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Sustainable Healthcare Governance in the NHS: Leadership, Regulation, and Legal Responsibility in Green Hospital Implementation

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Abstract

Healthcare sustainability governance research has often focused on technical interventions rather than on the leadership, regulatory and legal mechanisms that determine whether commitments are implemented. This study examines how green-governance implementation across NHS trusts in England changed within an evolving institutional environment of leadership, regulatory pressure and legal responsibility, with particular attention to the statutory sustainability duties introduced through the Health and Care Act 2022.

Using NHS England's Estates Returns Information Collection (ERIC), a trust-level panel of 1,281 trust-year observations from 226 NHS trusts spanning 2019/20 to 2024/25 was constructed. An interrupted longitudinal regression with trust-clustered standard errors was used to test whether the level and trajectory of two core implementation outcomes, energy-efficient scheme counts and waste-reuse scheme prevalence, changed around the 2022 statutory transition, supported by logistic, negative-binomial, fixed-effects and balanced-panel robustness specifications.

Green-governance implementation changed significantly over the study period. Waste-reuse implementation showed a significant, sustained positive change in trajectory following the 2022 transition (OR = 1.566, 95% CI 1.285–1.908, $p < .001$). Energy-efficient scheme counts instead showed a significant immediate reduction in level at the transition (IRR = 0.642, 95% CI 0.444–0.928, $p = .018$), with no corresponding change in subsequent trajectory. Supplementary governance-capacity indicators strengthened over the years for which comparable data were available.

The strengthened statutory and regulatory sustainability environment is associated with observable but heterogeneous changes in green-governance implementation across NHS trusts. These changes are domain-specific rather than uniformly positive. The findings are integrated within a proposed Green Hospital Governance and Accountability Framework (GH-GAF), which conceptualises legal and regulatory responsibility as an external accountability influence whose translation into implementation may depend on domain-specific organisational capacity.

Keywords: Green Hospital Governance, NHS Sustainability, Interrupted Longitudinal Analysis, Regulatory Pressure, Legal Accountability, Governance-Implementation Gap

1. Introduction

1.1 Background and Context

Environmental sustainability has increasingly come to be understood as an organisational governance challenge for healthcare systems, rather than as a purely technical or engineering problem (Berniak-Woźny & Rataj, 2023) [3]. Hospitals are resource-intensive organisations whose environmental footprint arises from energy use, waste generation, estates management, procurement, transport and the delivery of clinical activity itself, with healthcare systems worldwide estimated to generate close to 4.4 percent of global net carbon emissions (Karliner *et al*., 2019) [17]. Achieving environmentally sustainable healthcare therefore requires not only technical decarbonisation interventions but also leadership commitment, organisational accountability, regulatory direction and mechanisms capable of translating policy commitments into operational implementation.

The National Health Service in England provides an especially useful empirical setting in which to examine this governance

challenge, because its sustainability commitments have progressively moved from policy aspiration toward more formal governance and statutory responsibility over a relatively short period. In 2020, the NHS became the first national health system to commit to net zero emissions (England, 2022) [11]. This commitment was operationalised through board-approved Green Plans from 2021 onward, and in 2022 the Health and Care Act placed a statutory duty on NHS trusts and integrated care boards to have regard to specified emissions and environmental targets ("Health and Care Act 2022," 2022) [16]. Board-level net zero leadership, environmental reporting requirements, and evolving procurement and accountability mechanisms have since been layered onto this statutory foundation (Care Quality, 2024; England, 2025) [7, 12]. This timeline establishes a natural institutional reference point around which the trajectory of green-governance implementation can be examined.

1.2 Problem Statement

The core problem addressed in this study is not that hospitals are environmentally unsustainable in some general sense, a framing with limited analytical value. Rather:

> *Despite increasingly formal sustainability commitments, an unresolved governance question is how leadership and organisational capacity interact conceptually with regulatory and legal accountability, and whether green-governance implementation changes as the institutional sustainability environment strengthens.*

Organisations may formally adopt sustainability policies, appoint responsible managers, establish plans and report targets without necessarily showing corresponding operational implementation. This divergence creates the conceptual governance-implementation gap examined throughout this study (Section 2.6).

1.3 Research Gap

Four gaps in the existing literature motivate this study. First, much green-hospital research remains fragmented, focusing on technical interventions such as emissions, energy efficiency or waste management rather than on the governance mechanisms that determine whether such interventions are sustained (Section 2.1). Second, organisational leadership, regulatory pressure and legal responsibility have typically been studied separately rather than as interconnected governance mechanisms operating jointly on implementation (Sections 2.2 to 2.4). Third, longitudinal institutional evidence remains limited: cross-sectional studies cannot adequately determine whether implementation trajectories change as a regulatory environment strengthens, which is precisely the question this study's interrupted longitudinal design is intended to address (Section 3.7.3). Fourth, the distinction between formal governance commitment and operational implementation remains underdeveloped in healthcare sustainability research. Formal plans, leadership structures and reporting arrangements do not necessarily demonstrate corresponding implementation progress, creating a need for longitudinal evidence that examines operational implementation trajectories alongside available governance-capacity indicators. These four gaps lead directly to the integrated governance framework proposed in Section 2.8.

1.4 Aim

> *To examine longitudinal patterns in green-governance implementation across NHS trusts and assess how these patterns changed during the strengthened post-2022 statutory and regulatory sustainability environment, while situating the findings within an integrated framework of leadership, regulatory pressure and legal responsibility.*

1.5 Research Objectives

Objective 1: Examine longitudinal patterns in green-governance and implementation indicators across NHS trusts between 2019/20 and 2024/25.
Objective 2: Assess whether green implementation changed around the strengthened 2022 statutory sustainability environment.
Objective 3: Examine whether different sustainability domains exhibit similar or heterogeneous regulatory-period responses.
Objective 4: Evaluate available organisational sustainability-management capacity and governance indicators, including designated energy and waste management capacity and other reported sustainability mechanisms.
Objective 5: Develop an integrated governance framework linking leadership, regulatory pressure, legal responsibility and operational green implementation.

1.6 Research Questions

RQ1: How did green-governance implementation across NHS trusts change within an evolving institutional environment of leadership, regulatory pressure and legal responsibility?
This primary question is addressed through four secondary research questions:
RQ2: How did green-governance implementation evolve across NHS trusts from 2019/20 to 2024/25?
RQ3: Did implementation trajectories change during the strengthened post-2022 statutory and regulatory sustainability environment?
RQ4: Do regulatory-period changes differ across waste reuse, energy-efficiency initiatives and other governance indicators?
RQ5: What do observed differences between governance structures and implementation imply for sustainable healthcare accountability?

1.7 Contributions and Novelty

This study does not claim to be the first to examine NHS sustainability governance; rather, its contribution lies in bringing together three dimensions of novelty that are rarely combined within a single healthcare governance study.
Theoretical: Leadership, regulatory pressure and legal accountability are integrated within a single conceptual framework, the Green Hospital Governance and Accountability Framework (GH-GAF), developed in Section 2.8. The framework distinguishes the broader theoretical architecture from the implementation pathways that can be evaluated with the present data.
Empirical: The analysis draws on a multi-year national NHS trust panel of 1,281 trust-year observations from 226

trusts (Section 3.3), rather than relying exclusively on surveys, interviews or individual hospital case studies, which dominate the existing green-hospital literature (Section 2.1).

Methodological: The study combines an interrupted longitudinal specification with outcome-appropriate robustness modelling, logistic regression for the binary waste-reuse outcome and negative-binomial regression for the count of energy-efficient schemes, together with balanced-panel and fixed-effects checks (Section 3.7), providing a more rigorous longitudinal assessment of implementation trajectories than a single cross-sectional or pre/post comparison would allow.

The remainder of this paper proceeds as follows. Section 2 reviews the relevant literature and develops the theoretical framework and hypotheses. Section 3 describes the data, variables and statistical methods. Section 4 presents the empirical results. Section 5 discusses these results in relation to the literature and theoretical framework, and Section 6 concludes.

