Investigating potential health and health equality impacts of permitted development housing in England

Overall project report



UCL

Health Impacts of Converted Housing

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tcpa

Groundswell

Out of homelessness

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List of Acronyms and Abbreviations

BSR	Building Safety Regulator
CAZ	Central Activities Zone (in London)
CIEH	Chartered Institute for Environmental Health
CIL	Community Infrastructure Levy
CQC	Care Quality Commission
DC	District Council
DCLG	Department for Communities and Local Government, renamed the Ministry of Housing, Communities and Local Government in 2018
DHS	Decent Homes Standard
DLUHC	Department for Levelling Up, Housing and Communities, renamed the Ministry of Housing, Communities and Local Government in 2024
EA	Emergency Accommodation
EPC	Energy Performance Certificate
GIA	Gross Internal Area
GLA	Greater London Authority
GPDO	General Permitted Development Order
HMO	House in Multiple Occupation
HHSRS	Housing Health and Safety Rating System
LB	London Borough
LPA	Local Planning Authority
LGA	Local Government Association
MCU	Material Change of Use
MHCLG	Ministry of Housing, Communities and Local Government (2018 – 2021; 2024 – Present)
MCU	Material Change of Use
NDSS	Nationally Described Space Standard
NIHR	National Institute for Health and Care Research
NPPF	National Planning Policy Framework
PA	Prior approval
PD	Permitted Development
PDR	Permitted Development Rights
PRS	Private Rented Sector
RBCA	Registered Building Control Authority
RICS	Royal Institute for Chartered Surveyors
RSH	Regulator for Social Housing
RBCA	Registered building control approver
S106	Section 106 (Town and Country Planning Act 1990)
SoS	Secretary of State
SPD	Supplementary Planning Document
SPG	Supplementary Planning Guidance
TA	Temporary Accommodation
TCPA	The Town and Country Planning Association
UCL	University College London

Acknowledgements and research ethics

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Overall ethical approval for this study was obtained from UCL's Research Ethics Committee, Project ID: 24943/001. In relation to Work Package 1 health data, the NHS London – Surrey Research Ethics Committee gave a favourable opinion, REC reference: 23/LO/0976, and the NHS Confidentiality Advisory Group fully supported the study, CAG reference: 23/CAG/0177.

Illustrative photographs of the exterior of PDR housing used throughout this report were taken variously by the UCL team and Rob Clayton (commissioned by the TCPA). Internal photographs within PDR housing were taken as part of this project and we thank those residents who gave consent to share these images of their living circumstances.

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Executive Summary

Background

The expansion of Permitted Development Rights (PDR) in England since 2013 has enabled the conversion of offices, retail premises, agricultural buildings and other non-residential properties into housing without the need for full planning permission. These reforms were introduced principally to increase housing supply and encourage the reuse of existing buildings. As a form of planning deregulation, PDR has contributed to housing delivery, but concerns have been raised through existing research about the quality, location and suitability of some homes produced through this route.

Given existing knowledge about the important link between housing and health, this report presents findings from a major multidisciplinary research programme funded by the National Institute for Health and Care Research (NIHR) that investigated the health, wellbeing and health equality impacts of housing created through PDR.[1] Bringing together expertise from urban planning, public health, housing studies, building physics and environmental epidemiology, the study provides the most comprehensive assessment of PDR housing undertaken to date.

1. The project was funded by the NIHR as NIHR award ID 150963, see **Investigating potential health and health equality impacts of planning deregulation: The case of permitted development housing in England – NIHR Funding and Awards**

Across five interconnected work packages, the project examined where PDR homes are located, who lives in them, residents' lived experiences, indoor environmental conditions, potential health impacts including utilisation of healthcare services, self-report mental wellbeing and modelled potential health economic costs, and the policy and regulatory context that has shaped these developments.

Key findings

PDR housing is often located in environments associated with health risks

The project identified more than 77,000 individual PDR homes across England, with hotpsots in London and surrounding towns in the South East of England as well as key cities such as Birmingham, Bristol and Leicester. Office-to-residential conversions into flats accounted for the majority of units. Analysis of locations revealed that many PDR homes are situated in environments that would normally receive much closer scrutiny through the planning system. Around four in ten PDR homes were located close to uses potentially incompatible with residential occupation, including industrial facilities, vehicle repair businesses, waste management activities and night-time economy uses.

Many homes were also located close to major roads and other sources of air pollution. In Greater London, almost half of identified PDR homes were within 50 metres of a major road (A road or motorway). Many were located in areas experiencing significantly elevated levels of fine particulate pollution ($PM_{2.5}$) and environmental heat vulnerability. At the same time, some forms of PDR housing, particularly agricultural conversions, but also some conversions in industrial estates and business park locations, were found to be isolated from essential services and infrastructure, including primary healthcare, schools and public transport.

These findings suggest that planning deregulation has allowed residential development in locations that expose residents to environmental risks while limiting access to amenities known to support health and wellbeing.

Housing quality concerns remain widespread

Although regulatory changes introduced in 2020 and 2021 appear to have improved some aspects of PDR housing (with regard to natural light and minimum space standards), important quality concerns remain.

To understand the 2021 regulatory change around Nationally Described Space Standards compliance, we analysed Energy Performance Certificate (EPC) data on floorspace. This showed a significant increase in average total internal floorspace and space standards compliance for studio flats given prior approval in 2022–23 compared to 2013–19. The analysis also produced further evidence that the housing created prior to the introduction of minimum space standards often had extremely limited floor space: more than 16,000 identified units were potentially smaller than 37 square metres (nearly 30% of those we have this data for), with some exceptionally small units far below this threshold.

Other data from our study highlights housing design quality issues beyond just space standards, in addition to locational concerns. Across several datasets, our analysis has found that housing quality typically varied between conversion types. Agricultural conversions generally produced larger homes and showed much higher levels of compliance with NDSS than commercial-to-residential conversions, tended to have better indoor environmental quality and were less likely to be in areas with increased levels of air and noise pollution. Some data suggest that larger conversion schemes tended to produce lower quality housing than smaller developments. Poorer quality housing was often concentrated in more socio-economically deprived areas, raising important concerns about environmental and housing inequalities.

Residents report multiple housing problems

A national survey of more than 1,000 residents found widespread concerns about housing quality and everyday living conditions. Three quarters of respondents reported at least one significant housing problem and over half reported problems across multiple domains. The most commonly reported concerns related to:

- Lack of space and overcrowding
- Noise disturbance (36.1% agreed or strongly agreed that outdoor noise caused them, or someone in their household, trouble sleeping)
- Poor thermal comfort (keeping comfortable in hot summer weather was problematic for 45.4% of respondents)
- Ventilation problems
- Safety and security concerns
- Limited natural light
- Damp and mould
- Poor neighbourhood environments

Residents living in studios, larger developments and office conversions generally reported poorer outcomes than those living in other types of PDR housing.

Vulnerable groups experience disproportionate impacts

One of the most striking findings concerns the experiences of residents in temporary and emergency accommodation located within PDR schemes. The research estimates that more than 13,000 people may currently be living in temporary or emergency accommodation located within PDR conversions.

Many of these residents reported extreme housing difficulties, including overheating, overcrowding, inadequate storage, safety concerns, feeling of insecurity and social isolation. Importantly, accommodation described as 'temporary' was often occupied for years rather than months. Parents reported concerns about the impacts of housing conditions on children's development, education and wellbeing. These findings suggest that some of the most vulnerable residents in England are being concentrated in some of the poorest-quality housing environments.

Indoor environmental conditions present significant health concerns

Monitoring undertaken in 47 PDR homes revealed important concerns regarding indoor environmental quality. The study found evidence:

- Summer overheating (around 30% of monitored homes experienced potentially problematic overheating during summer periods)
- Winter underheating
- Elevated humidity levels
- Increased concentrations of indoor air pollutants, particularly fine particulate matter ($PM_{2.5}$) and carbon dioxide (CO_2) (seasonal $PM_{2.5}$ averages exceeded the World Health Organization (WHO) annual guideline value of 5 $\mu g/m^3$ in 40 of 42 homes in summer).

Many homes simultaneously experienced cold indoor temperatures during winter and elevated humidity levels, creating conditions that may contribute to damp and mould growth. Indoor air quality was also a concern. Elevated CO_2 concentrations suggested inadequate ventilation in many homes. Fine particulate matter ($PM_{2.5}$) concentrations exceeded WHO guideline levels in most monitored properties.

Buildings with small internal volumes, open-plan layouts, restricted windows and limited opportunities for cross ventilation appeared particularly vulnerable to poor indoor environmental conditions.

Design characteristics matter

The research identified several design features that appear to increase environmental risks.

Single-aspect layouts were particularly problematic because they limit natural airflow and make effective ventilation difficult. There were multiple issues with windows with many residents reporting that windows:

- could not be opened fully;
- were permanently restricted;
- provided limited views outside; and
- could not be effectively shaded.

These problems often reflected the original commercial design of buildings that were subsequently converted into dwellings. Modelling demonstrated that dual-aspect layouts and cross ventilation could substantially reduce overheating risk. However, improvements in one aspect of environmental performance can create other challenges, highlighting the need for integrated design approaches.

Residents report lower mental wellbeing

Mental wellbeing scores among PDR residents were significantly lower than those reported in the wider English population. Around 22% of respondents scored within a range suggesting probable depression. After controlling for demographic and socioeconomic factors, shortages of space, thermal discomfort and noise disturbance were all strongly associated with poorer wellbeing and increased likelihood of depression.

Evidence suggests increased healthcare needs

The project explored healthcare utilisation using linked health data in a detailed case study of Bradford residents who moved into PDR housing. Following transition into PDR housing, residents experienced a statistically significant increase in primary care usage. Adjusted analyses suggested approximately a 50% increase in primary care appointment rates following moves into PDR accommodation. While the study cannot conclusively attribute this increase solely to housing conditions, the findings provide an important signal that PDR residents may experience increased health needs requiring further investigation.

Preliminary evidence suggests potentially substantial health burdens

Using measured and modelled environmental conditions, the project undertook a preliminary assessment of health impacts associated specifically with indoor air pollution. Results suggest that exposure to elevated indoor $PM_{2.5}$ and NO_2 concentrations could contribute to increased risks of:

- Cardiovascular disease
- Respiratory disease
- Asthma
- Premature mortality

$PM_{2.5}$ appeared to represent a particularly significant contributor to potential health burdens, and air quality problems in small office-to-resident conversions representing about a third of the PDR housing stock were modelled as potentially associated with 28.8 excess deaths and 100.8 asthma cases per 10,000 residents leading to 5,644 years of life lost and a £413million per annum associated economic loss. While additional modelling is ongoing (including considering the health implications and health economic costs of overheating as well as indoor air quality), preliminary findings indicate that environmental conditions within some PDR housing may have meaningful implications for population health and healthcare costs.

Implications for public health

Taken together, the findings provide strong evidence that housing created through PDR can influence health through multiple interconnected pathways. These pathways include:

- Housing design and quality
- Indoor environmental conditions and environmental exposures
- Neighbourhood environments
- Access to services and infrastructure

Impacts include both physical and mental health and social and psychological wellbeing. The findings support a substantial body of existing international evidence showing that housing functions as a key social determinant of health.

In terms of health equity, there is evidence in the research to suggest that the health impacts identified are unlikely to be distributed equally across society. The risks associated with poorer-quality PDR housing are socially patterned: poorer quality PDR housing appears to be concentrated in more deprived locations and is frequently occupied by households with fewer housing choices and greater vulnerabilities. As a result, PDR housing may contribute not only to poor health outcomes but also to the widening of existing health inequalities.

Implications for planning and housing policy

The findings have important implications for planning and housing policy. Many of the issues identified in this study stem not from the general principle of building conversion itself, but from the removal of place-based considerations that would normally be assessed through the full planning process and, to some extent, building regulations. Thus, while adaptive reuse remains an important and potentially sustainable approach to housing delivery, the findings demonstrate that successful residential conversion requires appropriate regulatory oversight, design standards and an integrated consideration of the scheme with a view to achieving positive health outcomes.

Given the timelines that housing often exists, the difficulty of adaption post-occupation and the strong links of housing standards to health and wellbeing, it is vital not to consider housing quantity separately from housing quality. Instead, planning and regulation should not be understood as barriers to boosting housing supply but instead as a means to proactively protect residents from harm and to promote to promote healthier, more equitable and more sustainable places for the long term.

Overall conclusion

Taken together, this research provides new evidence that the expansion of PDR has had consequences extending beyond housing supply and into population health, wellbeing and health inequality. Although many PDR homes provide reasonable living environments, a substantial proportion expose residents to conditions associated with poorer physical and mental health outcomes. Across location, design, environmental performance and lived experience, the research identifies a consistent pattern in which deregulation has increased the risk of housing environments that fall short of established principles of healthy housing.

As a regulatory framework, PDR fails to provide sufficient regulatory safeguards to prevent the delivery of some poorly located and poorly designed housing. This has negative consequences for public health. Further, the findings indicate that poor-quality PDR housing can contribute to widening health inequalities by concentrating adverse housing and environmental conditions among residents and communities with fewer housing choices and greater existing vulnerabilities. It is vital there is consideration of how to improve the regulatory framework governing the adaptive reuse of existing buildings to residential use in England, and address the needs of those already housed in very poor-quality conversion schemes. Efforts to address housing need should not be allowed to inadvertently create new forms of health disadvantage for future generations.



Recommendations for policy and practice

Policy / legislative recommendations

Taking into account the negative consequences of PDR housing in terms of poor quality and location, especially for those in more deprived areas as well as the additional costs and burdens dealing with poor quality housing and its consequences once developed, on balance, **our key overall recommendation would be to remove the GPDO 2015 (PDR) conversion to residential use entirely, replacing it with a supportive policy on adaptive reuse / material change of use to residential in the National Planning Policy Framework.**

We believe this option would achieve the greatest overall health and wellbeing benefit, and actually simplify the regulatory landscape. However, if central government were unwilling to adopt our main recommendation, two alternative options would be:

- **Modify GPDO 2015 to set impact to promoting good health, preventing ill-health and/or reducing health inequalities as a prior approval consideration for conversion to residential use in all use classes** – following the NPPF and the Health and Care Act 2022. This could mean local authorities could apply a condition requiring developers to apply Health Impact Assessment of proposals. Alongside this, amend the Community Infrastructure Levy Regulations 2010 to include consents under PDR regarding the circumstances where planning obligations can be entered into.
- **Modify GPDO 2015 to exclude schemes producing 10 or more units from Class MA** (Class E to Class C3 commercial, business and services to residential), requiring them to go through full planning permission. This option could reduce the likelihood of harm to health and wellbeing and the potential population impacted by potential problems from the types of conversion most typically problematic, and also resolve the current loophole around planning gain, albeit there could still be additional burdens associated with the consequences of poorer quality issues in smaller PDR conversions so this does not represent a precautionary approach.

Alongside any changes to planning regulations, we recommend that the government should address the gaps in Building Regulations regarding the Material Change of Use to residential uses, including expanding Part M on visitable and accessible buildings, and Part O on overheating to include MCU housing (see further detailed recommendations under Work Packages 3 and 5).

Whilst planning and building regulation changes can improve housing quality and so health and health equality for new conversion schemes coming forward, this does not address the existing stock of PDR housing. **We therefore recommend that central government should fund a full review and, where required, retrofitting programme for existing PDR housing to ensure they are habitable and safe to live in.**

In the longer term, we need a systemic shift to how the built environment is regulated to better target positive health outcomes and reduce health inequalities. We would recommend that government elevates health improvement and reduction of health inequalities as primary legal duties in planning law and building control.



Introduction: context for the research

The housing crisis and the Permitted Development regime

The housing crisis is one of the most pressing and high-profile policy issues in England and many other countries. This has included persistent pressure on the planning system to facilitate housing delivery, characterised by rising demand, questions about sufficiency of supply, particularly of affordable housing, and mandatory housing targets. Political pressure around the housing crisis has intensified in recent years, prompting successive governments to introduce a deregulatory approach aimed at accelerating housing delivery by removing perceived regulatory barriers to certain types of residential development, in particular related to the planning system.

