Australia (n=3) [31,36,41], USA (n=2) [32,38], Germany (n=2) [34,35], France (n=1) [30], Switzerland (n=1) [37], and Israel (n=1) [43]. Most were either of qualitative (n=7) [30,31,34-36,43,44] or quantitative design (n=7) [32.37-42], with one mixed methods included (n=1) [33]. Cross-sectional surveys (n=7) [32,34,37,38,41-43] and semi-structured qualitative interviews (n=6) [30,31,34-36,44] were the most prominent methods used. Fewer studies used focus groups (n=3) [33,35,44], observations (n=2) [31,44], retrospective observational study (n=1) [39], and carbon footprint analysis and clinical outcomes analysis (n=1) [40]. Studies collected data from a range of participants, including staff (n=7): general practitioners (GPs) (n=3) [30,37,42], other healthcare staff (n=3) [31,35,42], and GP registrars (n=1) [41]; patients (n=5) [33,34,38,40,43], and health stakeholders (n=2) [36,44], the general public and stakeholders (n=1) [44].

Quality assessment

According to the MMAT guide[28], ten studies were rated high quality (green) [30,31,33-36,39-41,44], four were rated as moderate quality (orange) [32,37,38,42] and one was rated low quality (red) [43]. Quality assessment ratings for each study can be found in Supplementary Table 2.

Type of decarbonisation actions

There is evidence of general practices integrating decarbonisation actions into their operations to reduce carbon emissions and promote environmental sustainability. These initiatives include reorganising practices to allow reuse of resources, improving waste management through selective sorting, revising medical prescriptions to prevent overmedication and focus on preventive care [30], thus reducing healthcare costs and associated pollution. Other initiatives focus on prioritising energy conservation by adopting energy-efficient systems such as LED lighting and efficient heating [30]. Leadership support for environmental sustainability proves pivotal, as demonstrated in Australian practices where management buy-in significantly influences the success of these initiatives [31]. Strategies to minimise patient travel emissions include promoting public transport, walking, or carpooling,

complemented by administrative adjustments to optimise appointment scheduling and prescription collection [33]. Additionally, there is evidence of practices in Germany adopting climate-sensitive health counselling to educate patients about climate change impacts and encourage eco-friendly behaviours [35]. Meanwhile, the implementation of nature prescriptions in Australia involves prescribing outdoor activities to improve patient health while reducing environmental impact, highlighting the importance of community collaboration and robust clinical processes in achieving sustainable healthcare outcomes [36].

Table 1. Characteristics of included studies (Note: the setting of the studies is general practice or its equivalent in non-UK studies).

First author, year	Country	Setting and participants	Study design
Legrand, 2023 [30]	France	12 general practices, n=12 GPs	Qualitative design using face to face or phone semi-structured interviews.
Pavli, 2023 [31]	Australia	3 general practices, n=23 staff (nurses, administrative staff, and doctors)	Qualitative design, case study using semi-structured interviews and observations relating to environmental sustainability.
Muller, 2023 [32]	USA	Various primary care practices/clinics, n=103 primary care clinicians (including resident and attending physicians, clinical psychologists, nurse practitioners, and physicians' assistants)	Quantitative design using cross-sectional questionnaire survey.
Andrews, 2013 [33]	UK	1 general practice, n=306 patients (survey); n=12 NHS clinical staff (focus group 1); n=13 NHS non-clinical staff (focus group 2)	Mixed methods design, case study, using survey and two focus groups. The focus groups followed a semi-structured topic guide. Carbon footprint was estimated using the ArcInfo GIS software package.
Griesel, 2023 [34]	Germany	6 primary care practices, n=27 patients	Qualitative design using semi-structured interviews and cross-sectional survey.
Fehrer, 2023 [35]	Germany	Various primary care practices, n=40 physicians, medical assistants, health scientists and experts on the healthcare system	Qualitative exploratory design using semi-structured guide-based interviews and focus groups.
Foley, 2023 [36]	Australia	Nature-based prescribers and providers, n=13 health stakeholders (health service providers and managers)	Qualitative descriptive design using semi-structured interviews.
Andre, 2022 [37]	Switzerland	Various general practices, n=497 GPs	Quantitative design using cross-sectional survey.
Boland and Temte, 2019 [38]	USA	4 family medicine and community health clinics, n=403 patients; n=58 family physicians	Quantitative design using cross-sectional survey.
Maughan, 2016 [39]	UK	Social prescribing intervention 'The Connect project', n=30 Connect project group; n=29 (control group)	Quantitative design using retrospective observational data.
Woodcock, 2021 [40]	UK	Salford Lung Study in Asthma, n=2236 subset of study participants	Quantitative design using carbon footprint analysis and clinical outcomes analysis.
Wild, 2023 [41]	Australia	3 Australian Regional Training Organisations, n=879 GP registrars	Quantitative design using cross-sectional questionnaire.
Robinson, 2020 [42]	UK	Social prescribing intervention 'The Connect project', n=114 GPs; n=170 nature-based organisation participants	Quantitative design using online cross-sectional questionnaire.
Guggenheim, 2016 [43]	Israel	1 general practice, n=107 patients	Quantitative using questionnaire.
Sun, 2023 [44]	UK	1 region of the UK, n=34 stakeholders, n=64 members of the public	Qualitatively design using observations and shadowing, workshops and semi-structured interviews.