2. Literature Review and Theoretical Framework

2.1 Sustainable Healthcare and the Green Hospital Concept

Sustainable healthcare is generally understood as the delivery of health services in a manner that protects environmental, economic and social viability without compromising the capacity of future generations to meet their own health needs (Berniak-Woźny & Rataj, 2023) [3]. The related concept of the green hospital extends this definition operationally, encompassing energy efficiency, water management, waste reduction, sustainable procurement, low-carbon estates and resource-efficient clinical delivery (Rojas-Rueda, 2025) [22]. The scale of the underlying problem is considerable: healthcare systems are estimated to generate approximately 4.4 percent of global net carbon emissions, a footprint attributable primarily to building energy use, procurement and clinical waste rather than to direct patient care activity (Karliner *et al*., 2019) [17].

Much of the green hospital literature, however, remains descriptive rather than explanatory. Existing reviews catalogue the operational domains in which hospitals can act, including energy, waste, water, procurement and transport, but offer comparatively little theoretical account of why implementation varies across organisations facing similar environmental obligations (Berniak-Woźny & Rataj, 2023) [3]. This is a material gap in the literature: cataloguing what green hospitals should do says little about the organisational conditions under which such activity is actually sustained. Addressing that gap requires attention to governance, since the translation of environmental ambition into operational practice depends on internal leadership structures, external accountability mechanisms, and the interaction between the two (Bauer *et al*., 2025) [2].

2.2 Leadership in Healthcare Sustainability

A substantial body of work identifies leadership commitment, and specifically board-level engagement, as a principal enabler of sustainability implementation in healthcare organisations. Bauer *et al*. (2025) [2] find that green leadership and board-level commitment drive resource allocation and cultural change around environmental, social and governance matters, while Calabrese *et al*. (2023) [5] similarly identify decision-maker commitment as a preventing and developmental factor for sustainability across a national hospital sample. Sijm-Eeken *et al*. (2024) [24] formalise this relationship within a maturity model comprising four domains, governance, organisational structures, processes, and outcomes and control, in which governance capacity is treated as foundational to the other three.

This literature broadly supports the proposition that:

> *Leadership Commitment → Green Governance Implementation*

In the present study, this relationship provides theoretical context rather than a directly estimated causal pathway. ERIC does not provide a consistent six-year measure of board-level leadership commitment; available indicators of energy and waste management staffing are therefore treated as supplementary measures of organisational sustainability-management capacity rather than as direct proxies for leadership commitment.

The empirical base underlying this proposition is, however, disproportionately qualitative and cross-sectional: interview studies, maturity-model self-assessments and exploratory factor analyses dominate, with few longitudinal tests of whether leadership indicators actually precede or track measurable implementation change over time. Moreover, the same literature is careful not to treat leadership as sufficient on its own. Robinson *et al*. (2025) [21], in an interview-based study of London NHS trusts, find that strong local leadership was consistently cited as an enabling factor but was regularly undermined by unclear national prioritisation, constrained funding and infrastructural limitations beyond any single trust's control. This suggests that internal leadership commitment operates within, rather than independently of, an external regulatory and resourcing environment, a proposition examined in Section 2.3.

2.3 Regulatory Pressure and Green Healthcare

The evolution of healthcare sustainability governance is often characterised as a progression from voluntary commitment, through policy expectation and regulatory accountability, to statutory responsibility. Institutional theory provides the principal explanatory account of this progression: DiMaggio and Powell (1983) [9] argue that formal and informal pressures exerted through dependent regulatory relationships, described as coercive isomorphism, push organisations toward convergent structures and practices. Applied to healthcare sustainability, regulation is expected to establish minimum expectations, standardise reporting and reduce organisational discretion, thereby increasing the pressure to implement rather than merely announce environmental commitments.

The empirical evidence for this expectation is considerably more contested than the theory alone implies. Marculetiu *et al*. (2026) [18], examining sustainability strategy formation across 388 supply chain organisations, find that coercive and mimetic institutional pressures show no significant association with either symbolic or substantive sustainability strategy, a result that directly challenges the assumption that regulatory pressure reliably converts into implementation. Cepêda *et al*. (2025) [8], synthesising the sustainability decoupling literature, similarly conclude that the extent to which regulatory and reporting pressure produces genuine practice change is conditional on organisational governance

characteristics rather than automatic. Set against this, Graafland and Smid (2019) [14] find no evidence of complete decoupling between CSR policy and CSR outcomes across a large multinational sample, indicating that regulatory and reporting pressure is associated with at least partial implementation rather than wholesale symbolic compliance. Taken together, this literature suggests that regulatory pressure may facilitate implementation but is unlikely to be sufficient on its own, and that its association with substantive organisational change is likely to vary across organisational contexts and activity domains, a proposition that motivates the domain-specific hypothesis developed in Section 2.9.

2.4 Legal Responsibility and Environmental Accountability

Legal accountability for environmental performance can be usefully decomposed into its constituent elements:

Legal Accountability = f(Duty, Responsible Actor, Disclosure, Enforcement, Sanction)

Three broad levels of accountability can be distinguished in the healthcare sustainability context. At the voluntary level, organisations adopt sustainability commitments in the absence of binding legal requirement. At the quasi-regulatory level, formal NHS guidance, contractual requirements and reporting expectations create governance standards without direct statutory force. At the mandatory or statutory level, legal obligations arise directly from legislation.

The Health and Care Act 2022 shifted NHS sustainability governance toward this third level, placing duties on NHS England, NHS trusts, foundation trusts and integrated care boards to have regard to the need to contribute to compliance with statutory emissions and environmental targets, and to have regard to the need to adapt to the impacts of climate change identified under the Climate Change Act 2008 (England, 2022; "Health and Care Act 2022," 2022) [11, 16]. It is important to characterise this duty accurately rather than overstate its legal force. The statutory language requires relevant NHS bodies to have regard to specified climate and environmental objectives, while NHS governance guidance operationalises these responsibilities through mechanisms including board-approved Green Plans and designated leadership arrangements. The legislation does not, however, impose a direct output-based obligation requiring individual trusts to achieve specified environmental-performance thresholds with automatic sanctions for non-attainment. This distinction matters analytically, because a due-regard duty of this kind is theoretically compatible with considerable variation in implementation intensity across organisations, even where formal compliance, in the form of a board-approved Green Plan and a named net zero lead, is close to universal. The present study does not treat the Act as a source of enforceable performance standards; it is treated instead as an institutional reference point around which implementation trajectories can be examined.

2.5 NHS Sustainability Governance Evolution

The institutional timeline relevant to this study can be summarised in four stages. In 2020, the NHS became the first health system internationally to commit to net zero emissions (England, 2022) [11]. In 2021, NHS England strengthened Green Plan guidance, establishing an organisational expectation that systems and trusts develop three-year, and board-approved sustainability strategies. In 2022, the Health and Care Act placed the statutory due-regard duty described in Section 2.4 on trusts and integrated care boards, and NHS England guidance required every trust to appoint a board-level net zero lead, a requirement subsequently incorporated into the Care Quality Commission's assessment of trust governance (Care Quality, 2024; England, 2022) [7, 11]. From 2023 onward, additional implementation and accountability mechanisms were layered onto this framework, including a minimum net zero and social value weighting in NHS procurement and the incorporation of Green Plan delivery into the Care Quality Commission's well-led assessment framework (Care Quality, 2024; England, 2025) [7, 12].

This timeline provides the institutional justification for treating 2022 as an interruption point in an otherwise continuous longitudinal series. It should be read with an important caveat, however. The accountability mechanisms introduced from 2023 onward, particularly procurement weighting and inclusion within CQC assessment, overlap substantially with the post-2022 period under examination. Consequently, any observed change in implementation trajectory around 2022 cannot be attributed to the Health and Care Act in isolation, since it coincides with a wider tightening of the NHS sustainability governance environment rather than a single, cleanly isolable legal event.

2.6 Governance-Implementation Gap

Because the present analysis is constrained by the unavailability of a complete, harmonised ERIC Site-level environmental dataset (Section 3.8), the governance-implementation gap construct developed in this section is presented as a conceptual extension for future empirical operationalisation rather than as a relationship measured within the current study. Subject to that limitation, the construct can be expressed formally as:

$$GIG_{it} = Z(GLGI_{it}) - Z(GHEP_{it})$$

Where GLGI denotes a standardised Green Leadership and Governance Index and GHEP denotes a standardised Green Hospital Environmental Performance measure. Three theoretical states follow from this formulation. Where governance strength and environmental performance are both high, governance and performance are aligned. Where governance is strong but environmental performance is weak, a governance-implementation gap is indicated: formal governance commitment has not translated into corresponding environmental performance. Where both governance and environmental performance are weak, the pattern reflects institutional weakness rather than a specific implementation failure.