One of the most significant of these deregulatory measures was the expansion of Permitted Development Rights (PDR) which – since enshrinement in s.12 Town and Country Planning Act 1947 and formalisation in The Town and Country Planning (General Development) Order, 1948 – allow certain types of development to proceed without the need for full planning permission.[2]

2. Rankl, F., 2024. Planning in England: permitted development and change of use (Research Briefing SN 0485). **Available at https://commonslibrary.parliament.uk/research-briefings/sn00485/**

The development of PDR since 2013 is shown in **Table 1** below. Among the most consequential changes introduced through these reforms has been the ability to convert commercial buildings – in particular office buildings – into residential accommodation without undergoing the traditional planning approval process.[3]

This introduction of office-to-residential permitted development rights in 2013 represented a major shift in England's planning system because, although PDR had existed since 1948, it had not previously been possible to create new dwellings under the regime (other than in limited circumstances related to agriculture and forestry). The policy was framed as part of a broader strategy to stimulate economic growth, reduce regulatory barriers and address housing shortages by facilitating the reuse of underused commercial space.[4] By removing the requirement for full planning permission, the government aimed to accelerate the delivery of housing while encouraging developers to repurpose vacant office buildings, particularly in areas experiencing changes in commercial demand. Since their introduction, these rights have been expanded and extended through subsequent policy reforms, becoming a prominent and controversial mechanism through which housing can be developed outside of the full control of the planning system.[5]

The scale of housing delivered through permitted development conversions has been substantial, if still very much a minority of overall new supply. Government data indicate that over 100,000 residential units have been produced through commercial-to-residential conversions since the policy's introduction.[6] Proponents argue that these reforms have made an important contribution to national housing supply,[7] particularly in Greater London and the Southeast of England, as well as other urban areas where demand for housing is high and land availability is constrained. From this perspective, the policy is seen as a low cost mechanism for increasing housing stock by using existing buildings rather than requiring costly and environmentally unfriendly demolition and reconstruction.[8]

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3. DCLG, 2013. Relaxation of planning rules for change of use from offices to residential: Impact assessment. Available at: **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/207922/Relaxation_of_planning_rules_for_change_of_use_from_offices_to_residential_-_impact_assessment.pdf**
4. Pickles, E., 2013. Written Ministerial Statement. Available at: **https://publications.parliament.uk/pa/cm201213/cmhansrd/cm130124/wmstext/130124m0001.html** ; DCLG, 2012. Relaxation of planning rules for change of use from commercial to residential. Summary of consultation responses and the Government's response to the consultation. Available at: **https://assets.publishing.service.gov.uk/media/5a79e753ed915d6b1deb42fa/2172423.pdf**
5. Rankl, F., 2024. Planning in England: permitted development and change of use (Research Briefing SN 0485), available at: **https://commonslibrary.parliament.uk/research-briefings/sn00485/**
6. MHCLG, 2021. Live tables on housing supply: net additional dwellings. Available at: **https://www.gov.uk/government/statisticaldata-sets/live-tables-on-net-supply-of-housing**
7. Vitali, J., 2023 *Homes for growth: How housebuilding can revitalise the UK economy.* London: Policy Exchange. Available at: **https://policyexchange.org.uk/publication/homes-for-growth/**; Breach, A. and Sells, T., 2019 *Making room: How and why living space varies between cities.* London: Centre for Cities. Available at: **https://www.centreforcities.org/publication/making-room-living-space-cities/**; Breach, A. (2019) *Capital cities: How the planning system creates housing shortages and drives wealth inequality.* London: Centre for Cities. Available at: **https://www.centreforcities.org/publication/capital-cities/**; Pickles, E., 2013. Written Ministerial Statement. Available at:
https://publications.parliament.uk/pa/cm201213/cmhansrd/cm130124/wmstext/130124m0001.htm
8. Rankl, F., 2024. Planning in England: permitted development and change of use (Research Briefing SN 0485). Available at: **https://commonslibrary.parliament.uk/research-briefings/sn00485/**

In addition, the reuse of vacant office space can be a means of revitalising underused buildings, adapting space to changing economic conditions, and avoiding the environmental harms of demolition and new construction materials.

Despite these potential benefits, the expansion of PDR has also generated significant debate among planners, policymakers and researchers. Critics argue that the removal of full planning oversight can undermine the ability of local authorities to ensure that new housing meets adequate standards of quality, design and sustainability.[9] Under traditional planning processes, proposed developments are typically assessed under the local plan (s.38(6) Planning and Compulsory Purchase Act 2004), which contains a range of criteria relating to design standards, environmental conditions, infrastructure provision and community impacts, as well as the local authority's spatial vision for the area, and consideration of a wide range of other material considerations allowing a holistic overview of the proposed scheme.

By contrast, developments proceeding under PDR are exempt from planners considering anything not specified explicitly for 'prior approval' under the permitted development regulations, raising concerns that the policy may prioritise housing quantity over quality.[10] Prior approval is limited to matters such as transport and highways impacts, noise, contamination, flooding defined in the GPDO (2015). This has included since 2020 provision of adequate natural light to habitable rooms, and since 2021 minimum space standards, defined in the Nationally Described Space Standards.[11] The requirements of the prior approval process are set centrally rather than locally specified. The exterior and interior design, liveability and amenity of the housing being created is not in the scope of the prior approval process, nor are local plan policies which might relate to health and wellbeing. Since the principle of development has already been established for these schemes, issues like whether the building could still be used in employment use or whether it is in a location suitable for residential use cannot be considered as part of the prior approval by the local planning authority.

9. Clifford, B. and Ferm, J., 2021. Planning, regulation and space standards in England: From 'homes for heroes' to 'Slums of the future'. *Town Planning Review*, 92(5), pp.537–560. Available at: **https://www.liverpooluniversitypress.co.uk/doi/abs/10.3828/tpr.2021.11**
10. TCPA, 2018. Planning 2020: Raynsford Review of Planning in England. Available at: **https://tcpa.org.uk/wp-content/uploads/2022/03/Planning-2020-Raynsford-Review-of-Planning-in-England-Final-Report.pdf**
11. Technical housing standards – nationally described space standards. Available at: **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524531/160519_Nationally_Described_Space_Standard____Final_Web_version.pdf**

The prior approval process for residential conversions does not generally allow applicants to make external changes to the building being converted (aside from, Classes M, N, and Q). Clifford et al found that 40% of the PDR conversions studied applied for full planning permission for external changes such as installations of windows alongside or shortly after prior approval.[12] This shows the complexity of interaction between full planning permission and prior approval processes, whereby PDR can be used as a fallback position or negotiating tool by developers, and a means by which to usually avoid providing any planning gain through the Community Infrastructure Levy or Section 106.[13] Prior approval regulations are complex and have been amended multiple times since 2013, yet their overall effect has been to reduce the scope of local planning authority control over converting commercial and agricultural buildings into residential use. We can therefore understand them as a form of planning deregulation.

Developments proceeding under PDR are still subject to building regulations, however it is important to note that in a number of areas the building regulations applying to a material change of use scheme (whether through PDR or under full planning permission) are different to those applying for a new build development, for example in relation to accessibility and overheating.[14] There has also been recent concern about the building control system as fragmented and inconsistent.[15]

12. Clifford, B., Canelas, P., Ferm, J. Livingstone, N., Lord, A and Dunning R. 2020. Quality standard of homes delivered through change of use permitted development rights. Available at: **https://www.gov.uk/government/publications/quality-standard-of-homes-delivered-through-change-of-use-permitted-development-rights**
13. Local Government Association, 2025. New LGA analysis shows nearly 28,000 affordable homes lost due to permitted development rights. Available at: **https://www.local.gov.uk/about/news/new-lga-analysis-shows-nearly-28000-affordable-homes-lost-due-permitted-development**
14. TCPA, 2024. Permitted development, housing and health: a review of national policy and regulations. Available at: **https://www.tcpa.org.uk/wp-content/uploads/2024/02/PD-HousingHealth_National-policy-review-FINAL-1-1.pdf**
15. MHCLG, 2026. Building Control Panel Independent Report. Available at: **https://www.gov.uk/government/publications/building-control-independent-panel-report/building-control-independent-panel-report**

Table 1: Changes to PDR conversion rights in the GPDO in England since 2013

Year	Policy / Legislative Change	Description	Regulation	Effective Date
2013	Office-to-residential permitted development introduced	Offices (Use Class B1(a)) permitted to convert to residential dwellings (Class C3) without full planning permission, subject to a prior approval process. Initially introduced as a temporary measure to increase housing supply and reuse vacant office buildings.	The Town and Country Planning (General Permitted Development) (Amendment) (England) Order 2013	30th May 2013
2014	Agricultural buildings to residential (Class Q)	Permitted development rights extended to allow agricultural buildings to convert into residential dwellings, subject to restrictions on building size and location.	The Town and Country Planning (General Permitted Development) (Amendment and Consequential Provisions) (England) Order 2014	6th April 2014
2014	Retail and financial and professional services to residential (Class IA) (Replaced by Class MA in 2021)	Permitted development rights extended to allow retail and financial and professional services building conversions into residential dwellings, subject to restrictions on building size and location.	The Town and Country Planning (General Permitted Development) (Amendment and Consequential Provisions) (England) Order 2014	6th April 2014
2015	PDR conversions made permanent	Following significant uptake, the government confirmed the continuation of office-to-residential conversion rights (Class O) beyond the initial temporary period. Conversion rights also confirmed in respect of agricultural (Class Q), retail (Class M) buildings and introduced in respect of specified sui generis uses (Class N) and storage and distribution centres (Class P).	Town and Country Planning (General Permitted Development) (England) Order 2015	15th April 2015
2016	Introduction of further PDR conditions, and light industrial and laundrette uses to residential conversions.	Added the impacts of noise from commercial premises on the intended occupiers to the list of prior approval matters in respect of Class O (office to residential) and added PDRs in respect of light industrial and laundrette uses to residential conversions.	The Town and Country Planning (General Permitted Development) (England) (Amendment) Order 2016	6th April 2016

Year	Policy / Legislative Change	Description	Regulation	Effective Date
2018	Removal of Class P (storage or distribution centres to residential)	As evidence of the poor quality of PDR residential conversions grows, the GPDO is amended to remove PDR conversion rights in respect of distribution centres.	The Town and Country Planning (General Permitted Development) (England) (Amendment) Order 2018	6th April 2018
2019	Extension of Class M and restriction on Class Q	Extended Class M (retail and specified sui generis uses) to permit buildings with a use falling within Class A5 (hot food takeaways) to change use to a dwellinghouse. Also clarified that the floor space of any dwellinghouse created by Class Q (agricultural buildings) cannot exceed 465 square metres.	The Town and Country Planning (Permitted Development, Advertisement and Compensation Amendments) (England) Regulations 2019	25th May 2019
2020	Introduction of minimum standards within prior approval	Made provision that the minimum size for any new dwelling permitted under the GPDO is 37sqm and it must meet the nationally described space standard.	The Town and Country Planning (General Permitted Development) (England) (Amendment) Regulations 2020	6th April 2021
2020	Additional residential development rights	New permitted development rights introduced allowing additional storeys to be constructed on existing residential buildings and allowing demolition and rebuild of certain commercial buildings for housing.	The Town and Country Planning (General Permitted Development) (England) (Amendment) (No. 2) Order 2020	31st August 2020
2020	Creation of Use Class E	Use Class E (Commercial, Business and Service) introduced, merging several commercial uses such as shops, offices, restaurants and gyms.	The Town and Country Planning (Use Classes) (Amendment) (England) Regulations 2020	1st September 2020
2021	Introduction of Class MA (commercial to residential)	Buildings within Use Class E permitted to convert to residential use under Class MA, subject to a prior approval process. Amongst other conditions, a size limit on Class MA conversions of 1,500sqm is introduced.	The Town and Country Planning (General Permitted Development etc.) (England) (Amendment) Order 2021	21st April 2021

Year	Policy / Legislative Change	Description	Regulation	Effective Date
2021	Introduction of fire safety and provision of adequate natural light as a prior approval conditions	Amended the GPDO so as to require developers to obtain the prior approval of the local planning authority as to certain matters relating to fire safety where it is proposed to introduce dwellinghouses in buildings above a height threshold (18m or 7+ storeys). Where a prior approval application is made pursuant to these provisions, the local planning authority must consult the Health and Safety Executive. Also provided that all habitable rooms must have adequate natural light.	The Town and Country Planning (General Permitted Development etc.) (England) (Amendment) (No. 2) Order 2021	1st August 2021
2024	Vacancy and floorspace restrictions removed	Removed the requirement that a building must have been vacant for a continuous period of at least 3 months immediately prior to the date of an application for prior approval. Additionally, removed the 1,500sqm floorspace upper limit for buildings changing use.	Town and Country Planning (General Permitted Development) (England) (Amendment) Order 2024	5th March 2024
2024	Changes to Class Q (agricultural buildings to residential)	Amended Class Q to allow former agricultural buildings to be converted to dwellings. Introduced a cumulative limit of new dwellings of 10 and a cumulative size limit of 1,000sqm for the development of multiple dwellings.	The Town and Country Planning (General Permitted Development etc.) (England) (Amendment) Order 2024	21st May 2024

Building design

The impacts of PDR as a form of planning deregulation have been subject to a number of studies over the last decade, particularly the reports produced by Clifford et al in 2018 (funded by the RICS Research Trust) and in 2020 (as an independent review funded by MHCLG) which have focussed in particular on issues of the quality of housing being produced through this route.[16] These previous reviews found widespread issues around adequacy of window arrangements, internal space standards, the mix of units and access to outdoor space in particular. Media investigations and public commentary have further drawn attention to the conditions found in some converted commercial buildings. Reports have described developments consisting of extremely small studio units arranged along narrow corridors, with limited windows and minimal connection to surrounding neighbourhoods.[17] In certain cases, these developments have been criticised as resembling institutional accommodation rather than proper housing, leading to descriptions such as 'human warehouses'.[18]

While such examples may not represent all – or even a majority – of PDR conversions, they illustrate broader concerns about the potential consequences of removing planning oversight from the development process and the extremes of low quality which were made permissible through this deregulation. The physical characteristics of commercial buildings themselves can also present challenges for residential conversion. Commercial buildings are typically designed for such uses, prioritising large open floorplates, artificial lighting and centralised ventilation systems. These design features can make it difficult to create residential units with adequate daylight, ventilation and spatial layout. As a result, some conversions produce residential environments that are far less well suited to everyday living compared to purpose-built housing.

Environmental performance is another important issue in the context of commercial-to-residential conversions. Building design and materials play a critical role in determining indoor thermal comfort and energy efficiency.

16. Clifford, B., Canelas, P., Ferm, J. and Livingstone, N. 2018. Assessing the impacts of extending permitted development rights to office-to-residential change of use in England. Available at: **Assessing the impacts of extending permitted development rights to office-to-residential change of use in England**
Clifford, B., Canelas, P., Ferm, J., Livingstone, N., Lord. A., and Dunning, R. 2020. Quality standard of homes delivered through change of use permitted development rights. Available at:
https://www.gov.uk/government/publications/quality-standard-of-homes-delivered-through-change-of-use-permitted-development-rights
17. Wall, T., 2019. 'It feels almost like prison': the developers building homes with no natural light. Available at:
https://www.theguardian.com/cities/2019/dec/19/it-feels-almost-like-prison-the-developers-building-homeswith-no-natural-light ; Moore, R., 2020. 'It's like an open prison': the catastrophe of converting office blocks to homes. *The Guardian*. Available at: **https://www.theguardian.com/society/2020/sep/27/housing-crisis-planning-converting-office-blocks-homes-catastrophe-jenrick**
18. Glass, K., 2019. "Human warehouses": the families forced to spend Christmas in repurposed office blocks. Available at:
https://www.thetimes.co.uk/article/human-warehouses-the-families-forced-to-spendchristmas-in-repurposed-office-blocks-d8l7h8d2x

Poorly adapted office buildings may be susceptible to problems such as over- and under-heating, particularly in conversions in older buildings with poorly constructed windows that do close or open, or let too much heat in or out due to their glazing. Research by Zurich UK has suggested that certain office-to-residential conversions may face heightened over and under heating risks due to their original building configurations and glazing systems.[19] Such conditions can negatively affect residents' comfort and wellbeing, particularly during winter and periods of extreme heat that are being experienced more regularly in England due to climate change.

Wider spatial considerations

Beyond individual building design, the location and surrounding environment of housing developments also influence residents' quality of life. Access to green space, public transport, healthcare facilities, and amenities are all important determinants of wellbeing within urban environments.[20] Local authorities typically consider these factors when evaluating development proposals for full planning permission, better ensuring that new housing contributes to sustainable, healthy and well-connected communities. However, development undertaken through PDR can occur in locations that were previously characterised by town centre or industrial uses and may therefore lack appropriate residential infrastructure.[21] PDR may introduce residential use into locations where there are nearby 'bad neighbour' uses with environmental externalities that can harm health, wellbeing and quality of life, including through atmospheric and noise pollution. Residents alongside busy main roads or industrial facilities may then face, for example, overheating if they do not open the windows but extreme levels of noise disturbance if they do.

These spatial considerations raise broader questions about the role of the English planning system in shaping healthy and equitable urban environments. Historically, planning in England has played a crucial role in regulating land use, protecting public health and ensuring that new development meets appropriate standards.[22] The emergence of local plans and building regulations during the twentieth century reflected growing recognition of the need to separate incompatible land uses and maintain minimum housing conditions.[23] By enabling development to bypass certain planning controls, PDR represents a significant shift in how development is (un)governed.

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19. Zurich UK, 2021. Office to flat conversions at risk of serious overheating. Available at: **https://www.zurich.co.uk/news-andinsight/hot-homes**
20. Bird, E.L., … and Burgess-Allen, J., 2018. Built and natural environment planning principles for promoting health: an umbrella review. *BMC Public Health*, 18(1), pp.1–13. Available at: **https://link.springer.com/article/10.1186/s12889-018-5870-2**
21. Ferm, J., Clifford, B., Canelas, P. and Livingstone, N., 2021. Emerging problematics of deregulating the urban: The case of permitted development in England. *Urban Studies*, 58(10), pp.2040–2058. Available at: **https://journals.sagepub.com/doi/full/10.1177/0042098020936966**
22. Cherry, G. E.,1996. *Town Planning in Britain since 1900.* Oxford: Blackwell.
23. Thomson, H. and Thomas, S., 2015. Developing empirically supported theories of change for housing investment and health. *Social Science & Medicine*, 124, pp.205–214. Available at: **https://www.sciencedirect.com/science/article/pii/S0277953614007758**

Another area of concern relates to the potential concentration of lower-quality housing in particular locations. Because permitted development conversions often take place in former commercial areas, including some in active industrial areas, the resulting residential developments may be spatially clustered in environments that lack established residential communities or amenities. Some researchers have suggested that this pattern may contribute to new forms of socio-spatial inequality, where certain groups are more likely to inhabit housing environments characterised by lower quality or limited infrastructure.