Integrating decarbonisation actions into general practice settings has been found to be both feasible and potentially beneficial. One study [39] demonstrated that social prescribing can reduce healthcare use, including secondary-care referrals, thereby lowering the carbon footprint. Another study [40] found that switching asthma patients from pressurised metered-dose inhalers (pMDIs) to dry powder inhalers (DPIs) significantly reduced the carbon footprint without compromising asthma control, suggesting that environmentally friendly options can be effectively incorporated into patient care.

Institutional and policy support

Institutional factors emerge as playing a crucial role in shaping decarbonisation efforts in general practice. Financial incentives and supportive policies are essential for the adoption of decarbonisation actions [35,36]. However, barriers such as the lack of clear guidance in some regions hinder widespread implementation. Guidelines such as the WONCA declaration provide frameworks that may motivate GPs to integrate climate change considerations into their practices [35,36]. Effective decarbonisation also requires system-level changes, including better networking and centralisation of sustainability efforts [31,35]. For a summary, see Table 2.

Organisational leadership, support and constraints

Strong leadership and a supportive workplace culture that values sustainability are critical for successful decarbonisation [31,41]. Practices with proactive leadership and a culture prioritising environmental responsibility tend to achieve higher engagement and successful implementation of green practices. Effective practice management, including supportive leadership and staff engagement, are essential for integrating decarbonisation actions into general practice activities [31,35,41]. However, high costs and resource constraints limit the ability of practices to adopt sustainable measures; financial support and cost-effective solutions are necessary to overcome these barriers [31,42].

One study [37] found that Swiss GPs believe they can serve as role models for sustainability and advocate for stronger outreach from medical associations on climate change and health. For a summary, see Table 2.

Professional knowledge, awareness and engagement

Knowledge and awareness of climate change and its health impacts among general practice clinicians are crucial for promoting decarbonisation actions. Many clinicians acknowledge the existence and threat of climate change but lack specific knowledge and feel uncomfortable discussing it with patients. Enhancing clinician competence through education and training on decarbonisation is essential [32,41, 35]. Moreover, GPs who are environmentally conscious in their personal lives are more likely to advocate for and adopt decarbonisation actions professionally. GPs perceive themselves as influential in promoting sustainability to both patients and colleagues [32,41].

Awareness and engagement among general practice professionals vary significantly. While most may be aware of the general impacts of climate change on health, their knowledge on specific topics such as planetary health is limited [37]. Despite high willingness to learn more, only 17% of US physicians feel comfortable counselling patients on climate-related health issues [38].

Preferences and acceptance of such measures among general practice professionals vary. One study [41] reported that most GP registrars support leadership roles in environmental sustainability within their practices. Another study [42] emphasised that effective green prescribing depends on the availability of services and green spaces, with GPs in less deprived areas more likely to prescribe nature-based interventions. However, significant constraints exist, including limited awareness, funding, and patient motivation, which can hinder the widespread adoption of green prescribing [42]. For a summary, see Table 2.