This formulation draws directly on the organisational decoupling literature. Meyer and Rowan (1977) [19] originally characterised decoupling as the divergence between an organisation's formal structure and its actual operating activity, adopted to maintain external legitimacy independent of technical efficiency. The more recent sustainability decoupling literature (Cepêda *et al*., 2025; Graafland & Smid, 2019) [8, 14] has operationalised this idea

principally within corporate ESG reporting contexts. An equivalent, empirically grounded measure for public healthcare governance is largely absent from the literature, which is the gap the GIG construct is intended to address in principle, even though its full empirical estimation lies beyond the scope of the present dataset.

2.7 Theoretical Foundations

Institutional theory, and specifically the coercive isomorphism mechanism identified by DiMaggio and Powell (1983) [9], provides the principal theoretical account of why regulatory and legal pressure is expected to shape organisational behaviour: NHS trusts depend on national regulators and commissioners in ways that create pressure toward convergent compliance. This account is usefully complemented by stakeholder and accountability theory. (Freeman, 1984)'s [13] stakeholder framework establishes that organisations are answerable not only to a narrow principal but to the wider set of parties affected by their conduct, including government, patients, communities and future generations, a framing directly applicable to NHS boards navigating statutory sustainability responsibility alongside clinical and financial obligations.

Neither theory alone, however, explains how external pressure is translated into internal operational change. This is the role played by the leadership literature reviewed in Section 2.2: leadership and governance capacity can be conceptualised as potential internal mechanisms through which external institutional pressure may be translated into implementation. A single, layered theoretical logic therefore underlies the conceptual framework developed in this study:

External Pressure → Leadership and Governance → Implementation

A notable theoretical tension follows from this synthesis. Classical institutional theory predicts isomorphic convergence: organisations subject to a common regulatory pressure are expected to adopt increasingly similar practices over time. The domain-specific heterogeneity anticipated in this study's third hypothesis (Section 2.9) represents a partial departure from that prediction, and is more consistent with organisational capacity and resource-dependence explanations, in which the same external pressure produces different implementation outcomes depending on the capital, infrastructure and coordination requirements specific to each sustainability domain. Section 5.4 returns to this point in light of the empirical results.

2.8 Green Hospital Governance and Accountability Framework (GH-GAF)

Drawing together Sections 2.2 to 2.7, the Green Hospital Governance and Accountability Framework (GH-GAF) is proposed as an integrating conceptual model:

RP → GGI

LAS → GGI

LC → GGI

GGI → Environmental Performance

Where RP denotes Regulatory Pressure, LAS denotes Legal Accountability Strength, LC denotes Leadership Commitment, and GGI denotes Green Governance Implementation. The framework theorises regulatory pressure, legal accountability strength and leadership commitment as distinct but potentially interacting influences on green-governance implementation, which is subsequently expected to shape environmental performance. These pathways represent the full conceptual architecture of GH-GAF rather than a claim that every relationship is separately identified in the present empirical analysis.

It is necessary to be precise about what the present study evaluates within this framework. The empirical analysis reported in Sections 4 and 5 directly examines GGI-type implementation outcomes, specifically the trajectory of energy-efficient scheme counts and waste-reuse scheme prevalence around the 2022 statutory transition. The GGI → Environmental Performance relationship is proposed as a theoretical extension of the framework rather than as a relationship tested in this study, consistent with the data limitation described in Section 2.6. Fig 1 presents the GH-GAF framework in diagrammatic form.

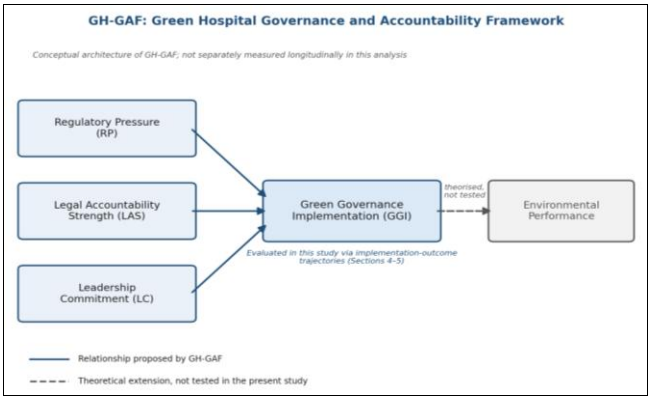


Fig 1: Green Hospital Governance and Accountability Framework (GH-GAF)

2.9 Hypotheses

Consistent with the data actually available for testing, four hypotheses are proposed.

H1: Green-governance implementation changes significantly over time across NHS trusts.

H2: The post-2022 regulatory and legal environment is associated with significant changes in green-governance implementation trajectories.

H3: Post-2022 changes differ across green-governance implementation domains rather than occurring uniformly.

H4: Organisational sustainability-management capacity strengthens over the study period.

A fifth hypothesis, that legal accountability directly improves environmental performance, is deliberately not proposed. As Section 2.6 makes clear, the present dataset does not permit direct measurement of environmental performance, and testing such a hypothesis without the corresponding outcome data would overstate what the available evidence can support.

3. Methodology

3.1 Research Philosophy and Approach

This study adopts a quantitative longitudinal observational approach, complemented by documentary analysis of legal and regulatory sources. A quantitative panel design is appropriate because the research question concerns

measurable organisational implementation, tracked across a large number of NHS trusts and multiple financial years, rather than individual experience or interpretive meaning. The legal and regulatory analysis is used to establish the institutional timeline against which implementation is assessed and to inform the coding of the study's intervention variables, rather than to provide an independent source of trust-level outcome data.

3.2 Research Design

The study uses a longitudinal panel design in which the unit of analysis is the NHS trust-year. The panel spans six financial years, from 2019/20 to 2024/25, and is structured around the strengthened statutory sustainability responsibilities introduced through the Health and Care Act 2022. The design is best characterised as an interrupted longitudinal temporal analysis with a defined institutional reference point, examining whether the level and trajectory of implementation outcomes changed around that point, without random assignment of trusts to treatment and comparison conditions. Findings are accordingly interpreted as temporal associations rather than as causal estimates of the effect of any single piece of legislation.

3.3 Setting and Sample

The analytic sample comprises 1,281 trust-year observations drawn from 226 unique NHS trusts reporting between 2019/20 and 2024/25. Annual reporting counts declined from 224 trusts in 2019/20 to 207 trusts in 2024/25, potentially reflecting organisational and reporting-structure changes over the study period. Because changes in panel composition could influence longitudinal estimates, a balanced subpanel of 205 trusts reporting in all six years (1,230 trust-year observations) was analysed as a robustness check.

3.4 Data Sources

3.4.1 Estates Returns Information Collection (ERIC)

The principal quantitative data source is NHS England's Estates Returns Information Collection (ERIC), an annual mandatory return completed by NHS trusts covering estates, facilities, and sustainability-related activity. Trust-level ERIC datasets were obtained directly from NHS England's official file-hosting service for each of the six financial years included in the study. Data were retrieved from official CSV endpoints rather than through extraction of publication landing pages, and column names were normalised to enable consistent matching across years, since ERIC's underlying question wording and field naming changed periodically over the study period.

A cross-year schema audit was conducted prior to variable construction to identify which fields were reported consistently across all six annual releases. This audit indicated that certain sustainability-related indicators, principally detailed energy-consumption, floor-area, and waste-volume measures, are reported at the ERIC Site level rather than the ERIC Trust level and are governed by a separate data structure from the Trust-level files used in this study. The analysis therefore distinguishes between a Trust-level governance and implementation layer, drawn from fields present and comparably defined across the Trust CSVs, and a Site-level environmental-performance layer. The Site-level layer could not be incorporated into the present analysis; this limitation is addressed in Section 3.8.

3.4.2 Legal and Regulatory Sources

The study draws on official legal and regulatory sources, including the Health and Care Act 2022, NHS Green Plan guidance, NHS net-zero governance requirements, and related NHS sustainability and procurement guidance, to construct an institutional timeline for the study period. These sources establish the regulatory and legal context for the intervention variables described in Section 3.6 and are not treated as sources of trust-level outcome data.