The health impacts of Permitted Development housing

The quality, accessibility and distribution of housing have long been recognised as central determinants of social wellbeing and public health.[24] Housing environments influence a wide range of health outcomes through factors such as indoor environmental quality, access to natural light, thermal comfort, noise exposure and spatial adequacy. The importance of housing quality for health is a well-established public policy concern, with early public health reforms in the nineteenth and early twentieth centuries focusing heavily on improving living conditions in overcrowded and unsanitary urban housing.[25] Contemporary research continues to emphasise the role of housing in shaping physical, mental and social health outcomes, highlighting the ways in which poor housing conditions are linked to illness, stress and social inequality.[26, 27]

The planning system in England's control, or lack thereof, over the design of new dwellings plays a particularly important role in determining the health impacts of housing. Design features such as building orientation, ventilation, daylight access and spatial configuration influence residents' daily experiences and wellbeing. Adequate exposure to natural light, for example, has been associated with improved mood, sleep patterns and circadian rhythm regulation.[28] Conversely, housing that lacks sufficient daylight or ventilation can contribute to discomfort, reduced wellbeing and potential long-term health effects. Similarly, issues such as overcrowding and limited personal space have been linked to increased psychological stress and reduced quality of life.[29]

24. Marsh, R., Chang, M. and Wood, J., 2022. The relationship between housing created through permitted development rights and health: a systematic review. *Cities & Health*, 6(4), pp.833–852. Available at: **https://doi.org/10.1080/23748834.2020.1833281**
25. Thomson, H., … and Petticrew, M., 2009. The health impacts of housing improvement: A systematic review. *American Journal of Public Health*, 99, pp.S681–S692. Available at: **https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2008.143909**
26. Evans, G.W., Wells, N.M. and Moch, A., 2003. Housing and mental health: A review of the evidence and a methodological and conceptual critique. *Journal of Social Issues*, 59(3), pp.475–500. Available at: **https://doi.org/10.1111/1540-4560.00074**
27. WHO (2018) **World Health Organisation. Housing and health guidelines**
28. Andersen, M., Gochenour, S.J. and Lockley, S.W., 2013. Modelling "non-visual" effects of daylighting in a residential environment. *Building and Environment*, 70, pp.138–149. Available at **https://doi.org/10.1016/j.buildenv.2013.08.018**; Swanson, V., … and Shearer, D., 2016. Indoor annual sunlight opportunity in domestic dwellings may predict well-being in urban residents in Scotland. *Ecopsychology*, 8(2), pp.121–130. Available at: **https://doi.org/10.1089/eco.2015.0059**
29. Evans, G.W., Wells, N.M. and Moch, A., 2003. Housing and mental health: A review of the evidence and a methodological and conceptual critique. *Journal of Social Issues*, 59(3), pp.475–500. Available at: **https://doi.org/10.1111/1540-4560.00074**

In recent years, a growing body of research has examined the relationship between housing design and broader health outcomes. Studies have demonstrated that the built environment can influence physical activity, social interaction and mental wellbeing, highlighting the importance of integrated planning approaches that consider health alongside urban development.[30] Poor housing conditions have also been associated with increased vulnerability to infectious diseases, as demonstrated during the COVID-19 pandemic, when overcrowded housing environments were linked to higher transmission risks.[31] These findings reinforce the importance of maintaining local governmental oversight of housing quality as part of wider public health strategies.

Within this context, the expansion of PDR has raises important questions about whether deregulated planning processes can adequately safeguard housing quality. As already noted, several studies have suggested that residential units created through commercial-to-residential conversions may exhibit significantly worse characteristics from housing developed through traditional planning routes. A particular problem affecting a majority of PDR units approved from 2013 to 2021 was inadequate internal space standards (compared to the nationally described space standards) and many appear to lack essential design features associated with healthy housing such as proper ventilation or appropriate thermal comfort.[32] Further issues identified in these studies include inadequate access to natural light and the absence of communal or outdoor spaces. In a peer-reviewed academic paper published in 2022, Marsh et al argued that concerns around the quality of new residential dwellings developed using PDR are significant and suggested that there could be a detrimental impact on the health of residents of such housing.[33] This study did not involve new empirical research but rather drew on existing studies linking housing in general to health, and known pathways through which housing impacts physical and mental health.

At the same time, it is important to recognise that the relationship between housing policy and health outcomes is complex and influenced by a wide range of social, economic and environmental factors. Housing conditions interact with broader determinants of health such as income, employment and social support networks.

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30. Bird, E.L., … and Burgess-Allen, J., 2018. Built and natural environment planning principles for promoting health: an umbrella review. *BMC Public Health*, 18(1), pp.1–13. Available at: **https://link.springer.com/article/10.1186/s12889-018-5870-2**
31. Aldridge, R.W., … & Hayward, A., 2021. Household overcrowding and risk of SARS-CoV-2: analysis of the Virus Watch prospective community cohort study in England and Wales. *Wellcome Open Res*. 15(6), 347. Available at: **https://pmc.ncbi.nlm.nih.gov/articles/PMC11130583/**
32. Clifford, B., Canelas, P., Ferm, J. and Livingstone, N. 2018. *Assessing the impacts of extending permitted development rights to office-to-residential change of use in England*. RICS. Available at: **www.rics.org/content/dam/ricsglobal/documents/to-be-sorted/assessing-the-impacts-of-extending-permitted-development-rights-to-office-to-residential-change-of-use-in-england-rics.pdf**; Clifford, B., Canelas, P., Ferm, J. Livingstone, N., Lord, A. and Dunning, R. 2020. *Quality standard of homes delivered through change of use permitted development rights*. MHCLG. Available at: **https://www.gov.uk/government/publications/quality-standard-of-homes-delivered-through-change-of-use-permitted-development-rights**
33. Marsh, R., Chang, M. and Wood, J., 2022. The relationship between housing created through permitted development rights and health: a systematic review. *Cities & Health*, 6(4), pp.833–852. Available at: **https://doi.org/10.1080/23748834.2020.1833281**

For example, housing insecurity and financial strain can contribute to psychological stress, while neighbourhood environments influence opportunities for social interaction and physical activity.[34] As a result, evaluating the impacts of housing policy requires consideration of both the physical characteristics of housing and the broader social contexts in which it exists.

Studying permitted development housing and health

The introduction of PDR for the conversion of commercial and agricultural buildings into housing reflects broader political and economic priorities that emphasise market-led development and the reduction of regulatory barriers to the financialisaton of housing.[35] From this perspective, PDR can be seen as a mechanism for accelerating housing production by reducing administrative processes and widening profit margins for developers. However, critics argue that such deregulation risks undermining the planning system's capacity to protect public interests, particularly when it comes to housing quality and community wellbeing.[36]

Given widespread pressure for, and discussion of, further deregulation in planning and built environment regulation to apparently address the housing crisis in England (and many other places), it is vital to fully understand the consequences of such policy approaches. Previous studies have demonstrated some of the issues associated with these forms of PDR, including the loss of planning gain contributions (particularly those funding social and green infrastructure and affordable housing) but most particularly in relation to the design quality of housing that such deregulation can produce. Although there is a large existing literature on the relationship between housing and health, there was no assessment of potential health impacts when the PDR deregulations were introduced in 2013 and 2015 and there has been no original empirical studies which have examined the relationship between PDR housing and health and wellbeing. We know very little about the population occupying this housing or their perceptions of it. We have therefore undertaken a major multi-disciplinary study, funded by NIHR, to try and fill this evidence gap.

Our overall research question was:

what are the health and health inequality impacts of housing created through the new Permitted Development Rights?

34. Gelormino, E., Melis, G., Marietta, C. and Costa, G., 2015. From built environment to health inequalities: An explanatory framework based on evidence. *Preventive Medicine Reports*, 2, pp.737–745. Available at: **https://doi.org/10.1016/j.pmedr.2015.08.019**
35. Gelormino, E., Melis, G., Marietta, C. and Costa, G., 2015. From built environment to health inequalities: An explanatory framework based on evidence. *Preventive Medicine Reports*, 2, pp.737–745. Available at: **https://doi.org/10.1016/j.pmedr.2015.08.019**
36. TCPA, 2020. The Raynsford Review 'One Year On': 21st Century Slums? at: **https://www.tcpa.org.uk/resources/the-raynsford-review-one-year-on/**

This report summarises our findings. Please note that this report supplements and complements a series of academic journal articles being produced from the project data and undergoing a full peer-review process. Our aim here is to bring key findings from the project to a broad audience rather than presenting a complete and comprehensive overview of all of our project data.

In the next section we turn briefly to key existing work relevant to this topic. We then give a brief overview of our overall approach to studying this topic and how the project was divided into five 'work packages'. We then report the approach taken and results found from each work package in turn, before reaching some overall conclusions from this study and making some recommendations for policy and practice.



Key existing work on planning, adaptive reuse, housing and health in context

Existing work on permitted development housing

The implications of these policy changes have been explored in a number of planning and housing studies to date, including both academic work and that from other sectors. In the first few years following the introduction of office-to-residential PDR, a number of consultancy and sector reports were produced, often taking a desk based and secondary data approach to understand emerging use of the new powers and their consequences. These raised initial concerns about loss of office space in some locations, loss of affordable housing contributions and the quality of housing being produced, particularly in relation to small space standards.[37]

An early comprehensive academic study of the impact of office-to-residential PDR was produced by a team at UCL, funded by the Royal Institution of Chartered Surveyors Research Trust. Published in 2018, this found significant variation in the quality and location of homes produced

37. An overview of research up to that date is in Clifford, B., Canelas, P., Ferm, J. and Livingstone, N. 2018. *Assessing the impacts of extending permitted development rights to office-to-residential change of use in England*. RICS. Available at: **www.rics.org/content/dam/ricsglobal/documents/to-be-sorted/assessing-the-impacts-of-extending-permitted-development-rights-to-office-to-residential-change-of-use-in-england-rics.pdf**

through office-to-residential permitted development conversions.[38] While some developments were found to provide acceptable living environments, others exhibited substantial shortcomings in relation to space standards and environmental conditions. These findings suggest that the removal of planning oversight can lead to uneven outcomes, with the quality of housing depending heavily on the priorities and practices of individual developers.

Overall, though, the report found that PDR residential quality was significantly worse than schemes which required planning permission, even though it clearly was still possible to deliver viable office-to-residential schemes through the more stringent full planning permission process. A key issue was space standards, with just 30% of the PDR units examined across five English case study local authorities meeting the recommended NDSS, very low rates of access to private or communal amenity space (outdoor space especially), some poor locations in industrial estates and 77% of units in the case study buildings being studio or one bedroom flats, only catering to a very narrow segment of the residential market. There was also widespread evidence of negative implications for local authorities and communities through the loss of planning gain.[39]

Following the 2018 report and ongoing media coverage highlighting living conditions in some poor quality conversions, in March 2019 the then Secretary of State for Housing, Communities and Local Government confirmed the intention to review PDR conversions in respect of the quality standard of homes delivered[40]. An independent review team from UCL and the University of Liverpool was commissioned to undertake this review, which was published in 2020. This review looked at commercial to residential PDR and full planning permission conversions in eleven English local authorities as case studies. It found that rates of making exterior alterations and energy performance were broadly similar between planning permission and PDR schemes. Most PDR schemes were located in town centre and local high street areas but a notable minority (about 8%) of the schemes considered were in primarily commercial areas like industrial estates and business parks than offered extremely poor residential amenity.

38. Clifford, B., Canelas, P., Ferm, J. and Livingstone, N. 2018. *Assessing the impacts of extending permitted development rights to office-to-residential change of use in England.* RICS. Available at: **www.rics.org/content/dam/ricsglobal/documents/to-be-sorted/assessing-the-impacts-of-extending-permitted-development-rights-to-office-to-residential-change-of-use-in-england-rics.pdf**

39. Clifford, B., Canelas, P., Ferm, J. and Livingstone, N. 2018. *Assessing the impacts of extending permitted development rights to office-to-residential change of use in England.* RICS. Available at: **www.rics.org/content/dam/ricsglobal/documents/to-be-sorted/assessing-the-impacts-of-extending-permitted-development-rights-to-office-to-residential-change-of-use-in-england-rics.pdf**

40. Brokenshire, J 2019 Written Ministerial Statement: Planning Update. Available at: **https://questions-statements.parliament.uk/written-statements/detail/2019-03-13/hcws1408**

There were also significant differences between PDR schemes and full planning permission conversions in terms of internal design and consequent housing quality. Overall, only a fifth (22.1%) of housing units created through PDR would meet the nationally described space standards (NDSS), compared to 73.4% of units created through full planning permission, with the planning permission units only just below the suggested standards compared to PDR units being significantly below, with studio flats of just 16m^2 not uncommon. 72.0% of the housing units created under PDR only had single aspect windows, compared to 29.5% created through planning permission and a small number of PDR units were found without any windows at all. Regarding amenity space, just 3.5% of the PDR units analysed benefitted from access to private amenity space. The report concluded that "permitted development conversions do seem to create worse quality residential environments than planning permission conversions in relation to a number of factors widely linked to the health, wellbeing and quality of life of future occupiers." [41]

Since the 2020 report, further research from UCL has begun to explore this relationship between PDR housing and the health and wellbeing of residents. A pilot study funded by Impact on Urban Health was published in 2023, and involved a survey with 218 residents and interviews with 41 residents of PDR conversions located in four London boroughs. The report found that residents were often reporting housing quality issues like a shortage of space (46% of survey respondents) and street noise (40% of survey respondents). 37% of residents reported they could not keep comfortably cool during hot summer weather. A high proportion of the cohort reported not having a single window they would open (14%) with only 68% reporting at least one window they could easily see outside through. Strong associations were found between housing quality issues such as having sufficient space in the home and thermal comfort and the self-reported mental wellbeing of residents. Overall, the proportion of survey respondents low wellbeing was higher than the UK average (23% of survey respondents compared to 15% UK average) and the proportion with a score that indicates high wellbeing was lower than the UK average (6.8% of survey respondents compared to 15% UK average).[42]

41. Clifford, B., Canelas, P., Ferm, J. Livingstone, N., Lord, A. and Dunning, R. 2020. *Quality standard of homes delivered through change of use permitted development rights*. MHCLG. Available at: **https://www.gov.uk/government/publications/quality-standard-of-homes-delivered-through-change-of-use-permitted-development-rights**

42. Clifford, B., Pineo, H., Aldridge, R. and Eyre, M. 2023. *An exploratory study investigating the health and wellbeing impacts of housing created through permitted development in London*. UCL. Available at **https://www.ucl.ac.uk/bartlett/sites/bartlett/files/ucl_pd_housing_and_health_study_-_may_202350.pdf**

Existing research has begun to document the physical and spatial characteristics of PDR conversions,[43] whilst contributing to empirical evidence regarding the lived experiences of residents within these developments.[44] Much of the existing literature has focused on planning policy analysis or quantitative assessments of housing quality, leaving a gap in understanding how individuals navigate and interpret – their lived experience of – these environments in practice. Existing research on PDR housing does not give a comprehensive understanding of who is living in this housing or sufficient sense of the implications of this housing on their health and wellbeing. In particular, there is a need to better understand how residents experience living in converted buildings and how the design and spatial characteristics of these environments affect daily life. Understanding these experiences is particularly important in light of ongoing debates about the future of the planning system in England.

Key broader insights on adaptive reuse

The conversion of buildings between types of use is known as 'adaptive reuse'. Broader than PDR, adaptive reuse has often contributed to the retention of valued historic environments in contemporary cities, for example early nineteenth-century houses in British inner cities no longer in demand as dwellings in the post-war period becoming offices (such as for small legal and accountancy firms) before returning to domestic use more recently, or nineteenth-century brick built warehouses becoming high-value residential units.

Although a longstanding phenomenon with scholarly interest dating back many years,[45] the intersection of the housing and climate crises and a desire for sustainable solutions to these challenges is driving renewed interest in adaptive reuse. Overall, the construction sector is the largest emitter of greenhouse gases, accounting for 37% of global emissions but with more progress made on reducing the operational carbon emissions of buildings than the embodied carbon. A recent UN report calls for extending the life of buildings through adaptions and predicts that such renovations will rapidly increase in coming decades as part of a 'circular economy' approach.[46] This could increasingly see environmental benefits from adaptive reuse alongside social and economic gains such as urban regeneration.[47]

43. Clifford, B., Canelas, P., Ferm, J. and Livingstone, N., 2020. *Quality standard of homes delivered through change of use permitted development rights*. MHCLG. Available at: **https://www.gov.uk/government/publications/quality-standard-of-homes-delivered-through-change-of-use-permitted-development-rights**

44. TCPA, 2020. The Raynsford Review 'One Year On': 21st Century Slums? Available at:**https://www.tcpa.org.uk/resources/the-raynsford-review-one-year-on/**

45. For example Kincaid, D. (2002) *Adapting buildings for changing uses. Guidelines for change of use refurbishment*. London: Spoon Press and Douglas, J. (2006*) Building Adaptation*. London: Butterworth-Heinemann Publishing

46. UNEP (2023). Building Materials And The Climate: Constructing A New Future, available at **https://wedocs.unep.org/handle/20.500.11822/43293**

47. Wilkinson, S. J., & Remøy, H. (Eds.). (2018). Building urban resilience through change of use. John Wiley & Sons

Although the PDR deregulation in England predates the pandemic, clearly there has been some increase in vacancy of office and retail buildings, associated with shifts to hybridised and online working – albeit in some places office demand has increased more recently.[48] Given these broader trends, it is perhaps unsurprising that there has been an increasing international interest in commercial–to–residential conversion as well as a campaign by the *Architects' Journal* called 'RetroFirst'.[49]

The broader existing literature on adaptive reuse is heavily focussed on the adaptability of different buildings and some of the design issues associated with that. For residential conversion, typology and location are seen as significant determinants of conversion possibility with different intrinsic conversion potential for different building types but also original build quality and current state of the building influencing the viability of conversion.[50] Physical building features such as their structural integrity, floor span (depth of floorplate) and layout, cladding, access and means of escape are key issues in terms of ability to subdivide a larger commercial building into new residential units with appropriate light, insulation, ventilation and utilities provision.[51]

As well as building types in terms of original design function (office, retail, light industrial and so on), age is important for adaptive reuse conversion given the evolution of building design through time: buildings predating artificial light and mechanical ventilation are very different from those developed after these became usual in commercial premises.[52] Looking at typical UK office deigns over time, those from the 1950s to 70s often have optimal conversion to residential possibility as they are not so old as to be likely to have more restrictive heritage designations but still have shallower floorplates and existing (or originally having had) cellular spaces and corridors.[53]

48. For example, Stevens, L. 2026 Heightened demand for premium office space leads to double digit percentage increases in fit-out costs. Available at **https://www.turnerandtownsend.com/news/heightened-demand-for-premium-office-space-leads-to-double-digit-percentage-increases-in-fit-out-costs/**
49. For example, Oldfield, P. (2023). 'Should we convert empty offices to address housing shortages?' at **https://www.businessthink.unsw.edu.au/articles/office-buildings-housing-conversion**; see also **https://www.architectsjournal.co.uk/news/retrofirst**
50. For example Madeddu, M., & Clifford, B. (2023). The conversion of buildings to housing use: England's permitted development rights in comparative perspective. *Progress in Planning*, 171, 100730. Available at: **https://doi.org/10.1016/j.progress.2022.100730**; and Olivadese, R., Remøy, H., Berizzi, C. and Hobma, F. (2017) 'Reuse into housing: Italian and Dutch regulatory effects', *Property Management*, 35 (2), pp. 165–180. Available at: **https://doi.org/10.1108/PM-10-2015-0054**
51. Gann, D. M. and Barlow, J.G. (1996) 'Flexibility in building use: The technical feasibility of converting redundant offices into Flats', *Construction Management and Economics*, 14, 55–66. Available at: **https://doi.org/10.1080/01446199600000007**
52. Remøy, H. & de Jonge, H. (2007) Transformation and typology. Vacancy, characteristics and conversion-capacity, *Building Stock Activation 2007 Conference Proceedings*, Tokyo, Tokyo Metropolitan University, 163–170
53. CGL – Child Graddon Lewis, NLP – Nathaniel Lichfield & Partners, RLF – Robinson Lowe Francis & Gifford (2011) Departments to Apartments: converting office buildings to residential, available at **https://lichfields.uk/media/2493/departments-to-apartments.pdf**

That said, although some building features can make conversion to other uses (particularly residential) more difficult, few make conversion impossible if appropriate financing and regulatory approvals are available. For example, kitchens, bathrooms and storage areas can be located in more internal points of deeper floorplan buildings. Location, however, is much more difficult to resolve. Locational issues can include the presence, quality and accessibility of social and green infrastructure, services and amenities including essential retail, primary schools, primary healthcare facilities and public parks / open spaces, the general accessibility of the site (particularly in relation to public transport), and potential externalities from neighbouring uses (particularly noise and pollution, noxious or dangerous uses).[54]

Beyond architectural and locational features of buildings, existing work on adaptive reuse further identifies a range of other important issues such as the viability of conversions and how this interacts with economic risks and potential regulatory barriers. This can include planning related barriers but also those associated with building regulations as well.[55] These issues are heavily varied between national governance contexts and so international literature requires careful appraisal of applicability to different contexts.