Patient and community engagement

Patient and community engagement are pivotal in promoting decarbonisation actions within general practice. One study [37] reported that 78% of GPs in Switzerland discuss climate change with patients, with 44% doing so in over 10% of their consultations. However, many GPs feel uncomfortable advising on this topic due to barriers such as time constraints and lack of clinical recommendations. Another study [38] reported that 44% of patients in the USA believe climate change affects their community's health, but only 6% consider their physician a top source of environmental information, indicating underutilisation of physicians as sources of information despite high patient trust [37,34].

Another study [44] revealed that while local communities engage in nature-based activities, awareness of Green Social Prescribing (GSP) is limited, with most participants learning about activities through informal channels such as social media rather than formal referrals.

Patients, while concerned about environmental issues, often rely on non-medical sources for information. Two studies [38,37] indicated that patients' primary sources of environmental information include news outlets, social media, and family and friends, highlighting a gap between patient concern and the information provided by general practice professionals. For a summary, see Table 2.

Table 2. Factors influencing the adoption, implementation and integration of decarbonisation actions.

Factors	Description
1. Institutional and policy support	
1.1. Financial incentives and policies	Financial incentives are essential for the adoption of decarbonisation actions, but inconsistent policy guidance in some regions acts as a barrier [35,36].
1.2. Frameworks and declarations	Guidelines such as the WONCA declaration motivate GPs to integrate climate change considerations into their practices by providing structured guidelines and strategic vision [35,36].
1.3. System-level changes	Effective decarbonisation requires better networking and centralisation of sustainability efforts to ensure coherence and efficiency across the healthcare system [31,35].
2. Organisational leadership, support, and constraints	
2.1. Leadership and culture	Proactive leadership and a culture that values sustainability are critical for driving successful decarbonisation efforts within general practices [31,41].
2.2. Practice management	Effective leadership and staff engagement are essential for integrating decarbonisation actions into daily practice activities [31,41].
2.3. Resource constraints	High costs and resource limitations hinder the adoption of sustainable measures, requiring financial support and cost-effective solutions [31,35].
3. Professional knowledge, awareness, and engagement	
3.1. Knowledge and awareness	Clinician awareness of climate change impacts is crucial, but many lack specific knowledge and feel uncomfortable discussing it with patients [32,37,38].
3.2. Education and training	Enhancing clinician competence through targeted education and training on decarbonisation is needed [32,43].
3.3. Personal environmental consciousness	GPs who are environmentally conscious personally are more likely to adopt decarbonisation actions professionally [32,35].
3.4. Variation in awareness and engagement	Significant differences exist among clinicians, with high willingness to learn but low comfort in counselling patients on climate-related issues [37,38].

3.5. Preferences and acceptance	Variability in acceptance of sustainability roles and measures, with constraints including limited awareness, funding, and patient motivation [41,42].
4. Patient and community engagement	
4.1. Patient discussions and barriers	Many GPs discuss climate change with patients, but barriers such as time constraints and lack of recommendations limit these discussions [34,37,38].
4.2. Patient perception and information sources	Patients believe climate change affects health but rely on non-medical sources for information [37,38].
4.3. Community engagement in activities	Local communities engage in nature-based activities, but awareness of initiatives like Green Social Prescribing is limited [42,44].
4.4. Information gap	Patients trust physicians but do not view them as primary sources of environmental information, relying instead on news outlets, social media, and personal networks [37,38].

DISCUSSION

Summary

This systematic review identified 15 studies of variable quality and scale undertaken in seven different countries, with most having been published since 2022. General practices are adopting decarbonisation actions to reduce carbon emissions and promote environmental sustainability. These actions include resource reuse, improved waste management, energy-efficient systems, and preventive care to reduce overmedication [30]. Leadership support is crucial, with management decisions significantly impact the success of these initiatives [31]. Efforts also focus on minimising patient travel emissions and educating patients on climate change through climate-sensitive health counselling [33-35] and integrating nature prescriptions into everyday healthcare practices [36].

Institutional support, including financial incentives and clear policies, is essential for overcoming barriers to implementation [35,36]. Strong leadership and a supportive culture within practices enhance the adoption of decarbonisation actions [31,41].