3.5 Variable Operationalisation

Table 1 reports the operational definition, measurement level, and ERIC coverage of each variable used in the analysis. Three implementation outcomes form the core of the analysis: the number of energy-efficient schemes reported by a trust in a given financial year (a count variable), the associated scheme expenditure (a continuous variable, reported in pounds sterling), and whether the trust reported an active waste-reuse scheme (a binary variable). A set of supplementary governance indicators, covering energy and waste management staffing, green-energy usage, and heat-decarbonisation activity, is reported descriptively because the underlying ERIC fields were revised during the study period and do not offer consistent six-year coverage.

Table 1: Variable Operationalisation and ERIC Coverage

Variable	Type	Operational Definition	Years Covered	N
Energy-efficient schemes	Count	Number of energy-efficient schemes reported by the trust	2019/20-2024/25	1,279
Scheme expenditure (GBP)	Continuous	Reported expenditure associated with energy-efficient schemes	2019/20-2024/25 (reduced coverage from 2022/23)	967
Waste-reuse scheme	Binary (0/1)	Whether the trust reported an active waste-reuse scheme	2019/20-2024/25	1,279
Energy manager present	Binary (0/1)	Whether the trust reported an energy manager (yes/no format)	2020/21-2022/23	639
Waste manager present	Binary (0/1)	Whether the trust reported a waste manager (yes/no format)	2019/20-2022/23	863
Energy manager WTE	Continuous	Whole-time-equivalent (WTE) energy management staffing	2023/24-2024/25	416
Waste manager WTE	Continuous	Whole-time-equivalent (WTE) waste management staffing	2023/24-2024/25	416
Green-energy usage	Binary (0/1)	Whether the trust reported use of green or renewable energy sources	2019/20-2021/22	652
Heat-decarbonisation indicator	Binary (0/1)	Whether the trust reported heat-decarbonisation planning or implementation activity	2021/22-2022/23	423
Trust identifiers	Categorical	Trust code, name, and organisational type	2019/20-2024/25	1,281

Note. Energy-manager and waste-manager presence were collected as yes/no fields through 2022/23 and were subsequently replaced in the ERIC schema by whole-time-equivalent (WTE) staffing measures from 2023/24 onward. The two measurement forms are reported as distinct variables rather than harmonised into a single longitudinal series.

3.6 Intervention Variables

Three time-related variables were constructed to support the interrupted longitudinal specification described in Section 3.7.3. Continuous time was coded sequentially from 0 to 5 across the six financial years, such that 2019/20 = 0, 2020/21 = 1, 2021/22 = 2, 2022/23 = 3, 2023/24 = 4, and 2024/25 = 5:

$$Time_t = \{0, 1, 2, 3, 4, 5\}$$

A binary indicator was used to identify the post-2022 statutory sustainability period, coded 0 for 2019/20-2021/22 and 1 for 2022/23-2024/25:

$$Post2022_t = 0 \text{ for } 2019/20\text{-}2021/22;\ 1 \text{ for } 2022/23\text{-}2024/25$$

A post-period time variable was constructed to capture the change in slope during the post-2022 statutory period. It was coded 0 for all pre-period observations and for the first post-period year (2022/23), followed by 1 in 2023/24 and 2 in 2024/25:

$$TimeAfter2022_t = \{0, 0, 0, 0, 1, 2\}$$

3.7 Statistical Analysis

3.7.1 Descriptive Analysis

Descriptive statistics, including sample size, mean, standard deviation, median, and quartiles, were computed for each core outcome across the full panel and by financial year. Annual proportions were used for the binary waste-reuse outcome, and annual means were used for the count and continuous outcomes, to characterise year-on-year variation prior to formal modelling.

3.7.2 Pre/Post Comparison

Unadjusted comparisons between the pre-2022 period (2019/20 to 2021/22) and the post-2022 period (2022/23 to 2024/25) were conducted using Welch's t-test for mean differences and the Mann-Whitney U test for distributional differences. Non-parametric tests were included alongside mean comparisons because the count and expenditure outcomes are right-skewed and zero-inflated, properties for which a comparison of means alone may not be fully informative.

3.7.3 Interrupted Longitudinal Model

The primary specification is an interrupted longitudinal regression, estimated by ordinary least squares with standard errors clustered by NHS trust to account for repeated observations within trusts:

$$Y_{it} = \beta_0 + \beta_1 Time_t + \beta_2 Post2022_t + \beta_3 TimeAfter2022_t + \varepsilon_{it}$$

In this specification, β1 represents the pre-2022 temporal trend, β2 represents the immediate level shift at the transition to the post-2022 period, and β3 represents the change in trajectory during the post-2022 statutory period. This decomposition allows the level and trend components of change to be distinguished, which a simple pre/post mean comparison cannot achieve.

3.7.4 Fixed-Effects Analysis

Trust and year fixed-effects models were estimated for the count and expenditure outcomes, with standard errors clustered by trust, to assess annual differences while accounting for unobserved time-invariant heterogeneity across trusts. Because a single national post-2022 indicator cannot be identified separately from a full set of year fixed effects, this specification is used as a descriptive check on the annual pattern of implementation rather than as an independent test of the post-2022 coefficients from the primary model.

3.7.5 Logistic Robustness Model

For the binary waste-reuse outcome, a logistic regression with trust-clustered standard errors was estimated using the same set of predictors as the primary model. Coefficients were converted to odds ratios, calculated as the exponentiated regression coefficient, to support interpretation of the trajectory-change term in a form appropriate to the binary outcome.

3.7.6 Negative-Binomial Robustness Model

For the count of energy-efficient schemes, a generalised linear model with a negative-binomial family and trust-clustered standard errors was estimated using the same interrupted-time predictors as the primary model. This specification was selected because the outcome exhibited substantial overdispersion (mean = 2.19, variance = 21.32, variance-to-mean ratio = 9.75), indicating that a standard Poisson specification would inadequately represent the observed variability. Regression coefficients were exponentiated and reported as incidence-rate ratios (IRRs) with 95% confidence intervals to characterise proportional differences in the expected scheme count associated with each model term.

3.7.7 Balanced-Panel and Winsorisation Robustness

The key interrupted longitudinal models were re-estimated using the balanced subpanel of 205 trusts reporting in all six financial years (1,230 trust-year observations) to assess whether changes in panel composition materially influenced the primary findings. As an additional sensitivity analysis, the continuous expenditure outcome and the energy-scheme count were winsorised at the 1st and 99th percentiles within the balanced-panel specification to assess whether extreme observations materially influenced the estimates. The binary waste-reuse outcome was not winsorised because it is bounded by construction.

3.7.8 Statistical Software and Inference

All data processing and statistical analyses were conducted in Python within a Google Colab environment using pandas, NumPy, SciPy, and statsmodels. Statistical tests were two-sided, with $p < .05$ used as the conventional threshold for statistical significance. Trust-clustered standard errors were used where specified to account for repeated observations within NHS trusts. Logistic and negative-binomial robustness estimates were reported as odds ratios (ORs) and incidence-rate ratios (IRRs), respectively, with 95% confidence intervals.

3.8 Missing Data and Data Quality

Two data-quality issues warrant explicit treatment. First, reported scheme expenditure exhibits a substantial reduction in coverage from 2022/23 onward, with approximately 212–224 reporting trusts per year in the pre-2022 period compared with only 100–108 per year in the post-2022 period. Because this reduction in coverage coincides with the study's intervention period, expenditure is treated throughout the analysis as a secondary, exploratory outcome rather than as a primary measure of regulatory-period implementation.

Second, a complete and consistently harmonised six-year ERIC Site-level dataset required to construct comparable

trust-level environmental-performance measures was not available within the implemented analytical pipeline. Consequently, energy intensity, waste intensity, recycling rate, the proposed Green Hospital Environmental Performance (GHEP) index, and the governance-environment linkage models were not estimated. These components are addressed as conceptual extensions for future empirical work and are not presented as outcomes of the current study.

3.9 Ethical Considerations

This study uses organisational-level public administrative data collected and published by NHS England through the ERIC return. The analysis contains no patient-identifiable information and involves no intervention with human participants. All legal and regulatory material analysed is publicly available. These characteristics are consistent with secondary analysis of publicly available institutional data.

4. Results

4.1 Sample Characteristics

The final trust-level panel comprised 1,281 trust-year observations drawn from 226 unique NHS trusts across six financial years, from 2019/20 to 2024/25. Annual reporting counts declined moderately over the study period, from 224 trusts in 2019/20 to 207 trusts in 2024/25, potentially reflecting organisational mergers and changes in NHS estates-reporting structures. A balanced subpanel of 205 trusts reported in all six years, yielding 1,230 balanced trust-year observations, which was used for the robustness analysis reported in Section 4.6. Table 2 reports the number of trusts reporting each core outcome by financial year.