Key broader insights on planning and health

The relationship between urban planning and health has become a core focus for a range of interdisciplinary research, reflecting growing recognition that the built environment is a fundamental determinant of population health and wellbeing. While public health and planning were closely linked during the nineteenth-century sanitary reforms – indeed, in the UK, the first planning legislation was promoted by the Ministry of Health – the two fields became increasingly separated during the twentieth century. Foundational concerns such as the design quality of housing, overcrowding and compatibility of neighbouring land uses (with particular respect to pollution and amenity) were increasingly viewed as resolved through comprehensive planning in the post-war decades. Since the 1990s, however, concerns about chronic disease, environmental degradation, climate change and widening health inequalities have renewed interest in how urban development shapes health and wellbeing outcomes.

54. Kincaid, 2002 Kincaid, D. (2002) *Adapting buildings for changing uses. Guidelines for change of use refurbishment*. London: Spoon Press
55. Remøy & van der Voordt 2014 Remøy, H., & Van der Voordt, T. (2014). Adaptive reuse of office buildings into housing: opportunities and risks. *Building Research & Information*, 42(3), 381–390. Available at: **https://doi.org/10.1080/09613218.2014.865922**

Planning processes and decisions influence health through multiple pathways, including housing quality (discussed further below), transport systems, access to green space, environmental exposures, social cohesion and economic opportunity. Land use change, infrastructure provision and neighbourhood design directly affect exposure to health risks,[56] whilst health-promoting design, such as walkable neighbourhoods, high-quality public space and access to good social infrastructure is often associated with improve public health and reduced health inequalities.[57] For example, there is strong evidence of the health benefits of green and outdoor amenity space close to housing, with systematic reviews indicating that open space provision is associated with improved mental wellbeing, lower chronic disease risk and greater child socio-emotional development with stronger health benefits among socio-economically disadvantaged groups.[58] In this context, health can be considered as being shaped by a series of nested environmental, social and economic conditions.[59]

More recent work has emphasised the need for systems-based approaches to healthy urban development. Pineo's book *Healthy Urbanism: Designing and Planning Equitable, Sustainable and Inclusive Places* argues that conventional approaches to healthy planning often focus too narrowly on individual behaviours and local-scale interventions. Instead, she proposes the THRIVES framework (Towards Healthy uRbanism: InclusiVe, Equitable and Sustainable), which connects health outcomes across local, ecosystem and planetary scales. This framework highlights the interdependence of public health, environmental sustainability and social justice, encouraging planners to consider how development decisions contribute not only to immediate wellbeing but also to climate resilience, biodiversity and intergenerational equity.[60]

Other work focuses on translating health evidence into planning practice and governance. For example, Chang et al argue that health and wellbeing should become a core organising principle of planning systems rather than a secondary consideration.[61] Planning policies can address health inequalities through interventions relating to housing, transport, green infrastructure and place-making, which can be supported and facilitated through collaborative working between planners, public health practitioners and local communities.[62]

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56. Corburn, J., 2009 *Toward the Healthy City: People, Places and the Politics of Urban Planning*. MIT Press.
57. Sarkar, C., Webster, C. & Gallacher, J. (2014) *Healthy Cities: Public Health through Urban Planning*. Edward Elgar.
58. Newton. D et al (2026). Impact of residential green spaces on health inequalities in the UK: A systematic review and exploratory meta-analysis at **https://www.sciencedirect.com/science/article/pii/S1618866726000440**
59. Barton, H. & Grant, M., 2006 'A Health Map for the Local Human Habitat', *Journal of the Royal Society for the Promotion of Health*, 126(6), 252-253. Available at: **http://dx.doi.org/10.1177/1466424006070466**
60. Pineo, H., 2022 *Healthy Urbanism: Designing and Planning Equitable, Sustainable and Inclusive Places*. Palgrave Macmillan.
61. Chang, M., Green, L. & Petrokofsky, C., 2022 *Public Health Spatial Planning in Practice*. Policy Press.
62. Bird, E.L., Hyde, G. et al. 2024. Planning for healthy places: a practical guide for local authorities on embedding health in Local Plans and planning policies in England. **https://www.tcpa.org.uk/wp-content/uploads/2024/09/Planning-for-healthy-places-Accessible.pdf**

Overall, the contemporary literature suggests that planning is not merely a technical process of regulating land use, but a powerful mechanism for improving population health and reducing inequalities that is shaped by social and political processes. The process of developing health urban environments requires governance arrangements that place wellbeing, equity and sustainability at the centre of urban decision-making, which does not seem to have been the case with regard to PDR.

Key broader insights on housing and health

Housing is well established as an important determinant of health with multiple, complex pathways linking the quality of housing to a range of physical and mental health outcomes.[63] The health burdens of factors related to housing are experienced unequally, with more deprived groups likely to be worst affected, particularly those on lower incomes.[64] Some population groups, such as older people and children, are also known to be more vulnerable to a range of environmental risk factors.

Home ventilation plays a central role in determining health risks. Good ventilation is critical for removing pollutants and moisture generated within the home, preventing overheating and limiting the transmission of infectious diseases indoors. However, increasing ventilation also tends to increase the rate of movement of ambient (outdoor) air pollutants, such as fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2), into the home.[65] Most epidemiological evidence on the impacts of air pollutants on health is based on monitoring (or modelling) of concentrations in the outdoor air.[66] This evidence suggests causal relationships between exposure to ambient $PM_{2.5}$ and NO_2 and a wide range of health outcomes, including cardio-respiratory disease and lung cancer.[67] Although there is a relative lack of equivalent evidence based on indoor exposure, primarily due to the challenges of wide-scale monitoring in indoor environments, indoor concentrations of many pollutants can be considerably higher than those outdoors.[68]

63. Mary Shaw. 2004. Housing and Public Health. *Annual Review of Public Health* 25:397-418. **https://doi.org/10.1146/annurev.publhealth.25.101802.123036**
64. Philippa Howden-Chapman, Julie Bennett, Richard Edwards, David Jacobs, Kim Nathan, David Ormandy. 2023. Review of the Impact of Housing Quality on Inequalities in Health and Well-Being. *Annual Review of Public Health* 44:233-254. **https://doi.org/10.1146/annurev-publhealth-071521-111836**
65. Hamilton I, Milner J, Chalabi Z, *et al* Health effects of home energy efficiency interventions in England: a modelling study *BMJ Open* 2015;5:e007298. Available at: **http://dx.doi.org/10.1136/bmjopen-2014-007298**
66. COMEAP, 2025. Statement on Possible Approaches to Estimating the Health Effects Attributable to Exposure to PM2.5 And NO_2 Indoors, Using Epidemiological Studies on Outdoor Air Pollution. London: UK Health Security Agency. Available at: **https://www.gov.uk/government/publications/estimating-health-effects-of-pm25-and-no2-indoors/comeap-statement-on-possible-approaches-to-estimating-the-health-effects-attributable-to-exposure-to-pm25-and-no2-indoors-using-epidemiological-stud#acknowledgements**.
67. Orellano P, Kasdagli M-I, Pérez Velasco R and Samoli E (2024) Long-Term Exposure to Particulate Matter and Mortality: An Update of the WHO Global Air Quality Guidelines Systematic Review and Meta-Analysis. *Int J Public Health* 69:1607683. Available at **http://dx.doi.org/10.3389/ijph.2024.1607683**
68. Mazaheri, M …. Lidia Morawska, L. 2018. Investigations into Factors Affecting Personal Exposure to Particles in Urban Microenvironments Using Low-Cost Sensors. *Environment International* 120 (November): 496–504. Available at: **https://doi.org/10.1016/j.envint.2018.08.033**

Indoor environments also include a range of toxic contaminants with well-established health risks, such as volatile organic compounds (VOCs).[69]

Evidence demonstrating the potential health trade-offs relating to the provision of home ventilation is provided by radon, for which modelling and observation has demonstrated higher concentrations in more airtight homes.[70] Radon is a known carcinogen, which is responsible for around 1,000 lung cancer deaths each year in the UK.[71] Similarly, exposure to secondhand smoke (SHS) from tobacco smoking in indoor air is a major public health issue associated with a range of adverse health effects, including lung cancer and heart disease.[72]

Temperature is another important environmental driver of housing-related health. The relationship between temperature and health is generally V- or U-shaped, with increased risk at both low and high daily temperatures.[73] In temperate climates, such as the UK, the main focus of research and policy has historically been on keeping homes warm during the winter and reducing the burden of cold-related mortality and morbidity (as well as damp and mould). The burden of excess winter mortality is typically around 30,000 deaths per year, although this number represents mortality during the winter period rather than necessarily related to exposure to the cold.[74] However, the UK Health Security Agency (UKHSA) estimated that 2,544 deaths were associated with cold weather between November 2024 and January 2025.[75] Although it is not straightforward to estimate how many deaths relate specifically to cold exposure inside the home, it is likely to be several thousand each year.

As the climate warms, home overheating and exposure to heat indoors has become an increasingly prominent problem affecting health in the UK. A range of housing factors can increase an individual's risk of exposure to high temperatures, including the size and orientation of dwellings and the level of energy efficiency.[76] An estimated 2,000 heat-related deaths occur annually in the UK, although this includes exposure to heat outside the home.

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69. Liu, N et al. 2022. Health Effects of Exposure to Indoor Volatile Organic Compounds from 1980 to 2017: A Systematic Review and Meta‐Analysis. *Indoor Air* 32 (5). Available at **https://doi.org/10.1111/ina.13038**
70. Symonds P, Rees D, Daraktchieva Z, McColl N, Bradley J, Hamilton I, Davies M. 2019 Home energy efficiency and radon: An observational study. *Indoor Air.*29(5):854–864. Available at **http://dx.doi.org/10.1111/ina.12575**
71. Gray, A., S. Read, P. McGale, and S. Darby. 2009. Lung Cancer Deaths from Indoor Radon and the Cost Effectiveness and Potential of Policies to Reduce Them. *BMJ* 338 (jan06 1): a3110–10. Available at: **https://doi.org/10.1136/bmj.a3110**
72. Flor LS, ..., Gakidou E. 2024 Health effects associated with exposure to secondhand smoke: a Burden of Proof study. *Nat Med.*30(1):149–167. Available at **http://dx.doi.org/10.1038/s41591-023-02743-4**
73. Gasparrini A, ... Armstrong B. 2015, Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *Lancet*. 2015;386(9991):369–75. Available at **http://dx.doi.org/10.1016/S0140-6736(14)62114-0**
74. ONS 2026. Excess Winter Deaths, 2024 to 2025 – Office for National Statistics at **https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/excesswinterdeaths2024to2025**.
75. UK Government. 2026. Cold Mortality Monitoring Report: Winter 2024 To 2025 at **https://www.gov.uk/government/statistics/cold-mortality-monitoring-report-england-winter-2024-to-2025/cold-mortality-monitoring-report-winter-2024-to-2025**.
76. Kenny GP, Tetzlaff EJ, Journeay WS, Henderson SB, O'Connor FK 2024. Indoor overheating: A review of vulnerabilities, causes, and strategies to prevent adverse human health outcomes during extreme heat events. Temperature (Austin). Jun 4;11(3):203–246. Available at **http://dx.doi.org/10.1080/23328940.2024.2361223**

Additional housing factors known to impact people's health include the use of particular building materials that are known to be toxic to humans (e.g. lead and asbestos), the adequacy of space, which may result in overcrowding and impacts on mental wellbeing, and the general quality of the housing environment, which may affect factors such as noise, physical activity and injury risk. Another important aspect of housing environments relates to residents' sense of control and autonomy within their living spaces. Previous research has shown that the ability to shape one's living environment and maintain stability in housing arrangements can play a crucial role in supporting wellbeing and personal development.[77] Housing that is poorly designed or socially isolating may undermine these capabilities, particularly when residents have limited alternatives or opportunities to relocate. These considerations highlight the importance of viewing housing not simply as a physical structure but as a social environment that shapes everyday experiences, in other words – as a home.[78]

Complementing the evidence on the health risks associated with poor quality and poor location of housing, there is now also evidence from evaluation studies showing that interventions to improve housing conditions may have beneficial effects on health.[79] For example, a growing number of studies show that improving the energy efficiency of housing, for example by increasing the insulation of walls and lofts, has the potential for benefits for people's physical and mental health.[80] There are also likely benefits for psychosocial health, for instance by improving levels social of social participation. However, it is important that any reduction in ventilation is compensated for using appropriate measures to avoid the build-up of indoor generated pollutants and moisture, which could result in adverse health impacts. A summary of the social and economic pathways through which the quality of housing impacts health including through risk of respiratory, cardiovascular and infectious diseases is provided in Figure 1, which is based on associations between housing and health discussed in previous systematic reviews.

77. TCPA, 2020. The Raynsford Review 'One Year On': 21st Century Slums? Available at:**https://www.tcpa.org.uk/resources/the-raynsford-review-one-year-on/**
78. Blunt, A. and Dowling, R. *(2006) Home.* London: Routledge.
79. Thomson H, Thomas S, Sellstrom E, Petticrew M. 2026 Housing improvements for health and associated socio□economic outcomes. Cochrane Database of Systematic Reviews 2013, Issue 2. Art. No.: CD008657. Available at **http://dx.doi.org/10.1002/14651858.CD008657**
80. Maidment, Christopher D., Christopher R. Jones, Thomas L. Webb, E. Abigail Hathway, and Jan M. Gilbertson. 2014. The Impact of Household Energy Efficiency Measures on Health: A Meta-Analysis, *Energy Policy* 65: 583–93. Available at: **https://doi.org/10.1016/j.enpol.2013.10.054**

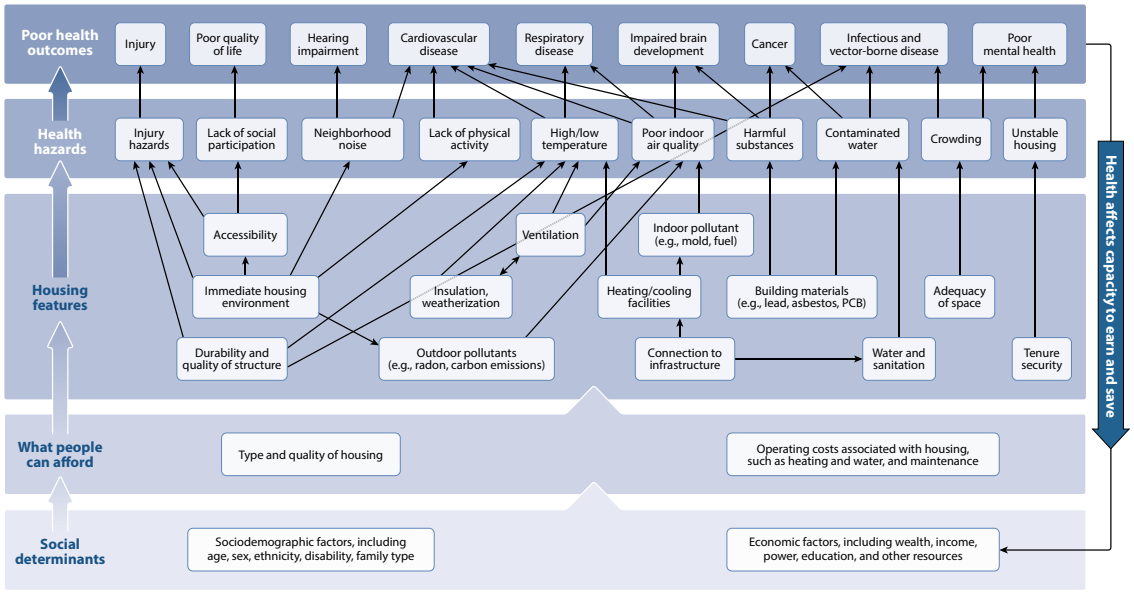


Figure 1: Key housing pathways to health, from Howden-Chapman et al (2023) [81]

81. Source: Howden-Chapman, P., Bennett, J., Edwards, R., Jacobs, D., Nathan, K., & Ormandy, D. 2023. Review of the impact of housing quality on inequalities in health and well-being. *Annual review of public health, 44(1), 233-254. Available at:* **https://doi.org/10.1146/annurev-publhealth-071521-111836**



Our overall research questions and summary of the approach to the research

The expansion of PDR has fundamentally reshaped the landscape of housing development in England since 2013. Whilst the overall number of new homes delivered under PDR is small compared to those delivered under full planning permission, it is both still a significant number itself but also significant of the broader policy direction of seeing planning as a barrier in need of deregulation as a means of addressing the housing crisis. In this case, whilst deregulation has enabled the rapid creation of new housing units through the conversion of commercial and agricultural buildings, it has also generated significant debate regarding housing standards and planning governance. There are also clear reasons to link housing quality with public health.