Education and training for clinicians on environmental sustainability are essential, as is their engagement in promoting these actions to patients [32,43]. However, barriers such as high costs, resource constraints, and limited awareness among both clinicians and patients remain significant challenges [31,37]. Patient and community engagement are also crucial, with structured promotion and integration of initiatives such as GSP needed to enhance participation [44]. Patients often rely on non-medical sources for environmental information, highlighting the need for improved communication within general practice settings [38,35]. Patient centred communication that links climate change to health and structured promotion of green prescribing can improve patient and community engagement in decarbonisation actions [34,38,44].

Strengths and limitations

This review addresses the urgent need for integrating decarbonisation actions into general practice and is the first systematic review to tackle this topic. Additionally, it provides a comprehensive and up-to-date analysis of the implementation of decarbonisation actions in general practice, drawing insights from internationally diverse sources and perspectives. Despite a comprehensive search and an iterative process to widen the scope, a relatively small number of papers were identified (n=15). Searches were restricted from 2007 onwards. The selected date coincides with the UN climate change conference where negotiations on a successor to the Kyoto Protocol began. Another limitation is the inclusion of studies published only in English, which may limit the generalisability of findings and may exclude valuable evidence from studies published in other languages.

Comparison with other literature

The integration of decarbonisation actions in general practice aligns with findings from other literature, emphasising the feasibility and benefits of decarbonisation actions. The review underscores the importance of reorganising resources, improving waste management, adopting energy-efficient systems, and promoting preventive care to reduce carbon emissions and healthcare costs. Similarly, some research [45] has highlighted the positive impact of streamlined systems and incentives but note challenges such as political affiliation and organisational constraints, which are echoed in this review through the need for leadership support and financial considerations [31].

The emphasis on reducing patient travel emissions through telemedicine and optimising appointment scheduling [33] resonates with those who advocate for telemedicine to mitigate environmental impacts [46]. Additionally, the implementation of climate-sensitive health counselling and nature prescriptions in general practice [35,36] parallels findings from others [47] on the effectiveness of nature-based interventions in community health.

Institutional and policy support are crucial, with guidelines such as the WONCA declaration [35,36] providing essential guidance, mirroring the need for systemic changes and better networking noted in the literature [31,35]. The pivotal role of leadership and a supportive workplace culture [31,35] is consistent with others [48], emphasising universal leadership significance across general practices.

Professional engagement through enhanced education and training on environmental sustainability [32,37,43] is essential, in addressing the gap between climate change awareness and clinician behaviour [49]. Despite high awareness, the discomfort in discussing climate-related health issues [38] indicates a systemic issue requiring targeted education and cultural change [41].

Patient and community engagement are vital, with findings indicating that structured promotion of GSP [44] and improved communication strategies [34, 38] are necessary to bridge the gap between patient concern and the information provided by general practice professionals. These insights align with the broader literature, underscoring the need for tailored approaches to sustainability in healthcare [3,5,50]. Overall, the comparison reveals consistent themes across general practice, hospital, and community care settings, highlighting the universal challenges and facilitators of decarbonisation actions.

Implications for decarbonisation and future research

General practices are showing that decarbonisation actions can be effectively incorporated into everyday operations, thereby reducing carbon emissions and promoting environmental sustainability. This involves practical measures such as resource reuse, improved waste management, and energy conservation through the adoption of energy-efficient systems such as LED lighting [30]. These actions not only contribute to environmental goals but also offer financial benefits by reducing healthcare costs associated with overmedication and inefficient energy use.

Leadership and effective management play a pivotal role in the successful implementation of these initiatives. Future research should explore strategies to foster strong leadership and supportive workplace cultures that prioritise environmental responsibility. Additionally, there is a need for financial support and cost-effective solutions to overcome the high costs and resource constraints that often limit the adoption of sustainable measures [31,35].

Institutional and policy support are critical for scaling up decarbonisation efforts. Financial incentives and clear guidelines, such as those provided by the WONCA declaration, are essential to motivate and guide general practitioners in integrating climate change considerations into their practices [35,36]. Future research should focus on evaluating the effectiveness of these policies and identifying best practices for systemic changes, including better networking and centralisation of sustainability efforts [31,35].