Table 2: Sample and Variable Coverage by Financial Year

Financial Year	Trusts Reporting Energy Schemes	Trusts Reporting Waste-Reuse Scheme	Trusts Reporting Scheme Expenditure
2019/20	224	224	224
2020/21	216	216	216
2021/22	212	212	212
2022/23	211	211	100
2023/24	209	209	107
2024/25	207	207	108

Note. Unique trusts across the full panel = 226. Balanced-panel trusts reporting in all six years = 205 (1,230 trust-year observations). Coverage of scheme expenditure declines substantially from 2022/23 onward; this limitation is addressed directly in Section 4.7.

4.2 Descriptive Trends in Green Implementation

Across the full panel, trusts reported a mean of 2.19 energy-efficient schemes per year (SD = 4.62, median = 1.00, interquartile range 0.00 to 2.00), and 48.6 percent of trust-years included an active waste-reuse scheme. Overall descriptive statistics for the three core implementation outcomes are reported in Table 3.

Table 3: Descriptive Statistics for Core Implementation Outcomes, Full Panel (2019/20–2024/25)

Variable	N	Mean	SD	Median	25th Pctl.	75th Pctl.
Energy-efficient schemes (count)	1,279	2.19	4.62	1.00	0.00	2.00
Scheme expenditure (£)	967	709,677	2,424,475	100,000	0	488,738
Waste-reuse scheme (0/1)	1,279	0.49	0.50	0.00	0.00	1.00

Annual trends diverge markedly between the two core implementation outcomes. The mean number of energy-efficient schemes rose from 1.94 in 2019/20 to a peak of 2.64 in 2021/22, fell to 1.99 immediately following the 2022 statutory change, and recovered gradually to 2.32 by 2024/25 (Fig 2). Waste-reuse scheme prevalence followed a different trajectory: prevalence stood at 54.9 percent in 2019/20, rose to 60.2 percent in 2020/21, then declined sharply to 42.0 percent in 2021/22 and 39.8 percent in 2022/23, before recovering to 44.5 percent in 2023/24 and 49.3 percent in 2024/25 (Fig 3). The pre-2022 decline in waste-reuse prevalence is material to the interpretation of the pre/post comparison reported in Section 4.3, since it indicates that a simple average comparison risks conflating a pre-existing downward trend with any post-2022 change in trajectory.

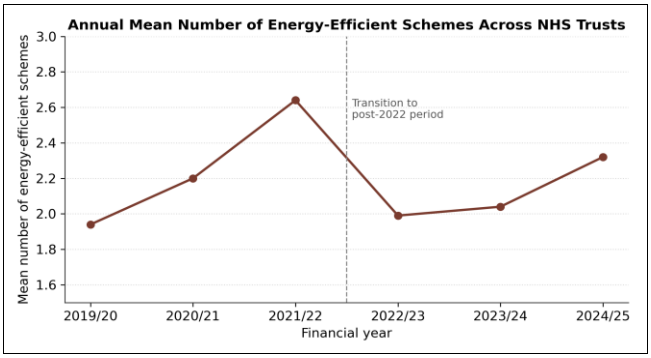


Fig 2: Annual mean number of energy-efficient schemes across NHS trusts, 2019/20–2024/25

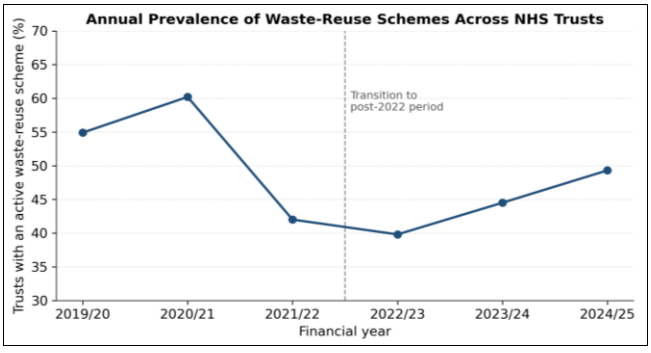


Fig 3: Annual prevalence of waste-reuse schemes across NHS trusts, 2019/20–2024/25

4.3 Simple Pre/Post-2022 Comparisons

Unadjusted comparisons of the pre-2022 period (2019/20 to 2021/22) and the post-2022 period (2022/23 to 2024/25) indicate that mean waste-reuse prevalence fell from 52.5 percent to 44.5 percent, a difference of 7.96 percentage points (Welch t = 2.85, p = .004; Mann-Whitney U = 220,665, p = .004). Considered in isolation, this comparison would suggest a negative association between the strengthened statutory sustainability environment and waste-reuse implementation. This raw average, however, obscures a downward trajectory that predates 2022, because a simple pre/post mean comparison collapses the level and trend components of change into a single, less interpretable difference. The interrupted longitudinal specification reported in Section 4.4 separates the level and trend components and therefore provides a more informative assessment of the post-2022 pattern.

Energy-efficient scheme counts did not differ significantly between the pre- and post-2022 periods in the unadjusted comparison (mean change = -0.14, Welch t = 0.54, p = .590), although the Mann-Whitney test detected a significant distributional shift (U = 219,329.5, p = .016), consistent with the low-count, zero-inflated nature of this variable rather than a clear directional change. Scheme expenditure increased substantially in raw terms, from a mean of £550,736 pre-2022 to £1,038,658 post-2022 (Welch t = -2.48, p = .013; Mann-Whitney p < .001), though this measure is subject to the substantial missing-data limitation addressed in Section 4.7.

4.4 Interrupted Longitudinal Results

Table 4 reports coefficients from the primary interrupted longitudinal model, estimated with standard errors clustered by NHS trust:

$$Y_{it} = \beta_0 + \beta_1 Time_t + \beta_2 Post2022_t + \beta_3 TimeAfter2022_t + \varepsilon_{it}$$

Table 4: Interrupted Longitudinal Regression Results (Trust-Clustered Standard Errors)

Outcome	Term	Coefficient	Clustered SE	p
Energy-efficient schemes (n)	Time	0.347	0.171	.042
	Post-2022	-1.002	0.454	.027
	Time After 2022	-0.183	0.281	.515
Scheme expenditure (£)	Time	226,458	89,602	.011
	Post-2022	205,793	486,139	.672
	Time After 2022	-397,079	210,333	.059
Waste-reuse scheme	Time	-0.064	0.017	<.001
	Post-2022	0.002	0.037	.963
	Time After 2022	0.111	0.025	<.001

Note. N = 1,279 (energy-efficient schemes; waste-reuse scheme), N = 967 (scheme expenditure); 226 trusts. Time is coded in years from the start of the panel; Post-2022 is an indicator for financial years from 2022/23 onward; Time After 2022 captures the change in slope during the post-2022 statutory period.

For waste-reuse implementation, the model indicates a significant negative pre-2022 trend (β = -0.064, p < .001), no significant immediate level shift at the transition to the post-2022 period (β = 0.002, p = .963), and a significant positive change in trajectory thereafter (β = 0.111, p < .001). This pattern indicates that waste-reuse implementation was declining prior to 2022 and that the rate of decline reversed materially afterward, rather than producing an abrupt change in level. This significant post-2022 change in trajectory represents the principal quantitative finding of the analysis.

For energy-efficient scheme counts, the model indicates a significant positive pre-2022 trend (β = 0.347, p = .042), a significant negative immediate level shift (β = -1.002, p = .027), and no significant subsequent change in trajectory (β = -0.183, p = .515). Scheme expenditure shows a significant positive pre-2022 trend (β = £226,458, p = .011) and no significant immediate level shift (β = £205,793, p = .672); the trajectory-change term approaches but does not reach conventional significance (β = -£397,079, p = .059).

Trust and year fixed-effects models indicate that the dip in energy-efficient scheme counts is concentrated specifically in the 2022/23 financial year relative to the 2019/20 baseline, although none of the individual year effects for scheme counts reach significance once trust-level heterogeneity is accounted for. Because a single national post-2022 indicator cannot be identified separately from a full set of year fixed effects, this specification is reported as a descriptive check on the annual pattern rather than as an independent test of the post-2022 coefficients reported above.