By examining these issues in greater depth, this research seeks to contribute to a more comprehensive understanding of the relationship between planning, housing quality and health in contemporary regulatory contexts. The lived experiences of residents of PDR conversions provides a valuable case study through which to examine the broader implications of planning deregulation. These developments sit at the intersection of housing policy, planning scholarship and public health, illustrating how regulatory decisions can shape the built environment in ways that affect everyday life.

By examining these processes in detail through the lens of post-occupancy lived experiences, it becomes possible to better understand the trade-offs and tensions inherent in contemporary housing policy.

Specifically, this study aimed to explore the characteristics and lived experiences associated with residential developments created through PDR conversions. By drawing on existing literature and through extensive new empirical research, the study provides a deeper understanding of how planning deregulation influences the quality of housing and the wellbeing of those who live within them. This contributes to discussions about the role the planning system in England plays in promoting healthy and equitable living environments. Housing is not merely a commodity or investment asset but a fundamental component of social infrastructure that shapes health, opportunity and quality of life.[82] Ensuring that the planning system supports these broader outcomes requires careful consideration of both different housing typologies, including PDR converted housing.

The overall research question that guided our study was:

What are the health and health inequality impacts of housing created through the new Permitted Development Rights?

In order to answer this overall research question, we organised the study into five separate but linked 'work packages'. These addressed the sub-questions identified under each work package and together meet the following objectives:

1. Identify as many PDR homes across England as possible, and identify the demographic, health and socioeconomic characteristics of populations living in PDR housing, understanding how this compares to people living in areas with a similar level of socioeconomic deprivation
2. Analyse the associations between homes developed via PD, hospital admissions and mortality and how these compare to all-cause and cause-specific morbidity and mortality for populations living in non-PDR housing
3. Characterise residents' common health-related behaviours and experiences related to the indoor environment of PDR housing, identifying variations across socio-economic status and housing tenure
4. Understand the exposures to excess heat and cold and indoor air pollutants of populations living in PDR housing

82. Blunt, A. and Dowling, R., 2006. *Home.* Routledge.

5. Perform an integrated assessment of all housing-related health risks of homes built under PD, their health economic costs and the potential cost-benefit of altered regulation or required adaptations
6. Explore the regulatory and policy 'levers' available to local policy makers to protect against the most negative health effects of PDR housing, and produce guidance to help them use these levers as effectively as possible

The five work packages were:

1. Identifying PDR housing addresses and health data linkage
2. Lived experience of PDR housing and resident perspectives on health and wellbeing
3. Monitoring and modelling indoor environmental conditions in PDR housing
4. Integrated quantification of environmental health risks and economic evaluation
5. Policy levers and practitioner perspectives on PDR housing

Collectively these consider the extent of health impacts and inequities from PDR housing with identification of potential interventions and their cost implications. Figure 2, below, summarises the work packages. Appendix 1 lists the research team involved in the project and their roles. The project included the involvement of the Town and Country Planning Association (TCPA), a charity with longstanding expertise on the relationship between public health and urban planning, and the homelessness charity Groundswell – given that some PDR housing is used as temporary accommodation for those at risk of homelessness who can have additional vulnerabilities.

The project also benefitted from a Project Steering Committee, offering academic and professional expertise in planning, housing, public health, environmental health and local government, and a Public and Advisory Group which included existing residents of PDR housing and some third sector organisations who have provided support to some PDR residents. Appendix 2 lists the membership of these committees. The project additionally built upon pilot research involving some of the same researchers as this work. This looked at the relationship between permitted development housing and health in four London boroughs which was funded by the Impact on Urban Health charity (already introduced in the previous section). Some residents of PDR housing from that previous research helped shaped the original proposal and project plan for these residents.

Each of the five work packages was shaped by their own detailed research sub-questions sitting under our overall research question. We explain these and further detail on issues of research design and setting, study population, sampling, data collection and analysis through our explanation of these work packages in the following sections, which are structured by work package.

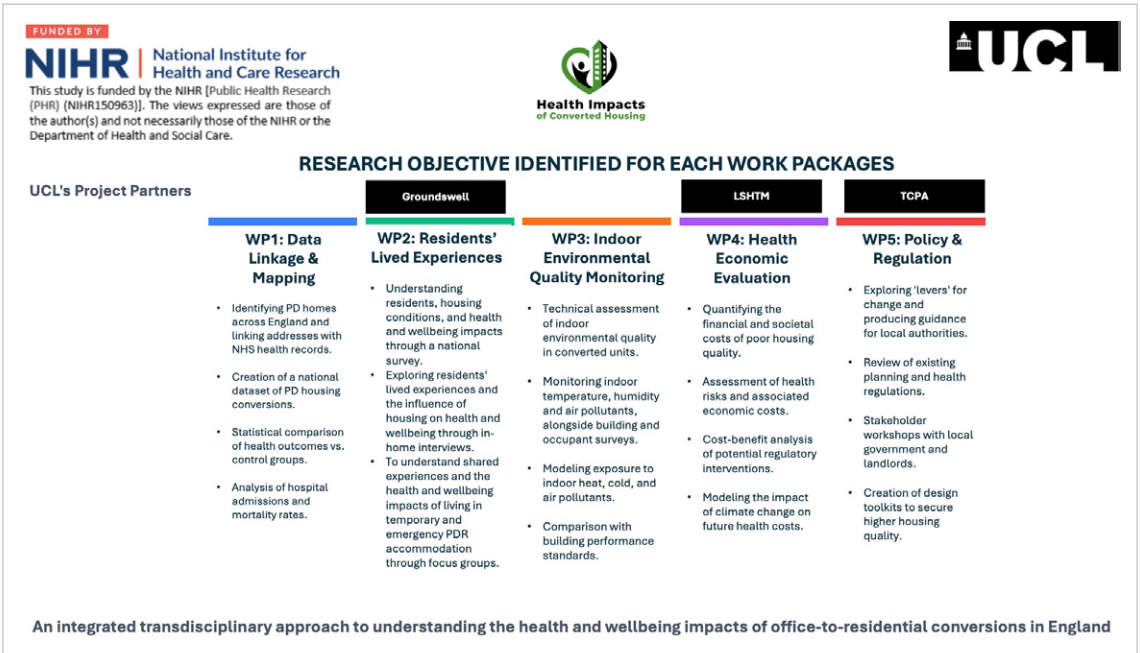


Figure 2: Research objectives by each work package



Work Package 1: Locating permitted development housing and health data analysis

Background

Work Package 1 asked where homes created through permitted development rights (PDR) are located in England and what rates of all-cause and cause-specific morbidity and mortality their residents experience. The original research questions for the work package were:

- **RQ1.1** Where are homes created through PDR located in England?
- **RQ1.2** What are the rates of all-cause and cause-specific morbidity and mortality in individuals living in PDR homes, compared to other properties in areas with a similar level of socioeconomic deprivation?

Having identified the addresses of as many residential units created through PDR from 2013-2023 as we could, the original design was for a cohort study built on individual-level linkage of the entire PDR address frame to NHS data, could not proceed: NHS England confirmed in 2024 that the linkage was technically feasible but declined to undertake it for resource reasons, after NHS research ethics and Confidentiality Advisory Group approvals had been obtained by December 2023.

Under the Work Package 1 recovery plan prepared in November 2024 and approved by NIHR, we instead commissioned a bespoke linkage of the PDR address frame to death registrations from the Office for National Statistics (ONS). Additionally, a subset of PDR addresses falling within Bradford could be linked at the individual level to Connected Bradford, a research database linking primary and secondary care records for the Bradford population. We present this as a case study of the kind of individual-level analysis the original national linkage was intended to support. Further, we were able to undertake some spatial analysis of the location of PDR housing using our address data set and to link this to Energy Performance Certificate (EPC) data where available.

This section will first describe where the homes created through Permitted Development rights are located and their surrounding environment, then describe the deaths identified through the ONS linkage. and finally present the Connected Bradford data as case study of within-person change in primary care service use following a move into PDR housing. Comparative analyses, in which observed deaths are set against the deaths expected at national mortality rates, will be reported separately following further analysis.

Methods

Identifying the location of homes create through Permitted Development in England

As no existing data set identifying the addresses of housing created through change-of-use PDRs across England was available, the project team assembled a national address frame of homes created through permitted development by obtaining prior approval planning records for 2013-2023 from every local planning authority (over 300), cross-referencing these against the Glenigan construction database to help identify whether large developments had proceeded under prior approval or full planning permission (multiple permissions on the same site not being uncommon) and address-matching to Ordnance Survey AddressBase to identify where residential units had actually been created following the granting of prior approval, utilising their classification scheme for each address point.[83]

83. See **https://docs.os.uk/osngd/code-lists/code-lists-overview/addressclassificationcodevalue**

Where one building or part of a building in commercial or agricultural use was converted into multiple residential units (as was the case most of the time), we refer to this as a 'scheme'. AddressBase data allowed the identification of each property within a scheme and the Unique Property Reference Numbers (UPRN) for each residential unit. These were then further matched to Energy Performance Certificate (EPC) data. In some cases, some parts of a building were converted under PDR whilst other parts were converted through a full planning permission (for example, an office building where some floors were in office use whilst others were in educational use). In other cases, buildings being converted under PDR had additional floors or extensions added under a full planning permission. We know from existing work that in these cases, there can be higher quality accommodation in the parts of the building being converted under the full planning permission due to the differing regulatory regimes. Where we could identify specific flats that resulted from the full permission rather than the prior approval, these were excluded from our address frame data set.

Using the prior approval data from local planning authorities, in the address frame data set we also identified the type of conversion it was, i.e. agricultural to residential, light industrial to residential, office to residential, retail and sui generis to residential or storage and distribution to residential. This was according to the PDR used for 2013–2021, and from 2021–23 for Class E to residential schemes by classifying the type of building according to the development description and/or site address data. We classified the size of the conversion scheme based on the number of residential units we found to have been created there as 'small minor' (1–4 units), 'large minor' (5–9 units), 'small major' (10–24 units), 'medium major' (25–99 units) and 'large major' (100 or more units). We also classified each PDR scheme into one of three year groups: 2013–19, 2020–21, or 2022–23. This was based on the prior approval data, usually the date of submission where available or the date of decision if that was all that was available. This is because of the key regulatory changes around natural light (introduced in June 2020) and space standards (introduced from April 2021) so that we might consider 2013–19 schemes with the most lax planning regulations, 2020–21 as during a flux period and 2022–23 with slightly tighter regulatory controls. Finally, using the identified residential addresses from the AddressBase data, we linked each address to its Lower Layer Super Output Area (LSOA). Using 2021 census data, we classified each LSOA across England into quintiles based on the 'household is not deprived in any dimension' data where 1 is the quintile with the highest deprivation and 5 the lowest. We then assigned each PDR housing scheme and unit into one of these five deprivation quintiles.

Given the previous use of PDR converted buildings, we analysed the proximity of PDR buildings to some land uses incompatible with residential use. We used 'Point of Interest' data obtained from the Ordnance Survey (EDINA DIGIMAP)[84]. We classified features into categories based on their OS classification codes as follows:

- **Waste, salvage, recycling** (threshold 200m): clearance and salvage dealers (0199), rag merchants (0198), recycling, reclamation and disposal (0196), scrap metal dealers and breakers yards (0200), wastepaper merchants (0202), refuse disposal facilities (0440), waste storage, processing and disposal (0441), recycling centres (0462).
- **Nightclubs** (Threshold 200m): Nightclubs (0312).
- **Vehicle repair and servicing** (threshold 100m) included vehicle repair, testing and servicing establishments (0212).
- **Industrial manufacturing** (threshold 200m) included metals manufacturers and fabricators (0585), vehicle bodybuilders (0613), general manufacturing (0612), paints, varnishes and lacquers (0591), rubber, silicones and plastics (0604), industrial coatings and finishings (0577), tools including machine shops (0579), concrete products (0562), adhesives and sealants (0545), colours and chemicals (0557), glass (0575), wood products (0616), engines (0569), ovens and furnaces (0589), pumps and compressors (0600), and extraction industries including coal mining (0500), oil and gas extraction (0501), ore mining (0502), sand and gravel extraction (0504), stone quarrying (0506) and unspecified quarries (0507).

Ordnance Survey Point of interest data was also used to identify GP surgeries (0369), primary schools (0375) and bus stops (0732) to assess closeness to basic amenities. Addresses were classified as poorly served if they were located more than 2 km from the nearest GP surgery, more than 2 km from the nearest primary school or more than 1 km from the nearest bus stop.

Point of interest analysis was conducted only for addresses with a valid unique property reference number (UPRN).

Outdoor air quality

Fine particulate matter ($PM_{2.5}$) is its most harmful air pollutant and a reliable proxy for ambient air quality.[85] The WHO 2021 guidelines recommend an annual mean below 5 µg $m^{-3}$and a 24-hour mean not exceeding 15 µg m^{-3} on more than 3 to 4 days a year.[86] England has a legally binding target of 10 µg m^{-3}annual mean by 2040.

84. Ordnance Survey. *Points of Interest Documentation.* Available at: **https://docs.os.uk/os-downloads/products/addresses-and-names-portfolio/points-of-interest**
85. WHO. 2022. *Billions of people still breathe unhealthy air: new WHO data. Available at:* **https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data**
86. WHO 2021 *WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Available at:* **https://www.who.int/publications/i/item/9789240034228**

We estimated annual mean $PM_{2.5}$ at each PD address using the Defra Pollution Climate Mapping (PCM) model which provides modelled concentrations on a 1km grid across England. In London, where the density of monitors allows the estimation of daily exposure, we also obtained hourly $PM_{2.5}$ for 2023 from monitoring sites in the national Automatic Urban and Rural Network and the London Air Quality Network. Hourly values outside 0–100 μg m^{-3} were excluded. Daily means required at least 75% valid hours, and monitoring sites were excluded if daily means were not available for at least 50% of days. Each London PD address was assigned the daily mean of its nearest qualifying monitor within 7km, using the second and third nearest if data were missing. We report the number of days on which the daily mean exceeded the WHO-2024 hour guidelines of 15 μg m^{-3}.

Proximity to sources of air pollution

We assessed the proximity of PD addresses to two sources of $PM_{2.5}$, commercial cooking and major roads, which following, for example, a recent clean air action plan from Camden Council listed as what would be the two largest external sources (outside the home) of air pollution impacting residents.[87] Commercial cooking outlets were identified from Ordnance Survey Points of Interest Data (EDINA Digimap) using the following classification codes: Banqueting/function rooms (01020012), Fast food/takeaway (01020018), Fast food delivery (01020019), Fish and chips (01020020), Pubs/bars/inns (01020034), and restaurants (01020043). Major roads (motorways and A roads) were obtained from OS Open Roads (Version Date April 2026).[88] For each address we calculated the distance to the nearest commercial cooking outlet and to the nearest major road centreline. We report the proportion of addresses within 50m and 100m of each source and the median distance (IQR), by area and PDR type.

Extreme Heat Vulnerability Index

To assess if PD housing were more vulnerable to extreme heat, we linked our PDR address framework with the Extreme Heat Vulnerability Index (EHVI),[89] an area-level measure of vulnerability based on 5 domains: low ability to respond to heatwaves, enhanced physical risk, access to cool spaces, outdoor environment and housing. The index score and each of its domains are ranked across all 33,755 LSOAs in England. We classified LSOAs into national deciles and defined high vulnerability as the most vulnerable 10% of LSOAs. We report the proportion of PD addresses in high vulnerability LSOAs, overall and for each domain.

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87. Camden Council 2027. *Draft clean air action plan. Available at:* **https://consultations.wearecamden.org/supporting-communities/camden-clean-air-action-plan-2027-2030/user_uploads/draft-camden-clean-air-action-plan-2027-2030---wf.pdf**
88. OS open Roads data available at: **https://osdatahub.os.uk/data/downloads/open/OpenRoads**
89. Oxford Consultants for Social Inclusion 2026. *Extreme Heat Vulnerability Index. Available at:* **https://ocsi.uk/wp-content/uploads/2026/08/Extreme-Heat-Vulnerability-Index-Report.pdf**

Linkage to EPC data on floorspace

With an identified address frame for PDR homes, we could then match these to Energy Performance Certificate (EPC) data. We were able to match for 57,169 of our 77,421 units (73.8%). The missing set is likely due to the complexities of address matching, a small number of properties being exempt but also some cases of non-compliance with the requirements. EPC data contains information on the number of habitable rooms for the dwelling and the overall total internal floorspace, as well as information about energy performance and related issues.