Professional engagement through education and training is also crucial. While many clinicians acknowledge the threat of climate change, they often lack specific knowledge and feel uncomfortable discussing it with patients [38]. Enhancing clinician competence through

targeted education on environmental sustainability can bridge this gap. Moreover, personal factors, such as parenthood, can motivate clinicians to adopt and advocate for decarbonisation actions, suggesting that personal triggers could be leveraged in professional training programs [32,37].

Patient and community engagement is essential for the success of decarbonisation actions. However, there is a significant gap between patient concern about climate change and the information provided by general practice professionals [38]. A patient centred approach that underscores health co-benefits of climate-friendly lifestyles as well as the integration of initiatives such as GSP within community health can enhance engagement and acceptance 3[4, 44]. Future research should investigate the most effective communication and education strategies to bridge this gap and enhance the use of general practice professionals as trusted sources of environmental information.

The findings from this review have significant implications for health policy, clinical practice, and patient care, aligning well with behaviour change frameworks such as the Theoretical Domains Framework (TDF) [51] and Normalisation Process Theory (NPT) [52,53]. Given that decarbonisation actions in general practice are influenced by institutional, organisational, and individual behavioural factors, as well as contextual factors like patient views and experiences, both TDF [51] and NPT [52,53] can be used to structure future data collection and analysis. Such combined approach will systematically identify cognitive, affective, and environmental determinants relevant to implementing decarbonising actions within general practice and understand the dynamic social processes involved [51-53].

Finally, while some general practices are making strides in integrating decarbonisation actions, the extent to which widespread implementation is occurring is unknown. Future research should focus on implementation strategies, including strengthening leadership, providing financial and policy support, enhancing professional education, and improving patient and community engagement. Tailored approaches that consider the unique contexts of different general practice settings may be crucial for the widespread adoption and success of decarbonisation actions.

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Table 1. Characteristics of included studies (Note: the setting of the studies is general practice or its equivalent in non-UK studies).

First author, year	Country	Setting and participants	Study design
Legrand, 2023 [30]	France	12 general practices, n=12 GPs	Qualitative design using face to face or phone semi-structured interviews.
Pavli, 2023 [31]	Australia	3 general practices, n=23 staff (nurses, administrative staff, and doctors)	Qualitative design, case study using semi-structured interviews and observations relating to environmental sustainability.
Muller, 2023 [32]	USA	Various primary care practices/clinics, n=103 primary care clinicians (including resident and attending physicians, clinical psychologists, nurse practitioners, and physicians' assistants)	Quantitative design using cross-sectional questionnaire survey.
Andrews, 2013 [33]	UK	1 general practice, n=306 patients (survey); n=12 NHS clinical staff (focus group 1); n=13 NHS non-clinical staff (focus group 2)	Mixed methods design, case study, using survey and two focus groups. The focus groups followed a semi-structured topic guide. Carbon footprint was estimated using the ArcInfo GIS software package.
Griesel, 2023 [34]	Germany	6 primary care practices, n=27 patients	Qualitative design using semi-structured interviews and cross-sectional survey.
Fehrer, 2023 [35]	Germany	Various primary care practices, n=40 physicians, medical assistants, health scientists and experts on the healthcare system	Qualitative exploratory design using semi-structured guide-based interviews and focus groups.
Foley, 2023 [36]	Australia	Nature-based prescribers and providers, n=13 health stakeholders (health service providers and managers)	Qualitative descriptive design using semi-structured interviews.
Andre, 2022 [37]	Switzerland	Various general practices, n=497 GPs	Quantitative design using cross-sectional survey.
Boland and Temte, 2019 [38]	USA	4 family medicine and community health clinics, n=403 patients; n=58 family physicians	Quantitative design using cross-sectional survey.
Maughan, 2016 [39]	UK	Social prescribing intervention 'The Connect project', n=30 Connect project group; n=29 (control group)	Quantitative design using retrospective observational data.
Woodcock, 2021 [40]	UK	Salford Lung Study in Asthma, n=2236 subset of study participants	Quantitative design using carbon footprint analysis and clinical outcomes analysis.
Wild, 2023 [41]	Australia	3 Australian Regional Training Organisations, n=879 GP registrars	Quantitative design using cross-sectional questionnaire.
Robinson, 2020 [42]	UK	Social prescribing intervention 'The Connect project', n=114 GPs; n=170 nature-based organisation participants	Quantitative design using online cross-sectional questionnaire.
Guggenheim, 2016 [43]	Israel	1 general practice, n=107 patients	Quantitative using questionnaire.
Sun, 2023 [44]	UK	1 region of the UK, n=34 stakeholders, n=64 members of the public	Qualitatively design using observations and shadowing, workshops and semi-structured interviews.