4.5 Logistic Robustness: Waste-Reuse Implementation

To confirm the primary linear probability result for the binary waste-reuse outcome, a logistic specification with trust-clustered standard errors was estimated. Table 5 reports odds ratios alongside the corresponding incidence-rate ratios from the negative-binomial model described in Section 4.6. The trajectory-change term is significant and substantively large (OR = 1.566, 95% CI 1.285–1.908, p < .001), confirming the direction and significance of the primary linear result. The immediate level-shift term remains non-significant (OR = 1.005, 95% CI 0.748–1.350, p = .975), and the pre-2022 trend term indicates declining odds of an active waste-reuse scheme prior to 2022 (OR = 0.774, 95% CI 0.673–0.890, p < .001). The odds ratio for the trajectory-change term should be interpreted as a shift in the odds trajectory relative to the pre-intervention trend, and not as an annual percentage increase in waste-reuse prevalence.

4.6 Energy-Efficiency Schemes: Distribution-Appropriate and Balanced-Panel Robustness

Because the variance of the energy-efficient scheme count (21.32) substantially exceeds its mean (2.19; variance-to-mean ratio = 9.75), a negative-binomial specification was used to accommodate overdispersion. The immediate post-2022 level term was significant and negative (IRR = 0.642, 95% CI 0.444–0.928, p = .018), corresponding to an estimated 35.8% lower expected count of energy-efficient schemes at the transition to the post-2022 period, conditional on the pre-existing temporal trend. The subsequent trajectory-change term is not significant (IRR = 0.926, 95% CI 0.729–1.178, p = .532), indicating no detectable change in the rate of growth in scheme counts following the initial level shift. The pre-2022 trend term is positive and significant (IRR = 1.165, 95% CI 1.016–1.336, p = .028).

Table 5: Logistic, Negative-Binomial, and Balanced-Panel Robustness Models

Outcome	Model	Term	Estimate	95% CI	p
Waste-reuse scheme	Logistic (OR)	Time	0.774	0.673–0.890	<.001
		Post-2022	1.005	0.748–1.350	.975
		Time After 2022	1.566	1.285–1.908	<.001
Energy-efficient schemes	Negative binomial (IRR)	Time	1.165	1.016–1.336	.028
		Post-2022	0.642	0.444–0.928	.018
		Time After 2022	0.926	0.729–1.178	.532
Waste-reuse scheme (balanced panel, n = 205 trusts)	OLS/LPM	Post-2022	0.015	—	.677
		Time After 2022	0.112	—	<.001
Energy-efficient schemes (balanced panel, n = 205 trusts)	OLS	Post-2022	-0.850	—	.047
		Time After 2022	-0.294	—	.209

Balanced-panel robustness, restricted to the 205 trusts reporting in all six years, reproduces the primary pattern: the immediate post-2022 reduction in energy-efficient scheme counts remains significant (β = -0.850, p = .047), and the waste-reuse trajectory-change term remains significant and of comparable magnitude to the full-panel estimate (β = 0.112, p < .001). This indicates that the primary findings are not attributable to compositional changes in the reporting panel across years.

4.7 Energy-Efficiency Scheme Expenditure

Reported scheme expenditure carries a substantial data-quality limitation. Coverage falls from 224, 216 and 212 reporting trusts in 2019/20 through 2021/22 to 100, 107 and 108 reporting trusts in 2022/23 through 2024/25 respectively, a reduction of approximately half the reporting base. Although the raw mean increases from approximately £550,736 pre-2022 to £1,038,658 post-2022, the interrupted longitudinal model does not identify a statistically significant post-2022 level shift (p = .672), and the balanced-panel specification likewise finds no significant effect (p = .900 for the level shift; p = .142 for the trajectory-change term). Given this missing-data pattern and the absence of a robust effect once trust-clustered standard errors and panel-composition checks are applied, expenditure is treated as a secondary, exploratory outcome and is not used as evidence of a regulatory-period implementation effect.

4.8 Leadership and Governance Indicators

Supplementary governance indicators, reported descriptively because of period-specific measurement changes in the underlying ERIC fields, provide mixed but generally strengthening signals of organisational sustainability-management capacity across the years for which individual measures are comparable. Waste-manager presence rose from 67.0 percent in 2019/20 to 73.5 percent in 2022/23, the final year for which the yes/no measure was collected before ERIC revised the field to a whole-time-equivalent measure. Energy-manager presence remained comparatively stable, ranging between 59.4 percent and 60.6 percent across 2020/21 through 2022/23. Green-energy usage rose markedly across the three years for which the measure is available, from 22.3 percent in 2019/20 to 41.2 percent in 2020/21 and 65.1 percent in 2021/22. Heat-decarbonisation planning or implementation indicators rose from 26.4 percent in 2021/22 to 34.6 percent in 2022/23. These patterns are reported as descriptive evidence of evolving organisational governance capacity and should not be interpreted as causally linked to the interrupted longitudinal results reported above, given the absence of a consistent multi-year measurement of any single governance indicator.

4.9 Robustness Summary and Hypothesis Evaluation

Table 6 summarises the evidentiary basis for each hypothesis in light of the results reported above.

Table 6: Hypothesis Evaluation and Evidence Synthesis

Hypothesis	Decision	Key Evidence
H1: Green-governance implementation changes significantly over time across NHS trusts.	Supported	Significant temporal coefficients were observed across the interrupted models, including pre-2022 trends in both core outcomes and a significant post-2022 trajectory change in waste-reuse implementation.
H2: The post-2022 regulatory and legal environment is associated with significant changes in implementation trajectories.	Partially supported	Waste-reuse trajectory change significant (OR = 1.566, p < .001); energy-scheme trajectory change not significant (IRR = 0.926, p = .532).
H3: Post-2022 changes differ across implementation domains rather than occurring uniformly.	Supported	Contrasting pattern between waste-reuse trajectory reversal and energy-scheme immediate level reduction.
H4: Organisational sustainability-management capacity strengthens over the study period.	Partially supported	Waste-manager presence and green-energy usage increase substantially; energy-manager presence remains stable; no indicator has consistent six-year coverage.

H1 is supported: significant temporal coefficients are observed across the interrupted models, including pre-2022 trends in both core outcomes and a significant post-2022 trajectory change in waste-reuse implementation. H2 is partially supported: waste-reuse implementation shows a significant and substantial trajectory change, whereas energy-efficient scheme counts show a significant immediate level shift but no corresponding change in trajectory. H3 is supported by the contrasting pattern observed between the two core outcomes. H4 is partially supported: waste-manager presence and green-energy usage increase substantially over the years for which data are available, whereas energy-manager presence remains comparatively stable and no single governance indicator

carries consistent six-year coverage.

5. Discussion

5.1 Summary of Principal Findings

The empirical analysis reported in Section 4 supports three principal conclusions. First, NHS green-governance implementation changed materially across the 2019/20 to 2024/25 panel, with significant pre-2022 trends evident in both energy-efficient scheme counts and waste-reuse scheme prevalence (Section 4.4). Second, waste-reuse implementation exhibited a strong and statistically robust positive change in trajectory following the 2022 statutory transition (OR = 1.566, 95% CI 1.285–1.908, $p < .001$), a result confirmed across the logistic and balanced-panel specifications (Sections 4.5 and 4.6). Third, energy-efficient scheme counts did not display the same pattern: a significant immediate negative level shift at the 2022 transition (IRR = 0.642, $p = .018$) was not followed by any significant change in subsequent trajectory (IRR = 0.926, $p = .532$). Taken together, these results support H1 and H3, while offering only partial support for H2 and H4 (Section 4.9). This pattern of qualified rather than uniform support is itself the most analytically important finding of the study, and it structures the interpretation that follows.

5.2 Regulatory and Legal Accountability Interpretation

The waste-reuse result is consistent with the institutional expectation, developed in Section 2.3, that strengthened regulatory and legal accountability may be associated with organisational change through evolving implementation trajectories rather than only through an immediate, one-off adjustment. The significant TimeAfter2022 coefficient (Section 4.4), alongside the non-significant Post2022 level term, indicates a positive change in the waste-reuse trajectory during the post-2022 statutory period. This pattern is compatible with the gradual institutional-pressure mechanism discussed in Section 2.4, although it cannot be attributed specifically to the Health and Care Act 2022 because other sustainability-governance mechanisms developed during the same period (DiMaggio & Powell, 1983; "Health and Care Act 2022," 2022) [9, 16].