As well as issues of data non-availability, the EPC data on total floorspace suffers from issues of persistent inaccuracy compared to the actual exact floorspace, which may be particularly problematic where the property has an unusually shaped floorplan as was common with some office-to-residential conversions, for example.[90] Whilst less accurate for determining actual compliance with Nationally Described Space Standards than detailed examination of floorplans, for example, the large size of the data set can help us understand differences between types of scheme and broad trends in change over time for internal floorspace in PDR units, a key indicator of broader quality of the housing and an important issue for health and wellbeing. We have attempted to also reduce potential sources of inaccuracy by, for example, excluding flats in PDR conversions actually created through planning permission (for example floors that were not originally in an eligible use class for PDR, or extensions added to the building) as far as possible.

Not all fields of the EPC data were available. We had floorspace and the number of habitable rooms available for 12,076 schemes in total. The NDSS is gradated by the number of bedrooms, number of people those bedrooms are designed for, and the number of floors. This information is not available in EPC certificates, however we can infer that the number of habitable rooms minus one is likely to be the number of bedrooms. For example, a flat showing one habitable room on the EPC data is likely to be a studio flat with no bedrooms where the NDSS standard of 37m^2 applies and two habitable rooms is likely to be a one-bedroom flat where the 50m^2 applies. Where there were two standards for a certain number of bedrooms, such as 3 person or 4 person, we used the lower standard and assumed all dwellings[91] were over one floor only. These assumptions are likely to be more accurate for smaller flats and less accurate for larger homes, and the overall compliance figures should be treated with due caution, however they give useful insight for differences between sub-groups of PDR housing and changed over time.

90. See Clifford, B., Canelas, P., Dunning, R., Ferm, J., Livingstone, N., & Lord, A. 2025. On the need for caution in using 'big data'for built environment research. *Environment and Planning A: Economy and Space, 57(5), 669–686. Available at:* **https://doi.org/10.1177/0308518X251331862**

91. Used in the planning policy sense, to mean any housing units created under PDR

Linkage to ONS mortality dataset

ONS allocated Unique Property Reference Numbers (UPRNs) to 5,025,523 death registrations for deaths occurring between 2013 and 2024, excluding deaths of people usually resident in care homes and other non-residential establishments, and linked these to the address frame, first on unique postcode and then on UPRN, with clerical checking of matches. Deaths occurring before the year the relevant permitted development right came into force were removed; this is the year of the enabling policy, not the date of each property's conversion. After removal of duplicate links, the final linked cohort comprised 2,148 deaths. ONS produced four aggregated output tables under its disclosure control rules and published them on the ONS website in February 2026: all-cause deaths by sex and five-year age group for each year of occurrence 2013 to 2024; all deaths under age 75, by sex and year of occurrence, classified into ten cause groups defined by the ICD-10 codes of the ONS avoidable mortality definition plus a residual "Other" group; deaths from suicide (ONS definition) by year and development size; and deaths from intentional self-harm, events of undetermined intent and assault by year and development size. Because the counts are small, the suicide and violent-cause tables could not be disaggregated by sex or age.

Case study: Connected Bradford

The Connected Bradford dataset covers 800,000 citizens, linking data from five NHS trusts and 86 general practices. It is representative of the Bradford population and allows health data to be linked to other government datasets and, through the inclusion of UPRN, to our PDR address framework. Our sampling framework identified 521 UPRN addresses within Bradford which were linked to the Connected Bradford whole System Data Linkage Acceleratorvia UPRN.[92]

Design

We used a within-person, before and after design to explore whether living at a PD-converted address was associated with differences in primary care appointments rates. Because each person acts as their own control, this design removes some potential confounders such as baseline health status, socioeconomic position, ethnicity, that are stable between person characteristics.

92. Sohal K, Mason D, Birkinshaw J *et al. 2022 Connected Bradford: a Whole System Data Linkage Accelerator Wellcome Open Res* 7:26. Available at: **https://doi.org/10.12688/wellcomeopenres.17526.2**)

Data Source

Connected Bradford holds clinical data of over 800,000 residents of Bradford. GP address histories are linked to properties via UPRNs. This linkage was built by georeferencing historical GP address records against Ordnance survey Data and using address-matching methods as detailed by Krenz et al.[93]

Exposure and index date definition

The index date marked the beginning of a person's exposure to PDR housing and was defined as the later of two dates a) the date of a person's GP registration at the PDR address and b) the date of approval of the PDR conversion. Property-level conversion approval dates were gathered from planning record prior approvals and are available as bands e.g. properties approved between a) 2013-2019, b)2020-2021 and c) 2022-2023. Some GP registration dates predated the date of approval, for these cases, the date of conversion approval was taken as the index date instead.

Follow-up and outcome

Pre-index and post-index person time were derived from each person's observation period (period for which they had continuous GP-recorded data available). The main outcome was the number of attended primary care appointments within each window. We determined an appointment was attended as the date of arrival was not null. Appointments included all types of clinical staff and telephone consultations.

Analysis

The primary analysis compared number of primary care appointments in matched pre and post index date windows. For each person, the length of both windows was set to the shorter of their available pre-or post-index follow-up, capped at 10 years; so the two windows compared were always equal in length for a given person.

Unadjusted pre post number of attendances were compared using the Wilcoxon signed rank test. We then fitted an adjusted mixed effects Poisson regression. The outcome was the number of appointments in a window, the main predictor was an indicator for whether the window was pre or post index date. The resulting exponentiated coefficient gives the rate ratio associated with the post-index period. Because window length varied between people, the model included an offset for the length of each window in years.

93. Krenz, K.; Dhanani, A.; McEachan, R.R.C.; Sohal, K.; Wright, J.; Vaughan, L., 2023 Linking the Urban Environment and Health: An Innovative Methodology for Measuring Individual-Level Environmental Exposures. *Int. J. Environ. Res. Public Health, 20, 1953. Available at:* **https://doi.org/10.3390/ijerph20031953**

We also included as covariate, the proportion of each window's person-time falling within 2020–2021, the period of the COVID-19 pandemic, to account for pandemic related disruption and any associated change in primary care contact. A person-level random-effect was also considered. Finally, a person-level random effect was included to account for each person contributing two linked observations.

The secondary analysis was an interrupted time series. Here, we constructed a person-level panel of appointment counts by year relative to the index date capped at 10 years at both sides. The same censoring rules than the primary analysis applied. This panel was then modelled with a mixed effects Poisson regression in which the outcome was the number of appointments in a person's relative year. The model included an indicator for whether that year fell after the index date, a continuous term for relative year itself to capture trends in appointment rate already present before or after the exposure to PDR housing and an indicator for whether the corresponding calendar year fell in 2020 or 2021. A person-level random intercept accounted for repeated observations. No offset was needed since each relative year corresponds to one year of follow-up. Rate ratios and 95% confidence intervals are presented.

Sensitivity analysis

We ran a sensitivity analysis excluding those whose index date was imputed (i.e., set to the year of conversion approval rather than their own registration date).

Morbidity prevalence

One of the objectives of WP1 was to describe the causes of morbidity in residents of PDR housing. We used the Connected Bradford to provide a description of the main causes in the PDR population living in Bradford. For this, we used a separate primary care coded entry table which records every clinical code entered in a patient's GP record, including diagnoses, procedures and investigations along with CTV3 read codes. We manually grouped the read codes to broad condition categories (i.e., asthma, COPD, respiratory infections, diabetes, hypertension, cardiovascular conditions, cancer, mental health, self-harm, substance use). Terms that did not correspond to a health condition like blood test and medication reviews were excluded from the morbidity description. For each condition category, prevalence was calculated as the proportion of the population with at least one matching code recorded and not as a count of coded entries since a single condition can generate several code entries per person.

Where are homes created with PDR located in England

We identified 77,421 residential PDR addresses across England, within 13,122 schemes. Table 2 shows the key characteristic data for the addresses identified. Office-to-residential conversions accounted for the largest share (85.0%, n=65,771), followed by agricultural-to-residential (8.5%, n=6,608) and retail/sui generis-to-residential conversions (5.3%, n=4,089). Most units were approved between 2013 and 2019 (85.3%, n=66,016), with 11.9% (n=9,213) approved in 2020–2021 and 2.8% (n=2,192) approved in 2022–2023.

Overall, the mean average scheme size was 64 units however this is influenced by some very large office-to-residential conversions (the largest found being 439 units) and the median scheme size of 31 units perhaps gives more sense of typical PDR conversion. Office-to-residential conversions were, on average, the largest in terms of the number of units created and agricultural-to-residential the smallest (some schemes identified are larger than the maximum number of permitted units under the agricultural PDR, however this is likely more than one scheme over time within the same location having been grouped together as a single scheme during our address matching work).

Nationally, PDR housing was fairly evenly distributed in terms of the deprivation of LSOAs as categorised into quintiles. However, there is notable difference in terms of agricultural-to-residential compared to the various commercial-to-residential changes of use here, with the agricultural conversion schemes far less likely to be found in areas of high deprivation than any of the commercial type conversion schemes (just 8% in the LSOAs with the highest levels of deprivation). Retail and associated sui generis to residential conversion schemes were the type most likely to be found in the most deprived neighbourhood locations (47.8% in quintile 1 and 2 LSOAs).

Agricultural conversions also were most likely to have led to the creation of houses (87.1%) whereas all the commercial-to-residential conversions were most likely to have led to the creation of flats (up to 93.3% of the units identified in the case of office-to-residential). The 'other' types of housing listed in Table 2's figures would be things like housing in multiple occupation and residential institutions.

The overall number of addresses we identified was lower than that suggested by MHCLG data (live tables on net additional dwellings) for housing created through change of use PDRs (see also Table 3). There are a number of possible factors that may help explain this.

Table 2: Characteristics of PDR housing identified through the address frame data set work

	Type of PDR scheme	Agri-to-resi	Light ind-to-resi	Office-to-resi	Retail SG-to-resi	Storage Dist-to-resi	Grand total
Resi units found	**Total**	6608	369	65771	4089	584	77421
Year group of prior approval	**2013-19**	4313 (65.3%)	242 (65.6%)	58569 (89.1%)	2336 (57.1%)	556 (95.2%)	66016 (85.3%)
	2020-21	1463 (22.1%)	98 (26.6%)	6564 (10.0%)	1062 (26.0%)	26 (4.5%)	9213 (11.9%)
	2022-23	832 (12.6%)	29 (7.9%)	638 (1.0%)	691 (16.9%)	2 (0.3%)	2192 (2.8%)
Scheme size	**Small minor**	5779 (87.5%)	184 (49.9%)	5810 (8.8%)	2571 (62.9%)	264 (45.2%)	14608 (18.9%)
	Large minor	501 (7.6%)	114 (30.9%)	6391 (9.7%)	727 (17.8%)	81 (13.9%)	7814 (10.1%)
	Small major	157 (2.4%)	71 (19.2%)	11700 (17.8%)	471 (11.5%)	108 (18.5%)	12507 (16.2%)
	Medium major	171 (2.59%)	0 (0%)	26942 (41.0%)	320 (7.8%)	131 (22.4%)	27564 (35.6%)
	Large major	0 (0%)	0 (0%)	15028 (22.9%)	0 (0%)	0 (0%)	15028 (19.4%)
Average scheme size (units)	**Mean**	3.45	5.73	74.65	7.62	19.4	64.28
	Median	1	5	42	3	6	31
Deprivation quintile	**1**	65 (1.0%)	48 (13.0%)	11543 (17.6%)	926 (22.7%)	71 (12.2%)	12654 (16.3%)
	2	460 (7.0%)	94 (25.5%)	14419 (21.9%)	1025 (25.1%)	133 (22.8%)	16133 (20.8%)
	3	1353 (20.5%)	64 (17.3%)	14363 (21.8%)	833 (20.4%)	125 (21.4%)	16741 (21.6%)
	4	2614 (39.6%)	108 (29.3%)	12815 (19.5%)	730 (17.9%)	111 (19.0%)	16382 (21.2%)
	5	2116 (32.0%)	55 (14.9%)	12631 (19.2%)	575 (14.1%)	144 (24.7%)	15526 (20.1%)
Type of dwelling	**RD02-04 (house)**	5756 (87.1%)	138 (37.4%)	2011 (3.1%)	596 (14.6%)	195 (33.4%)	8696 (11.2%)
	RD06 (flat)	504 (7.6%)	224 (60.7%)	61337 (93.3%)	3327 (81.4%)	356 (61.0%)	65748 (84.9%)
	Other	348 (5.3%)	7 (1.9%)	2423 (3.7%)	166 (4.1%)	33 (5.7%)	2977 (3.9%)

One issue is the complexity of address matching between the different data sets we were using: the prior approval data from local planning authorities show where proposed conversions were approved but not which were actually implemented, which required address matching to the OS AddressBase data but in many cases addresses changed during conversion. Address matching was particularly challenging for agricultural to residential schemes. The use of UPRNs could sometimes help but these were often not present in the planning data and even when they were, the UPRNs of the new residential units created were not always correctly linked to the historic UPRNs of their predecessor non-residential buildings. Another issue is schemes that have some units allowed under PDR and some allowed under full planning permission: we have excluded the planning permission units wherever we could identify these, but suspect these may all have been classified as 'PDR' in local authority data returns to MHCLG. That said, our broad distribution of the number of units we identified between the different types of permitted development and the different local authority locations is similar to that in the MHCLG data, suggesting that our identified addresses provide a good insight into the national stock of housing created through change of use PDR.

Figure 3 shows the number of PDR units relative to population size for each local authority. Hotspots are located in London and the Southeast with Slough, Crawley and Reading being the local authorities with highest ratio of PDR units per 1,000 population according to our address list and analysis (see also Table 3). There are large concentrations of PDR housing in most London boroughs, major urban areas across much of England but particularly in the south of England (for example, Bristol) and new town locations, particularly those in the south east of England (for example Crawley and Harlow).

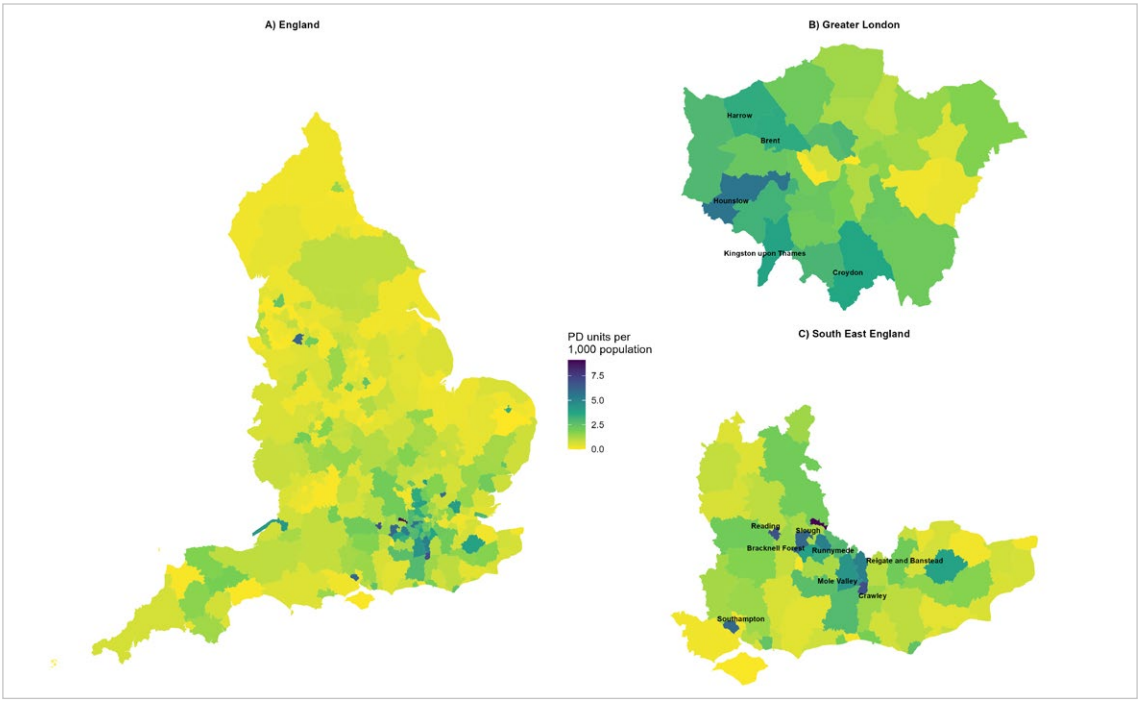


Figure 3: Number of PDR units per population size in A) England and B) Greater London, C) South East

Table 3: Number of PDR housing units per local authority in according to MHCLG data and our own identified address list, sorted by rate of units compared to population

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Brentwood	855	319	79326	10.78	4.02
Harlow	998	578	98235	10.16	5.88
Bracknell Forest	1264	792	130806	9.66	6.05
Croydon	3835	3029	409342	9.37	7.40
Slough	1555	1526	167359	9.29	9.12
Runnymede	805	475	92118	8.74	5.16
Crawley	972	855	124008	7.84	6.89
Basingstoke and Deane	1423	327	193110	7.37	1.69
Spelthorne	761	292	107074	7.11	2.73
Reading	1293	1241	182907	7.07	6.78
Surrey Heath	633	370	94492	6.70	3.92
Mole Valley	587	387	88709	6.62	4.36
Maidstone	1166	858	187767	6.21	4.57
Hounslow	1859	2222	299424	6.21	7.42
Stevenage	560	365	91774	6.10	3.98
Brent	2049	1683	352976	5.80	4.77
Norwich	836	510	147182	5.68	3.47
Peterborough	1225	332	223655	5.48	1.48
Woking	573	350	105679	5.42	3.31
Hertsmere	584	429	110212	5.30	3.89
Luton	1250	550	239090	5.23	2.30
Reigate and Banstead	823	819	159134	5.17	5.15
Trafford	1229	1479	241025	5.10	6.14
Harrow	1368	1104	270724	5.05	4.08
West Berkshire	832	347	165112	5.04	2.10
Bristol, City of	2417	2090	494399	4.89	4.23
Hart	502	84	103162	4.87	0.81
Basildon	941	138	193632	4.86	0.71
Sutton	1013	652	214525	4.72	3.04
Nottingham	1551	807	331077	4.68	2.44
Swindon	1121	473	243875	4.60	1.94
Welwyn Hatfield	519	253	122819	4.23	2.06
Bedford	791	334	194976	4.06	1.71
Worthing	459	222	113866	4.03	1.95
Mid Sussex	646	222	161755	3.99	1.37
Southend-on-Sea	721	548	185256	3.89	2.96
Hillingdon	1267	1043	329185	3.85	3.17
Ipswich	536	331	140274	3.82	2.36
Three Rivers	364	41	95807	3.80	0.43