Table 2. Factors influencing the adoption, implementation and integration of decarbonisation actions.

Factors	Description
1. Institutional and policy support	
1.1. Financial incentives and policies	Financial incentives are essential for the adoption of decarbonisation actions, but inconsistent policy guidance in some regions acts as a barrier [35,36].
1.2. Frameworks and declarations	Guidelines such as the WONCA declaration motivate GPs to integrate climate change considerations into their practices by providing structured guidelines and strategic vision [35,36].
1.3. System-level changes	Effective decarbonisation requires better networking and centralisation of sustainability efforts to ensure coherence and efficiency across the healthcare system [31,35].
2. Organisational leadership, support, and constraints	
2.1. Leadership and culture	Proactive leadership and a culture that values sustainability are critical for driving successful decarbonisation efforts within general practices [31,41].
2.2. Practice management	Effective leadership and staff engagement are essential for integrating decarbonisation actions into daily practice activities [31,41].
2.3. Resource constraints	High costs and resource limitations hinder the adoption of sustainable measures, requiring financial support and cost-effective solutions [31,35].
3. Professional knowledge, awareness, and engagement	
3.1. Knowledge and awareness	Clinician awareness of climate change impacts is crucial, but many lack specific knowledge and feel uncomfortable discussing it with patients [32,37,38].
3.2. Education and training	Enhancing clinician competence through targeted education and training on decarbonisation is needed [32,43].
3.3. Personal environmental consciousness	GPs who are environmentally conscious personally are more likely to adopt decarbonisation actions professionally [32,35].

3.4. Variation in awareness and engagement	Significant differences exist among clinicians, with high willingness to learn but low comfort in counselling patients on climate-related issues [37,38].
3.5. Preferences and acceptance	Variability in acceptance of sustainability roles and measures, with constraints including limited awareness, funding, and patient motivation [41,42].
4. Patient and community engagement	
4.1. Patient discussions and barriers	Many GPs discuss climate change with patients, but barriers such as time constraints and lack of recommendations limit these discussions [34,37,38].
4.2. Patient perception and information sources	Patients believe climate change affects health but rely on non-medical sources for information [37,38].
4.3. Community engagement in activities	Local communities engage in nature-based activities, but awareness of initiatives like Green Social Prescribing is limited [42,44].
4.4. Information gap	Patients trust physicians but do not view them as primary sources of environmental information, relying instead on news outlets, social media, and personal networks [37,38].

Supplementary Table 1

Search strategies

Concept	Description	Search Terms
1)	Setting	“General practice” OR “primary care” OR “family practice” OR “family clinic” OR “family medicine” OR “community health” OR “medical centre” OR “Primary healthcare” OR “Primary health care”
2)	Implementation	“Greenhouse gas*” OR “GHG” OR “Net zero” OR “Net-zero” OR “climate change” OR “carbon emissions” OR “*carbon footprint” OR “environmental sustainability”
3)	Intervention	“implement*” OR “strateg*” OR “action*” OR “intervention*” OR “policies” OR “policy” OR “solution*” OR “plan”
4)	Subjects	“staff” OR “patient*” OR “team*” OR “employee*”

Search term examples taken from two databases with key mesh terms:

	MEDLINE
1	("General practice" or "primary care" or "family practice" or "family clinic" or "family medicine" or "community health" or "medical centre" or "Primary healthcare" or "Primary health care").mp.
2	limit 1 to (english language and yr="2007 - 2023")
3	("Greenhouse gas*" or "GHG" or "Net zero" or "Net-zero" or "climate change" or "carbon emissions" or "*carbon footprint" or "environmental sustainability").mp.
4	limit 3 to (english language and yr="2007 - 2023")
5	2 and 4
6	("implement*" or "strateg*" or "action*" or "intervention*" or "policies" or "policy" or "solution*" or "plan").mp.
7	limit 6 to (english language and yr="2007 - 2023")
8	("staff" or "patient*" or "team*" or "employee*").mp.
9	limit 8 to (english language and yr="2007 - 2023")
10	7 and 9
11	5 and 10

Web of Science

(“General practice” OR “primary care” OR “family practice” OR “family clinic” OR “family medicine” OR “community health” OR “medical centre” OR “Primary healthcare” OR “Primary health care”) (Topic) and (“Greenhouse gas*” OR “GHG” OR “Net zero” OR “Net-zero” OR “climate change” OR “carbon emissions” OR “*carbon footprint” OR “environmental sustainability”) (Topic) and (“implement*” OR

“strateg*” OR “action*” OR “intervention*” OR “policies” OR “policy” OR “solution*” OR “plan") (Topic) and (“staff” OR “patient*” OR “team*” OR “employee*”) (Topic)

ProQuest

noft("General practice" OR "primary care" OR "family practice" OR "family clinic" OR "family medicine" OR "community health" OR "medical centre" OR "Primary healthcare" OR "Primary health care") AND noft("Greenhouse gas*" OR "GHG" OR "Net zero" OR "Net-zero" OR "climate change" OR "carbon emissions" OR "carbon footprint" OR "environmental sustainability") AND noft("implement*" OR "strateg*" OR "action*" OR "intervention*" OR "policies" OR "policy" OR "solution*" OR "plan") AND noft("staff" OR "patient*" OR "team*" OR "employee*")

Source type: Blogs, Podcasts, & Websites, Books, Conference Papers & Proceedings, Dissertations & Theses, Magazines, Reports

Language: English

CINAHL

(“General practice” OR “primary care” OR “family practice” OR “family clinic” OR “family medicine” OR “community health” OR “medical centre” OR “Primary healthcare” OR “Primary health care”) AND (“Greenhouse gas*” OR “GHG” OR “Net zero” OR “Net-zero” OR “climate change” OR “carbon emissions” OR “*carbon footprint” OR “environmental sustainability”) AND (“implement*” OR “strateg*” OR “action*” OR “intervention*” OR “policies” OR “policy” OR “solution*” OR “plan”) AND (“staff” OR “patient*” OR “team*” OR “employee*”)

Limiters - Publication Date: 20070101-20231231; English Language; Language: English
Expanders - Apply equivalent subjects
Search modes - Find all my search terms

Supplementary Table 2
MMAT Quality assessment tables for included papers

		Legrand et al 2023	Pavli et al 2023	Muller et al 2023	Andrews et al 2013	Griesel et al 2023	Fehrer et al 2023	Foley et al 2023	Andre et al 2022	Boland and Temte 2019	Maughan et al 2016	Woodcock et al 2021	Wild et al 2023	Robinson et al 2020	Guggenheim 2016	Sun et al 2023
SCREENING QUESTIONS	S1. Are there clear research questions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	S2. Do the collected data allow to address the research questions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1. QUALITATIVE STUDIES	1.1. Is the qualitative approach appropriate to answer the research question?	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes
	1.2. Are the qualitative data collection methods adequate to address the research question?	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes
	1.3. Are the findings adequately derived from the data?	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Can't tell	Yes
	1.4. Is the interpretation of results sufficiently substantiated by data?	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Can't tell	Yes
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Can't tell	Yes
4. QUANTITATIVE DESCRIPTIVE STUDIES	4.1. Is the sampling strategy relevant to address the research question?	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
	4.2. Is the sample representative of the target population?	N/A	N/A	Can't tell	Can't tell	N/A	N/A	N/A	Can't tell	Can't tell	Can't tell	Yes	Yes	Can't tell	N/A	N/A