This result nonetheless sits in tension with Marculetiu *et al.* (2026) [18], who find no significant association between coercive institutional pressure and either symbolic or substantive sustainability strategy across 388 US supply chain organisations. Two explanations for this divergence are worth considering critically rather than dismissing the tension. NHS trusts operate within a considerably more centralised public accountability structure than the private supply-chain firms studied by Marculetiu *et al*., which may make coercive pressure more consequential in this setting than in a diffuse private-sector market. Alternatively, the waste-reuse trajectory change may in part reflect a reversal of a pre-existing downward trend and post-pandemic recovery in organisational capacity rather than a response to the Health and Care Act specifically, a possibility the interrupted design cannot fully exclude (Section 4.3). Both explanations are consistent with the data, and the analysis cannot adjudicate definitively between them.

5.3 Leadership and Organisational Capacity

Supplementary governance indicators show a broadly strengthening pattern over the years for which they are available: waste-manager presence rose from 67.0 percent to 73.5 percent between 2019/20 and 2022/23, and green-energy usage rose from 22.3 percent to 65.1 percent between 2019/20 and 2021/22, while energy-manager presence remained comparatively stable (Section 4.8). Consistent with the caution established in Section 2.2, these indicators are treated here as evidence of organisational sustainability-management capacity rather than as direct measures of leadership commitment, since ERIC does not provide a consistent six-year board-level leadership measure.

Read alongside the implementation results, this evidence is compatible with a theoretical translation logic in which external institutional pressure may be translated into operational change through internal governance capacity:

> *External Institutional Pressure → Governance Responsibility → Implementation Capacity → Operational Change*

This logic reconnects to the GH-GAF pathway from LC to GGI (Section 2.8), while stopping short of claiming it as a directly estimated relationship. Aboueid *et al*. (2023) [1] identify leadership with a clear vision as a key enabler of environmentally sustainable practice in healthcare, and Robinson *et al*. (2025) [21] similarly find strong local leadership a consistently cited enabler within London NHS trusts, though one regularly undermined by funding constraints and infrastructural limitations beyond any single trust's control. The present results are consistent with both accounts: governance capacity strengthened broadly, but this strengthening did not translate uniformly into implementation, a divergence addressed directly in Section 5.4.

5.4 Why Did Outcome (Saha *et al*., 2025)s [23] Respond Differently?

The contrast between waste-reuse and energy-efficient scheme outcomes is arguably the most theoretically informative result in the study, and it resists a single-indicator account of regulatory effectiveness. Waste-reuse schemes are comparatively low-capital, procedural and behavioural interventions that can often be implemented within existing infrastructure and budgets. Energy-efficient schemes, by contrast, typically require capital investment, procurement lead times and estates-level coordination, meaning their implementation is considerably more resource- and time-intensive (Saha *et al*., 2025) [23]. This asymmetry offers a plausible, if not the only possible, explanation for why waste-reuse implementation showed a sustained positive trajectory change while energy-efficient scheme counts showed only an immediate level reduction followed by stagnation. This mechanism was not directly tested in the present analysis, because trust-level capital availability, procurement lead times and estates constraints were not included as explanatory variables; it should therefore be interpreted as a theoretically informed explanation of the observed heterogeneity rather than as an empirically identified mediator.

This pattern is well explained by Oliver (1991)'s [20] typology of strategic responses to institutional processes, which predicts that organisational responses to a common institutional pressure range from acquiescence to defiance depending on the alignment between that pressure and available organisational resources. Capano and Lepori (2024) [6] apply this logic directly to public sector

organisations, including healthcare, arguing that compliance is most likely when institutional pressure aligns with resource availability, while resource-constrained domains are more prone to strategic gaming or symbolic compliance. Harpur *et al*. (2024) [15], in a forcefield analysis of sustainable healthcare delivery across NHS Scotland, independently identify lack of resource as a major barrier specifically for capital-intensive organisational change, reinforcing a domain-specific reading of the present results. Formally:

Same Regulatory Environment ≠ Same Organisational Response

This is a central reason why environmental regulation in healthcare should not be evaluated using a single sustainability indicator, and why this study's use of two implementation outcomes, rather than one, is analytically necessary rather than incidental.

5.5 Governance-Implementation Gap

The governance-implementation gap construct introduced in Section 2.6 cannot be directly estimated in the present study, since it requires the GHEP measure that the unavailable ERIC Site-level data would have supported. The heterogeneous pattern of results does, however, illustrate the conceptual relevance of distinguishing formal governance capacity from domain-specific implementation. Governance indicators strengthened relatively broadly across the study period (Section 4.8), while implementation outcomes diverged sharply between domains (Sections 4.4 to 4.6). A visible governance signal accompanied by markedly uneven implementation is precisely the pattern that motivates the governance-implementation gap as a construct worth measuring directly in future research, even though it cannot be quantified here.

Bromley and Powell (2012)'s [4] distinction between policy-practice decoupling and means-ends decoupling is a useful refinement of this interpretation. The energy-efficient scheme pattern is conceptually compatible with means-ends decoupling, in which formal governance mechanisms do not necessarily translate into sustained progress toward substantive outcomes. However, because the present study does not directly measure the relevant governance-performance gap, this interpretation should be treated as a theoretical proposition for future testing rather than as evidence that decoupling occurred within the sampled trusts. The corporate ESG decoupling literature from which this distinction derives (Cepêda *et al*., 2025) [8] has rarely been applied to public healthcare governance, which underlines the novelty and the current limits, of extending it here.

5.6 Comparison with Previous Literature

The broadly strengthening governance-capacity indicators are consistent with Bauer *et al*. (2025) [2], Calabrese *et al*. (2023) [5] and Sijm-Eeken *et al*. (2024) [24], each of which identifies governance capacity as important to sustainability implementation in healthcare organisations. The present study complements this literature by documenting longitudinal changes in governance-capacity indicators alongside implementation trajectories, without directly estimating a causal relationship between the two.

On the effect of regulatory and institutional pressure, the present results occupy a middle position within a contested literature. They sit closer to Graafland and Smid (2019) [14], who find partial rather than complete decoupling between CSR policy and CSR outcomes, than to Marculetiu *et al*. (2026) [18], who find no significant effect of coercive pressure on sustainability strategy. The sectoral difference, public healthcare governance under a centralised statutory duty as against private multinational CSR policy and diffuse US supply-chain pressure, may explain at least part of this divergence, though the present design cannot test that explanation directly.

On whether organisational responses differ by resource context, the present results align closely with Oliver (1991) [20], Capano and Lepori (2024) [6], Harpur *et al*. (2024) [15] and Aboueid *et al*. (2023) [1], all of which identify resource availability as a key moderator of institutional compliance. On the question of symbolic versus substantive response, the waste-reuse trajectory more closely resembles a substantive, sustained change than the energy-efficient scheme pattern, which more closely resembles the means-ends decoupling described by Bromley and Powell (2012) [4].

Finally, Weimann and Weimann (2022) [25], comparing NHS and German healthcare governance, find the UK's more centralised and legally embedded approach to sustainability governance more advanced than Germany's decentralised, bottom-up model. The present finding, that a UK statutory duty is associated with measurable, if heterogeneous, trajectory change, is broadly consistent with that comparative assessment, while adding the qualification that even within a relatively centralised system, implementation heterogeneity across sustainability domains persists.

5.7 Theoretical Implications

These findings extend institutional theory in a specific direction. Coercive institutional pressure, represented here by the 2022 statutory transition, did not produce the homogeneous implementation that classical accounts of institutional isomorphism would predict (DiMaggio & Powell, 1983) [9]. This departure is not, however, a rejection of institutional theory so much as a confirmation of its resource-dependence-augmented variant: Oliver (1991) [20] explicitly predicted that organisational responses to institutional pressure vary with resource alignment, and the present results are consistent with that prediction rather than with strict isomorphic convergence. The relationship can be summarised as:

Regulatory Pressure (moderated by organisational capacity) → Domain-Specific Implementation

This pattern refines the theoretical contribution of GH-GAF (Section 2.8): legal and regulatory responsibility can be conceptualised as an external accountability influence, while leadership and governance capacity represent potential internal mechanisms through which external pressures may be translated into domain-specific implementation. The present findings are consistent with this layered interpretation but do not separately identify or causally estimate these pathways. External accountability and internal governance capacity are therefore best understood within GH-GAF as distinct but potentially interacting influences rather than as independently sufficient causes.