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Kingston upon Thames	641	666	172692	3.71	3.86
Chelmsford	688	279	188803	3.64	1.48
Southampton	934	1726	259424	3.60	6.65
Watford	383	375	107171	3.57	3.50
Barnet	1405	1026	405050	3.47	2.53
Richmond upon Thames	678	635	196678	3.45	3.23
Dacorum	548	26	161420	3.39	0.16
Horsham	514	431	151521	3.39	2.84
York	700	159	209301	3.34	0.76
Wychavon	438	185	138017	3.17	1.34
Brighton and Hove	900	549	283870	3.17	1.93
Lambeth	966	743	316920	3.05	2.34
Tunbridge Wells	363	189	119694	3.03	1.58
Milton Keynes	903	414	305884	2.95	1.35
Mid Devon	247	163	84993	2.91	1.92
Hammersmith and Fulham	548	418	188687	2.90	2.22
Sheffield	1679	488	582493	2.88	0.84
Newcastle-under-Lyme	364	184	127727	2.85	1.44
St Albans	417	526	151012	2.76	3.48
Preston	444	383	162864	2.73	2.35
Camden	591	739	216943	2.72	3.41
Elmbridge	385	407	141926	2.71	2.87
Sunderland	752	37	288606	2.61	0.13
Wokingham	486	267	187200	2.60	1.43
Redditch	227	105	87847	2.58	1.20
Wolverhampton	722	114	281251	2.57	0.41
Bradford	1441	521	563605	2.56	0.92
Windsor and Maidenhead	405	190	158943	2.55	1.20
Waverley	339	363	134284	2.52	2.70
Broxbourne	257	68	101900	2.52	0.67
Leicester	976	436	388348	2.51	1.12
Gloucester	346	5	138598	2.50	0.04
Merton	544	556	218539	2.49	2.54
Guildford	376	180	151359	2.48	1.19
Colchester	497	417	200222	2.48	2.08
Islington	549	719	223024	2.46	3.22
Solihull	539	210	221242	2.44	0.95
Derby	667	475	274149	2.43	1.73
Malvern Hills	201	69	83227	2.42	0.83
Newcastle upon Tyne	765	470	320605	2.39	1.47

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Birmingham	2821	2002	1183618	2.38	1.69
Eastbourne	240	257	104259	2.30	2.47
North Hertfordshire	312	81	137201	2.27	0.59
Leeds	1848	829	845189	2.19	0.98
Tower Hamlets	721	606	331886	2.17	1.83
Stockport	649	621	303929	2.14	2.04
Dudley	702	384	331930	2.11	1.16
Bromley	702	723	335319	2.09	2.16
Portsmouth	443	524	214321	2.07	2.44
Liverpool	1024	614	508961	2.01	1.21
Fareham	228	120	115428	1.98	1.04
Sandwell	675	33	353860	1.91	0.09
Wandsworth	639	812	337655	1.89	2.40
Warrington	405	15	215391	1.88	0.07
Tandridge	170	91	90586	1.88	1.00
Havering	504	672	276274	1.82	2.43
Braintree	298	236	164304	1.81	1.44
Redbridge	580	567	321231	1.81	1.77
St. Helens	335	40	188861	1.77	0.21
Enfield	560	517	327434	1.71	1.58
Epsom and Ewell	142	215	83288	1.70	2.58
Folkestone and Hythe	189	60	112411	1.68	0.53
North Devon	170	177	101222	1.68	1.75
Ealing	645	951	385985	1.67	2.46
Rugby	203	134	122378	1.66	1.09
Buckinghamshire	935	1209	578772	1.62	2.09
Manchester	933	465	589670	1.58	0.79
Haringey	417	350	263850	1.58	1.33
Ashford	220	238	140936	1.56	1.69
Lewisham	469	718	301255	1.56	2.38
Stafford	220	31	141556	1.55	0.22
North Somerset	342	144	224578	1.52	0.64
Waltham Forest	421	256	279737	1.50	0.92
Coventry	554	340	369026	1.50	0.92
Oxford	248	124	166034	1.49	0.75
Winchester	202	210	135632	1.49	1.55
Tonbridge and Malling	201	84	136853	1.47	0.61
Warwick	225	119	154889	1.45	0.77
Uttlesford	136	57	95106	1.43	0.60
Stratford-on-Avon	209	218	146258	1.43	1.49
South Ribble	163		116113	1.40	0.00

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Worcester	147	95	106671	1.38	0.89
Lewes	141	65	102363	1.38	0.63
Sefton	389	329	286281	1.36	1.15
Wyre Forest	141	211	103913	1.36	2.03
Wakefield	493	310	367666	1.34	0.84
Central Bedfordshire	422	258	315877	1.34	0.82
Newham	499	538	374523	1.33	1.44
Hyndburn	114	50	86058	1.32	0.58
Calderdale	278	102	210929	1.32	0.48
Burnley	130	98	99233	1.31	0.99
Bath and North East Somerset	258	247	200028	1.29	1.23
Huntingdonshire	243	234	190619	1.27	1.23
West Devon	75	96	58923	1.27	1.63
East Hertfordshire	197	264	156875	1.26	1.68
West Suffolk	233	61	188485	1.24	0.32
Kingston upon Hull, City of	339	133	275401	1.23	0.48
Epping Forest	169	95	137451	1.23	0.69
Bassetlaw	153	80	124937	1.22	0.64
South Oxfordshire	191	146	156470	1.22	0.93
Dover	142	71	119768	1.19	0.59
Lincoln	124	99	105114	1.18	0.94
Eastleigh	165	36	142933	1.15	0.25
New Forest	203	32	176116	1.15	0.18
Salford	335	123	294348	1.14	0.42
Medway	333	182	292655	1.14	0.62
Hinckley and Bosworth	127	38	116682	1.09	0.33
East Staffordshire	141	80	129659	1.09	0.62
Rossendale	79	26	73045	1.08	0.36
Gravesham	119	34	110671	1.08	0.31
Melton	58	44	54052	1.07	0.81
Nuneaton and Bedworth	151	123	141565	1.07	0.87
Bexley	267	181	256434	1.04	0.71
Cheltenham	125	10	121739	1.03	0.08
Bromsgrove	101	26	101685	0.99	0.26
Rutland	41	21	41443	0.99	0.51
Teignbridge	137	88	138548	0.99	0.64
Bolton	302	281	310085	0.97	0.91
Vale of White Horse	143	84	149347	0.96	0.56
Test Valley	129	176	135201	0.95	1.30

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Hastings	87	74	91219	0.95	0.81
Sevenoaks	117	258	122748	0.95	2.10
Cherwell	162	82	170426	0.95	0.48
Cotswold	87	6	91661	0.95	0.07
Doncaster	303	53	319765	0.95	0.17
Arun	161	121	170064	0.95	0.71
Walsall	279	243	295678	0.94	0.82
Exeter	130	111	138399	0.94	0.80
Barking and Dagenham	209	183	232747	0.90	0.79
Blackpool	129	76	144191	0.89	0.53
Wiltshire	466	442	523700	0.89	0.84
Cannock Chase	92	73	104088	0.88	0.70
Broadland	121	28	138157	0.88	0.20
Maldon	60	38	69131	0.87	0.55
Torridge	60	5	69841	0.86	0.07
Hackney	227	356	266758	0.85	1.33
North Tyneside	182	102	215025	0.85	0.47
Boston	59	10	71080	0.83	0.14
Swale	131	28	158379	0.83	0.18
Tendring	129	114	156759	0.82	0.73
Breckland	118	53	146620	0.80	0.36
Wirral	264	48	328873	0.80	0.15
Barnsley	198	152	251770	0.79	0.60
Rother	75	35	96133	0.78	0.36
Blackburn with Darwen	126	11	162540	0.78	0.07
East Cambridgeshire	72	68	92906	0.77	0.73
Havant	97	93	126985	0.76	0.73
Westminster	159	135	209996	0.76	0.64
Cambridge	110	10	149352	0.74	0.07
Herefordshire, County of	140	151	191047	0.73	0.79
Chorley	88	69	120839	0.73	0.57
Chichester	93	54	128934	0.72	0.42
Newark and Sherwood	92	78	127886	0.72	0.61
South Gloucestershire	220	204	306332	0.72	0.67
Bournemouth, Christchurch and Poole	293	574	408967	0.72	1.40
Derbyshire Dales	51	101	71757	0.71	1.41
Telford and Wrekin	138	38	195952	0.70	0.19
Gateshead	141	15	202760	0.70	0.07
Middlesbrough	108	34	156161	0.69	0.22
Stoke-on-Trent	187	81	270425	0.69	0.30

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Cheshire East	285	203	421298	0.68	0.48
South Hams	61	122	92148	0.66	1.32
South Cambridgeshire	114	150	172544	0.66	0.87
Shropshire	215	194	332455	0.65	0.58
Dartford	78	98	125011	0.62	0.78
Pendle	61	28	99777	0.61	0.28
Broxtowe	70	55	114565	0.61	0.48
Kirklees	272	211	447847	0.61	0.47
Southwark	182	356	314786	0.58	1.13
Wyre	68	48	118743	0.57	0.40
Tameside	134	98	239643	0.56	0.41
Greenwich	167	68	299528	0.56	0.23
Torbay	78	68	140126	0.56	0.49
West Northamptonshire	237	480	439811	0.54	1.09
Great Yarmouth	54	13	100529	0.54	0.13
South Norfolk	79	1	148448	0.53	0.00
Gosport	44	40	82921	0.53	0.48
East Lindsey	77	75	145183	0.53	0.52
Staffordshire Moorlands	51	55	96651	0.53	0.57
King's Lynn and West Norfolk	81	40	156206	0.52	0.26
Erewash	59	69	114253	0.52	0.60
North Lincolnshire	88	34	171336	0.51	0.20
West Oxfordshire	61	103	120941	0.50	0.85
West Lindsey	50	40	99208	0.50	0.40
Dorset	193	183	389947	0.49	0.47
High Peak	45	13	91959	0.49	0.14
Bury	97	21	198921	0.49	0.11
Cornwall	282	351	583289	0.48	0.60
East Devon	75	7	158239	0.47	0.04
Gedling	55	37	120179	0.46	0.31
Isle of Wight	63	6	141660	0.44	0.04
Rushmoor	46	11	105751	0.43	0.10
Cheshire West and Chester	159	133	371652	0.43	0.36
East Riding of Yorkshire	150	74	355884	0.42	0.21
Plymouth	114	80	272067	0.42	0.29
East Hampshire	53	72	129975	0.41	0.55
Stockton-on-Tees	84	42	206800	0.41	0.20
Canterbury	65	107	162100	0.40	0.66
East Suffolk	99	174	249664	0.40	0.70
Lancaster	57	33	145006	0.39	0.23

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Fenland	41	23	104896	0.39	0.22
Wigan	133	90	344922	0.39	0.26
Wealden	64	157	166908	0.38	0.94
Oldham	92	32	251560	0.37	0.13
Stroud	43	34	125680	0.34	0.27
Adur	22	11	64889	0.34	0.17
South Holland	33	26	99298	0.33	0.26
Northumberland	110	65	331420	0.33	0.20
Ashfield	43	39	129572	0.33	0.30
Chesterfield	35	20	106045	0.33	0.19
Thanet	47	21	142691	0.33	0.15
Somerset	192	551	588328	0.33	0.94
Ribble Valley	21	14	65794	0.32	0.21
North Kesteven	39	46	122468	0.32	0.38
Rushcliffe	39	20	126736	0.31	0.16
Castle Point	27	30	90581	0.30	0.33
Harborough	31	37	104713	0.30	0.35
North East Derbyshire	31	49	106646	0.29	0.46
Amber Valley	36	40	130451	0.28	0.31
North Norfolk	28	57	103217	0.27	0.55
North West Leicestershire	29	15	111881	0.26	0.13
Rochdale	61	73	235561	0.26	0.31
Oadby and Wigston	15	2	61695	0.24	0.03
Rotherham	64	141	276595	0.23	0.51
Charnwood	40	209	188385	0.21	1.11
South Derbyshire	23	26	117493	0.20	0.22
Darlington	22	60	112489	0.20	0.53
Thurrock	35	32	180989	0.19	0.18
Mansfield	21	1	113138	0.19	0.01
Rochford	15	39	89815	0.17	0.43
Forest of Dean	14	45	89753	0.16	0.50
Tamworth	12	13	81117	0.15	0.16
Blaby	15	14	108165	0.14	0.13
South Tyneside	20	8	151393	0.13	0.05
Knowsley	20	4	162565	0.12	0.02
North Warwickshire	8	51	67117	0.12	0.76
Kensington and Chelsea	16	9	144518	0.11	0.06
Lichfield	12	22	111932	0.11	0.20
West Lancashire	9	19	121995	0.07	0.16
City of London	1		15111	0.07	0.00

Local Authority	PDR units (MHCLG)	PDR units (Our data)	Population size 2024	Ratio MHCLG	Ratio Our data
Bolsover	5	10	83773	0.06	0.12
North Northamptonshire	20	262	373871	0.05	0.70
North Yorkshire	30	602	635270	0.05	0.95
Mid Suffolk	4	140	110775	0.04	1.26
Redcar and Cleveland	5	10	139228	0.04	0.07
South Staffordshire	4	64	114423	0.03	0.56
Westmorland and Furness	6	81	230185	0.03	0.35
Babergh	2	128	97033	0.02	1.32
Cumberland	5	52	280495	0.02	0.19
Fylde	1	2	85447	0.01	0.02
South Kesteven	1	63	147151	0.01	0.43
County Durham	0	98	538011	0.00	0.18
Halton	0	2	131543	0.00	0.02
Hartlepool	0	1	98180	0.00	0.01
Isles of Scilly	0		2366	0.00	0.00
North East Lincolnshire	0	5	159911	0.00	0.03
Tewkesbury	0	42	101949	0.00	0.41

Proximity to incompatible land uses

Of the 23,044 PDR addresses found in London with valid UPRNs, 39.2% (n=9,022) where within the relevant threshold distance (100 m or 200 m, depending on land use category, see methods for details) of an incompatible, 'bad neighbour' use. A similar proportion was seen in the rest of England (38%, n=20,411 addresses were in proximity to at least one bad neighbour use). Importantly, 42.7% of office conversions outside of London were near incompatible land uses. Table 4 presents the breakdown by PDR type and area.

Table 4: Percentage of PDR addresses located in close proximity to incompatible land use by region and conversion type

Area	PD_type	Waste/salvage & nightclubs (%)	Vehicle repair (%)	Industrial Manufacturing (%)	Any incompatible use (%)
London	Office (n=21,492)	15.2	17.1	15	39.1
	Retail / SG (n=1,188)	18	20.3	11.9	42
	Storage / dist (n=249)	13.7	14.9	3.6	24.5
	Light industrial (n=113)	12.4	19.5	19.5	41.6
	Agricultural (n=2)	0	50	50	50
Rest of England	Office (n=43,795)	23.2	13.9	15.4	42.7
	Agricultural (n=6,451)	3.7	1.7	2.6	6.8
	Retail / SG (n=2,871)	17.2	18.1	10.6	39.4
	Storage / dist (n=333)	6.9	12.3	9.3	22.2
	Light industrial (n=252)	5.6	19.8	18.3	34.5

n refers to the total number of addresses with valid UPRNs

Figure 4 presents the ten local planning authorities outside London with the highest proportion of PDR addresses in proximity to each category of incompatible land use. In Worcester, Bolton and Newcastle-under-Lyme, around 9 in 10 PDR addresses are within 200 metres of waste, salvage, recycling or nightclub uses (Fig.4A). Notably, several authorities appear repeatedly across multiple exposure categories: Walsall features among the ten most affected authorities in all four panels, while Worcester, Liverpool, Welwyn Hatfield, and Runnymede each appear in three of the four, suggesting that exposure to different types of incompatible land use is concentrated in the same local authorities. Walsall is the clearest example with 73.7% of its 243 addresses experiencing 2 or more incompatible uses.