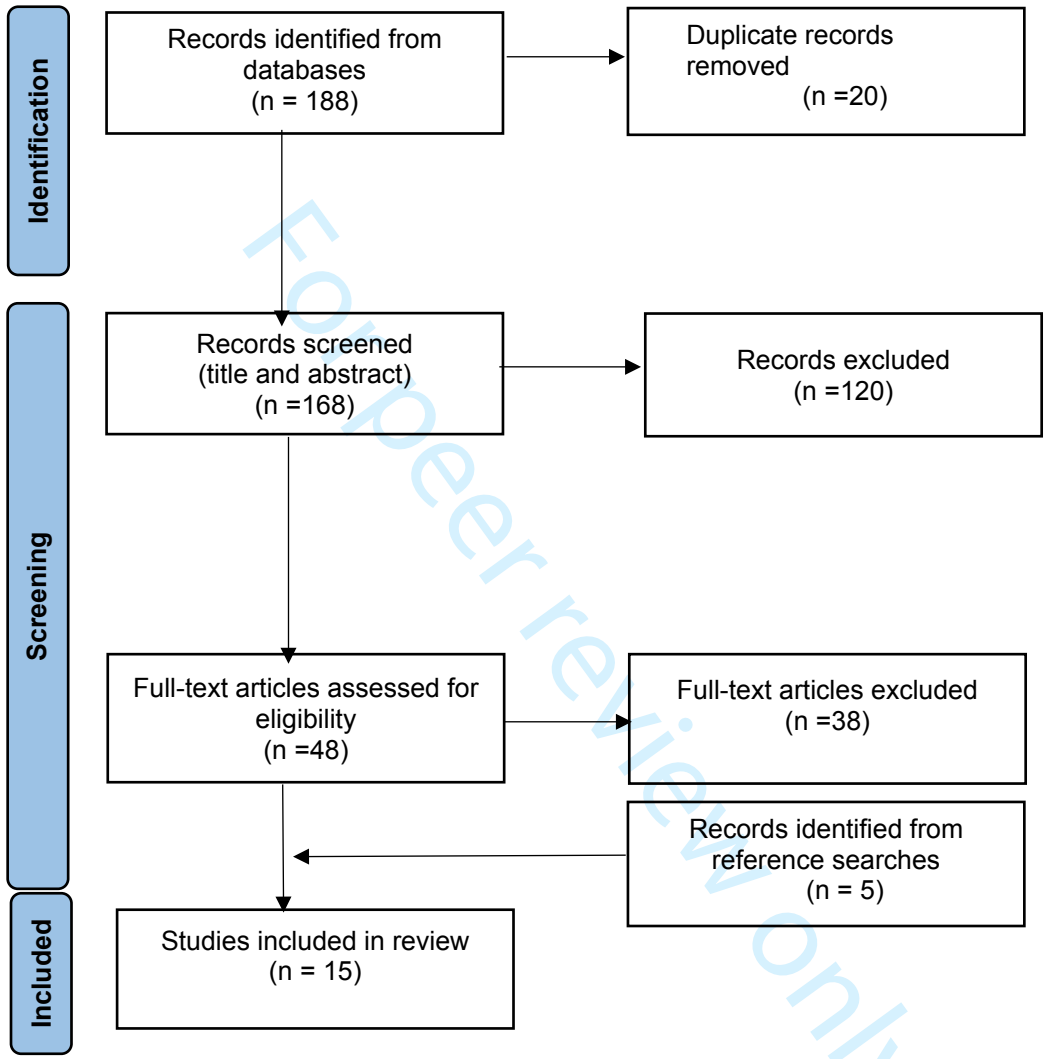
	4.3. Are the measurements appropriate?	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
	4.4. Is the risk of nonresponse bias low?	N/A	N/A	No	Yes	N/A	N/A	N/A	No	No	Yes	Yes	Yes	Can't tell	N/A	N/A
	4.5. Is the statistical analysis appropriate to answer the research question?	N/A	N/A	Yes	Yes	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A
5. MIXED METHODS STUDIES	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?	N/A	N/A		Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5.2. Are the different components of the study effectively integrated to answer the research question?	N/A	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	N/A	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	N/A	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	N/A	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: High quality studies are highlighted green, moderate quality studies are highlighted orange, and low quality studies are highlighted red.

Supplementary Figure 1

PRISMA flowchart

PRISMA diagram showing screening and included studies



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71