5.8 Managerial Implications

For NHS trust leadership, four implications follow directly

from these results. Named board-level sustainability responsibility should be paired with measurable implementation targets rather than presence indicators alone, because formal governance presence does not necessarily demonstrate corresponding implementation progress. Investment in energy and waste management capacity should be prioritised in capital- and infrastructure-intensive domains, which warrant particular attention given the absence of sustained improvement observed in the energy-efficient scheme trajectory. Elbardan *et al*. (2026) [10] find that the effectiveness of climate-linked accountability mechanisms is amplified when supported by robust governance structures, an argument that translates directly into a recommendation that NHS boards link net zero leadership roles to measurable, domain-specific key performance indicators rather than to generic governance presence. Annual board-level review of implementation progress, of the kind envisaged in the outcomes and control domain of Sijm-Eeken *et al*. (2024)'s [24] maturity model, would additionally allow trusts to identify stalled domains before they become entrenched. Finally, sustainability strategy should be domain-specific rather than generic, given the clear divergence documented in Section 5.4 between waste-reuse and energy-efficiency trajectories.

5.9 Regulatory and Legal Implications

For regulators and policymakers, the central implication is that assessing policy adoption, whether a trust has published a Green Plan or named a net zero lead, is insufficient to detect the pattern identified in this study. Adoption-based metrics alone would not capture the contrasting trajectories observed across waste-reuse and energy-efficiency implementation domains. A trajectory-based accountability structure is better suited to this task:

Duty → Named Responsibility → Measurable KPI → Disclosure → Review → Corrective Action

This recommendation is reinforced by Robinson *et al*. (2025) [21], whose own policy recommendation, drawn from interviews with London NHS sustainability staff, calls for increased regulatory sensitivity to trust-level context and greater support for underperforming trusts rather than uniform national targets alone. The present study's quantitative evidence of domain-specific heterogeneity provides an empirical basis for that qualitative recommendation.

5.10 Limitations

Several limitations qualify these findings and should be stated explicitly. The design is observational: no NHS trust or comparable system escaped the Health and Care Act 2022, so no untreated control group exists, and the interrupted longitudinal approach identifies temporal association rather than causal effect. The analysis cannot isolate the Act from contemporaneous initiatives, including procurement weighting and the incorporation of Green Plan delivery into CQC assessment from 2023 onward (Section 2.5), both of which overlap substantially with the post-2022 period under examination. ERIC field definitions and coverage changed across the study period, most notably the shift from yes/no manager indicators to whole-time-equivalent staffing measures in 2023/24 (Section 3.5), which prevents a single, harmonised six-year governance-capacity series. Scheme expenditure data suffer from a substantial coverage collapse from 2022/23 onward and are accordingly treated as secondary and exploratory (Section 3.8).

Most significantly, because a complete and consistently harmonised six-year ERIC Site-level environmental dataset was not incorporated into the present analytical pipeline, the GIG and GHEP constructs developed in Section 2.6, and the GGI → Environmental Performance pathway of GH-GAF (Fig 1), remain untested. This study evaluates governance implementation, not environmental performance, and the two should not be conflated when interpreting the results. Possible trust mergers and organisational restructuring over the study period may also affect panel composition; this concern is partially addressed through the balanced-panel robustness check (Section 4.6) but cannot be fully eliminated. Finally, the national NHS context limits generalisability. Weimann and Weimann (2022) [25] demonstrate that the German healthcare system's decentralised, bottom-up governance model differs substantially from the NHS's centralised statutory structure, and the trajectory-based findings reported here may not transfer directly to health systems with different institutional architectures.

6. Conclusion

6.1 Overall Conclusion

This study set out to examine how leadership, regulatory pressure and legal responsibility are associated with green-governance implementation across NHS trusts, with particular attention to change surrounding the strengthened statutory sustainability environment introduced in 2022 (Section 1.4). The evidence reported in Sections 4 and 5 supports a qualified answer to this question. Green-governance implementation changed significantly over the study period (H1, supported), and the pattern of change differed markedly across implementation domains rather than occurring uniformly (H3, supported). The post-2022 regulatory and legal environment is associated with significant change in at least one implementation domain, though not consistently across domains (H2, partially supported), and organisational sustainability-management capacity strengthened over the study period for the indicators with available coverage, though not for all of them (H4, partially supported). Taken together, these findings indicate that the strengthened post-2022 statutory and regulatory sustainability environment coincided with observable but heterogeneous changes in green-governance implementation across NHS trusts. The evidence therefore does not support a simple interpretation of uniformly positive regulatory effects; implementation trajectories differed materially across sustainability domains. This heterogeneous pattern, rather than a simple confirmation of regulatory effectiveness, is the central empirical contribution of the study.

6.2 Main Empirical Contribution

The clearest empirical result is the contrast between the two core implementation outcomes. Waste-reuse implementation exhibited a significant, substantial and robust positive change in trajectory following the 2022 statutory transition:

$$OR_{TimeAfter2022} = 1.566,\ 95\%\ CI\ 1.285–1.908,\ p < .001$$

A result confirmed across the primary interrupted longitudinal model, the logistic robustness specification and the balanced-panel check (Sections 4.4 to 4.6). Energy-efficient scheme counts, by contrast, showed a significant immediate reduction in level at the point of transition:

$$IRR_{Post2022} = 0.642,\ 95\%\ CI\ 0.444–0.928,\ p = .018$$

That was not followed by any significant subsequent change in trajectory ($IRR_{TimeAfter2022} = 0.926$, $p = .532$). This contrast, a sustained positive trajectory change in one domain against an initial adjustment with no further progress in another, is the central empirical finding of the paper and the primary evidence for treating implementation as domain-specific rather than uniform.

6.3 Theoretical Contribution

Theoretically, these findings extend the Green Hospital Governance and Accountability Framework (GH-GAF) developed in Section 2.8:

Legal/Regulatory Pressure → Governance Responsibility → Implementation Capacity → Domain-Specific Sustainability Action

Legal and regulatory responsibility is best conceptualised as an external accountability mechanism that establishes the conditions under which organisational change becomes more likely, rather than as a mechanism that automatically produces environmental performance once enacted. Within GH-GAF, governance responsibility and implementation capacity are conceptualised as potential internal mechanisms through which external accountability may be translated into domain-specific action. The present findings are consistent with this layered account but do not separately identify or causally estimate these pathways (Section 5.7). This reframing has a direct implication for how legal responsibility should be evaluated in future healthcare sustainability research: not as a single causal lever expected to produce uniform performance, but as one input into a governance system whose effectiveness depends on domain-specific implementation capacity.

6.4 Future Research

Several directions for future research follow directly from the limitations discussed in Section 5.10. Foremost among these is linking ERIC trust-level governance data with a harmonised ERIC Site-level environmental dataset, which would allow the Green Hospital Environmental Performance (GHEP) measure and the governance-implementation gap (GIG) construct proposed in Section 2.6 to be estimated directly rather than treated as conceptual extensions. Related to this, direct modelling of energy-intensity and waste-intensity outcomes, rather than scheme counts and scheme presence alone, would provide a more performance-proximate test of the GGI to Environmental Performance pathway in GH-GAF. Where comparable data from an appropriate control system become available, a difference-in-differences design would strengthen causal inference beyond what the interrupted longitudinal approach used here can support. Qualitative interviews with NHS sustainability leaders would help establish whether the capacity-based explanation proposed in Section 5.4 for domain-specific heterogeneity is consistent with practitioners' own accounts of why some implementation domains progressed while others stalled. Trust-type heterogeneity analysis, disaggregating by acute, community, mental health and ambulance trusts, would test whether the aggregate patterns reported here mask further heterogeneity at the organisational-type level. Finally, a longer post-2022 follow-up period would help distinguish a genuinely stalled energy-efficiency trajectory from one that simply requires more time to materialise, given the capital-intensive nature of that implementation domain (Section 5.4).

Overall, this study demonstrates that sustainable healthcare governance should be evaluated not simply by the presence of formal commitments, leadership structures or statutory duties, but by whether these governance arrangements are accompanied by sustained implementation across distinct operational domains. The NHS evidence shows that implementation trajectories can diverge substantially within the same national regulatory environment. Effective green-hospital governance therefore requires accountability structures that are sensitive to domain-specific implementation capacity and capable of tracking progress beyond formal policy adoption. By integrating these insights within GH-GAF, the study provides a foundation for more implementation-sensitive evaluation of sustainability governance in healthcare.

7. References

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