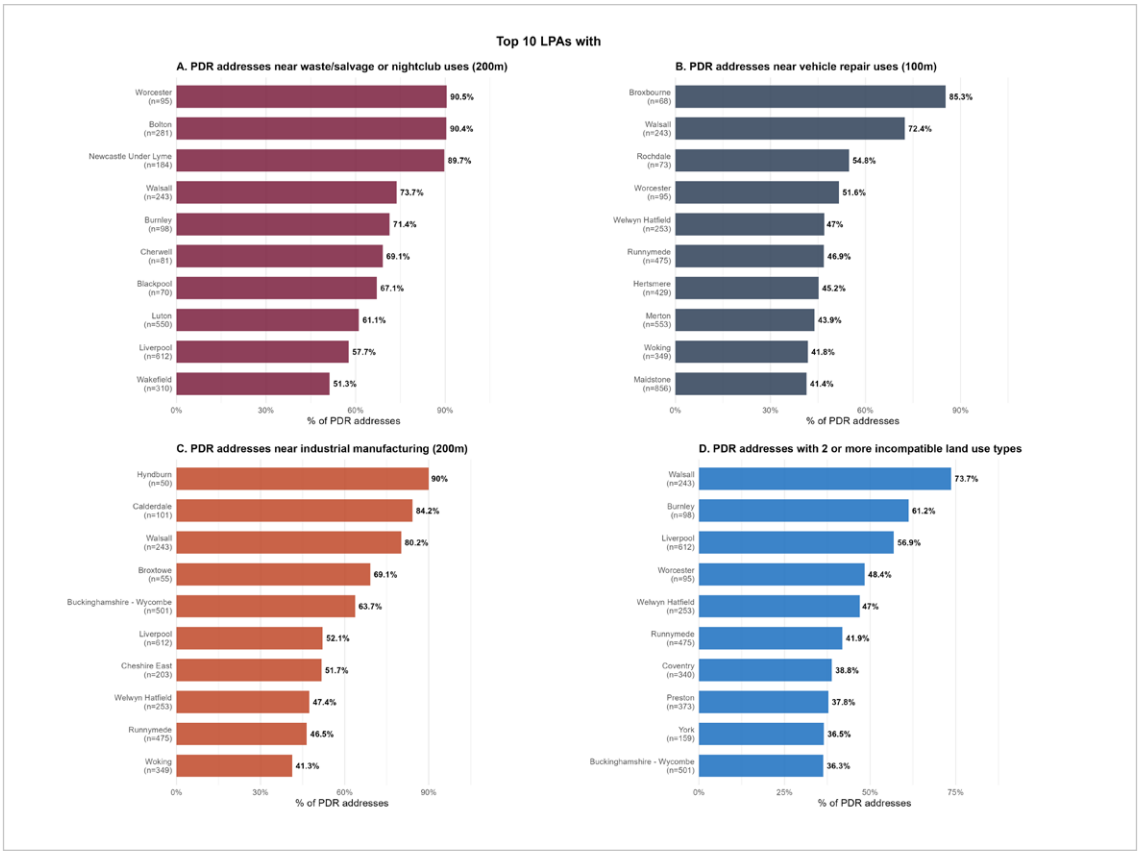


Figure 4: Top 10 local planning authorities with highest proportions of PDR addresses within A) 200 m of a waste/salvage or nightclub use, B) 100 m of a vehicle repair and servicing land use, C) 200 m of an industrial manufacturing land use and D) in close proximity of two or more incompatible land uses. Figures inside bars represent the total of PDR addresses in that local authority.

Access to basic services

Table 5 reports median distances and the proportion of addresses exceeding threshold distances for GP surgeries, primary schools, and bus stops by conversion type and area. In London, service access is consistently good across all three measures and all conversion types, with median distances to GP surgeries of 335m to 419m and fewer than 1% of addresses located more than 2km from a GP. Across the rest of England, office-to-residential and retail conversions have similar accessibility with median GP distances below 500m. Access is poorer for storage and light industrial conversions, where approximately 35% of addresses lie more than 2km from a GP surgery. Agricultural conversions record the most severe deficits, with a median GP distance of 2,951m and 72.5% of addresses more than 2km from the nearest surgery. A similar gradient is seen for school and bus stop access, with agricultural conversions the poorest served across all three measures.

Unlike incompatible land use, the concern for storage light industrial and agricultural conversions is isolation from essential services and infrastructure rather than proximity to incompatible land uses. For agricultural conversions, this reflects their frequent rural, remote locations while for light industrial and storage conversions it more likely reflects its location within industrial estates. Access to amenities is a standard consideration in full residential planning applications. Under PDR rights, these conversion types are not required to demonstrate this suitability, despite their poor access to essential services.

Table 5: Proximity of basic amenities to PDR addresses by type and area

		GP access		Primary school access		Bus stop access	
Area	**PDR type**	**Median distance (m)**	**% beyond 2km**	**Median distance (m)**	**% beyond 2km**	**Median distance (m)**	**% beyond 1km**
London	Office (n=21,492)	377	0.1	390	0	64	0
	Retail / SG (n=1,188)	335	0.2	291	0	62	0.1
	Storage / dist (n=249)	340	0	362	0	69	0
	Light industrial (n=113)	419	0	244	0	73	0
	Agricultural (n=2)	1744	50	879	0	688	0
Rest of England	Office (n=43,795)	409	2	512	0.6	82	0.3
	Agricultural (n=6,451)	2951	72.5	1695	38.3	713	33.8
	Retail / SG (n=2,871)	425	5.2	422	1.3	68	0.8
	Storage / dist (n=333)	969	35.4	590	14.7	162	11.4
	Light industrial (n=252)	993	34.9	678	13.1	144	8.7

The location of the conversions in industrial and commercial areas also suggest potential exposure to environmental pollution. Some London councils including Westminster,[94] Camden,[95] and Islington,[96] using data from the London Atmospheric Emissions Inventory have reported that commercial cooking is a leading local source of fine particulate matter ($PM_{2.5}$) emissions, sometimes overtaking road vehicles. In light of this evidence and the former uses of PDR buildings, we have examined the proximity of PD addresses to commercial cooking sources and to major roads (Table 6). Regardless of the type of conversion, in London more than half of PDR addresses are within 100 metres of a commercial cooking outlet. Retail conversions were the closest, with a median distance of 38 m (IQR 16–104) and 58.9% within 50m which is in line with their previous use. Outside London, similar proportions were seen only for office and retail conversions. Agricultural conversions were rarely near commercial cooking outlets.

The top London local authorities with the highest percentage of PDR addresses within 50m of a commercial cooking outlet were Westminster (78.5%, n=106), Waltham Forest (64.8%, n=168), Camden (63.2%, n=467) and Islington (62%, n=445).

PDR housing in London was also closer to major roads, which are long-established as sources of air pollution. Nearly half of London PDR addresses were within 50m of a motorway or A road compared with 28.8% in the rest of England. London median distances were shorter for every conversion type, outside London they ranged from 102m (office conversions) to over 1 km for agricultural ones.

Daily $PM_{2.5}$ data (for external air pollution; see Work Package 3 below for monitoring data from inside addresses) were available for 79.8% of London PD addresses (n=18,385). In 2023, PDR addresses experienced a median of 31 days (IQR 27–32, range 18–40) on which daily $PM_{2.5}$ exceeded the WHO 24-hour guideline of 15 μg m^{-3}. This is above the 3 to 4 days a year the WHO guideline establishes. The median annual mean $PM_{2.5}$ concentration was 7.9μg m^{-3} (IQR 7.7–8.2), around 1.6 times the WHO annual guideline. Daily concentrations ranged from 0.5 to 62.4 μg m^{-3}. Exposure was similar across conversion types which is consistent with the regional uniformity of background $PM_{2.5}$ across London. Variation in local exposure is better captured by proximity to sources of $PM_{2.5}$ such as commercial cooking and major roads (Table 6).

94. Air Quality Modelling Study: Compliance with WHO targets in Westminster 2024) at **https://www.westminster.gov.uk/sites/default/files/media/documents/Westminster%20WHO%20Compliance%20Study%20-%20Full%20Report%20AQ%20Consultants.pdf**
95. Clean Air For Camden. Draft Camden Clean Air Action Plan 2027-2030 at **https://consultations.wearecamden.org/supporting-communities/camden-clean-air-action-plan-2027-2030/user_uploads/draft-camden-clean-air-action-plan-2027-2030**
96. Islington Air Quality Action Plan 2025 – 2030 at **https://letstalk.islington.gov.uk/35445/widgets/135592/documents/94350**

Table 6: Proximity of PDR addresses to major sources of $PM_{2.5}$ by region and type

		Commercial Cooking			Major roads		
Area	**PDR type**	**% within 50m**	**% within 100m**	**median distance (IQR)**	**% within 50m**	**% within 100m**	**Median distance (IQR)**
London	Light industrial	41.6	77	56 (39-88)	46.9	65.5	63 (27-199)
	Office	36.6	62.3	68 (38-139)	48.4	67.2	53 (30-147)
	Retail/ SG	58.9	74.3	38 (16-104)	52.6	62.3	43 (18-265)
	Storage	12	51.8	93 (65-364)	53	69.5	42 (27-128)
	All	37.5	62.9	67 (37-139)	48.7	67	53 (29-147)
Rest of England	Agricultural	1.3	2.5	1368 (802-2053)	3	6.2	1374 (548-2568)
	Light industrial	17.5	32.1	329 (71-1004)	6.7	18.7	419 (143-1368)
	Office	36.7	63.2	70 (36-167)	33	49.7	102 (34-287)
	Retail/SG	48	66.1	53 (23-182)	27.4	35.9	206 (37-553)
	Storage/ dist	17.7	36	231 (60-1060)	7.5	15.6	570 (221-1680)
	All	32.9	55.8	84 (40-250)	28.8	43.4	145 (39-443)

Extreme Heat Vulnerability

Across England, 25.3% of PDR addresses were located in the 10% most heat-vulnerable LSOAs. The breakdown by domain shows that this is driven by the built and outdoor environment rather than the characteristics of the population. Almost half of PDR addresses (47.7%) were in areas with the highest housing related vulnerability.

In London, around half or more of each conversion type was in the most vulnerable decile for housing, with office and retail conversions showing the highest proportions (66.7% and 57% respectively, Figure 6). Retail (60.1%) and light industrial conversions (53.1%) were also concentrated in areas in the most vulnerable decile for the outdoor environment domain, which includes air quality, tree cover and exposure to very hot summer days. London PDR conversions were not concentrated in areas with low ability to respond (14.2% across all London PDs) or enhanced physical risk (less than 1% across London PDRs, Figure 6). The latter domain has as main indicators the proportion of the population aged 75 and over, under 5 and people with disability or limiting long-term condition, all groups with increased physiological vulnerability to heat.

In the rest of the country, 15.3% of PDR addresses were located in highly vulnerable areas. By PD type, this was mainly due to office conversions (18%). Agricultural conversions were almost never in vulnerable areas (0.4%). As in London, heat vulnerability was driven mainly by the housing domain (39.8%) with little concentration of PDR housing in areas vulnerable on other domains (Figure 5).

Vulnerability also accumulated across domains. In London, 11.2% of PD addresses were located in areas among the most vulnerable decile on three or more domains (Figure 6). This was highest for retail (22.4%) and office conversions (10.7%) (Figure 6). In London, almost all PD addresses in Tower Hamlets (98.5%), Westminster (93.3%), Camden (92.6%), Croydon (91.7%) and Islington (91.6%) were located in LSOAs among the 10% most vulnerable. In absolute terms, Croydon stands out as out of 3,026 PDR addresses, 2,775 were in highly heat-vulnerable areas (interestingly, in focus groups held under Work Package 2, overheating was a particularly strong and persistent theme in resident reports of their lived experience in PD homes). Outside London, the highest proportions were in Luton (92.7%), Walsall (77.4%), Slough (76.5%), Ipswich (65.9%) and Bradford (64.5%).

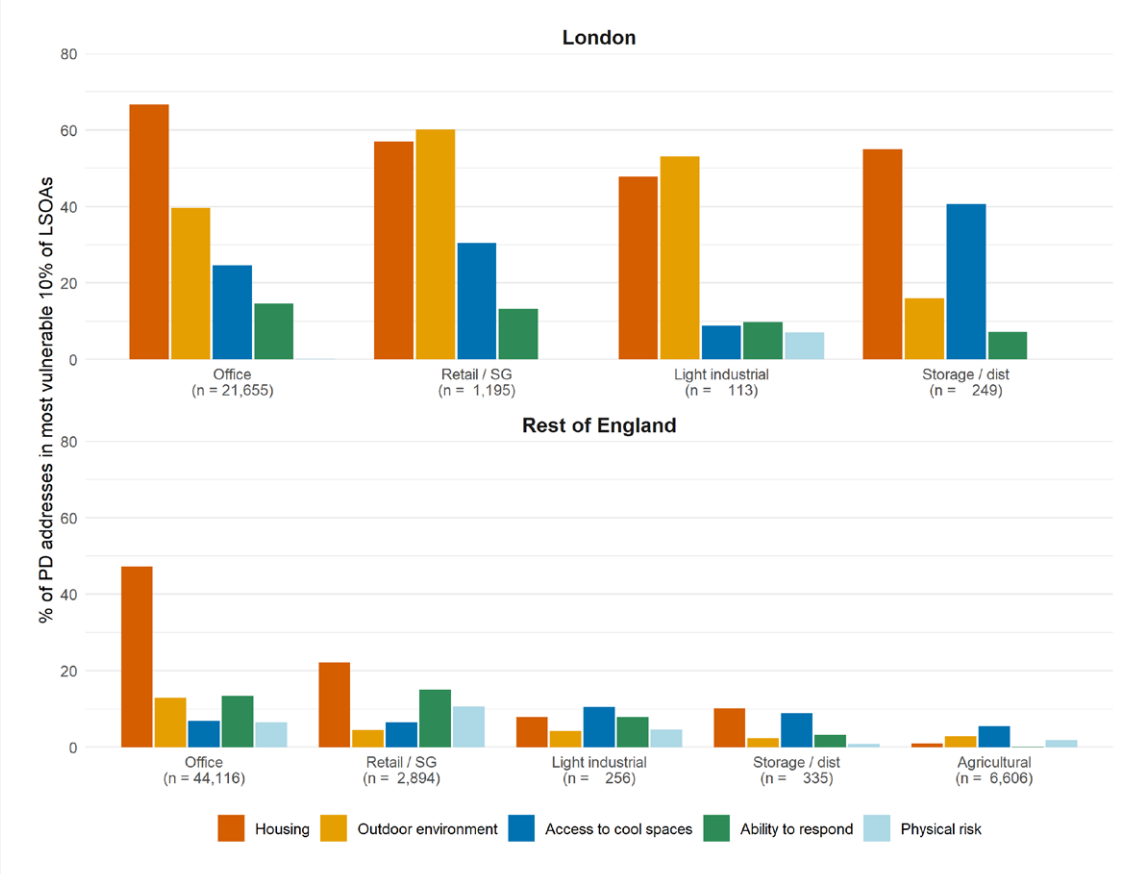


Figure 5: Percentage of PDR addresses located in the 10% most heat vulnerable LSOAS in England by heat related vulnerability index domain, PD type and area. Note: London agricultural conversions (n=2) are not shown.

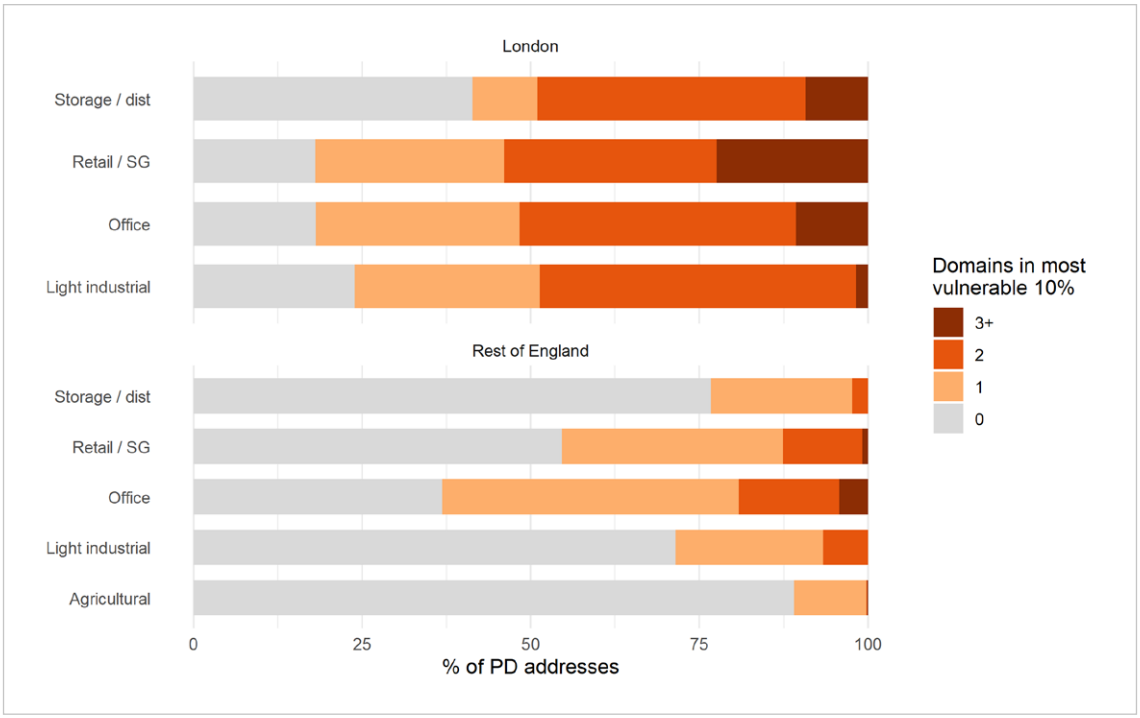


Figure 6: Number of domains on which PD addresses are located in highly vulnerable LSOAs, by PD type and area. Each PDR address is classified by the number of domains on which its LSOA ranks among the 10% most vulnerable in England.

Figure 7 shows London LSOAs by their national decile on the EHVI Housing domain, with the number of PD addresses in each LSOA. In inner London boroughs, where most LSOAs are in the most vulnerable decile, the high proportion of PD addresses in highly vulnerable areas reflects the borough as a whole.

To identify where PD housing was concentrated in vulnerable areas beyond what the borough vulnerability would suggest, we compared for each LPA with at least 100 PDR addresses, the proportion of PD addresses in the most vulnerable decile with the proportion of the boroughs LSOAs in that decile. The largest differences were in Croydon, 89.7% of PD addresses (2,714 addresses within 53 schemes) were located in the most vulnerable decile for housing, compared with 17.9% of the boroughs LSOAs. Similar patterns were seen in Havering (55.8% vs 6.5%), Harrow (58.0% vs 9.7%), Redbridge (59.8% vs 14.6%) and Brent (87.0% vs 44.2%). In these boroughs, PD housing was concentrated in their most housing-vulnerable neighbourhoods in relation to extreme heat vulnerability.

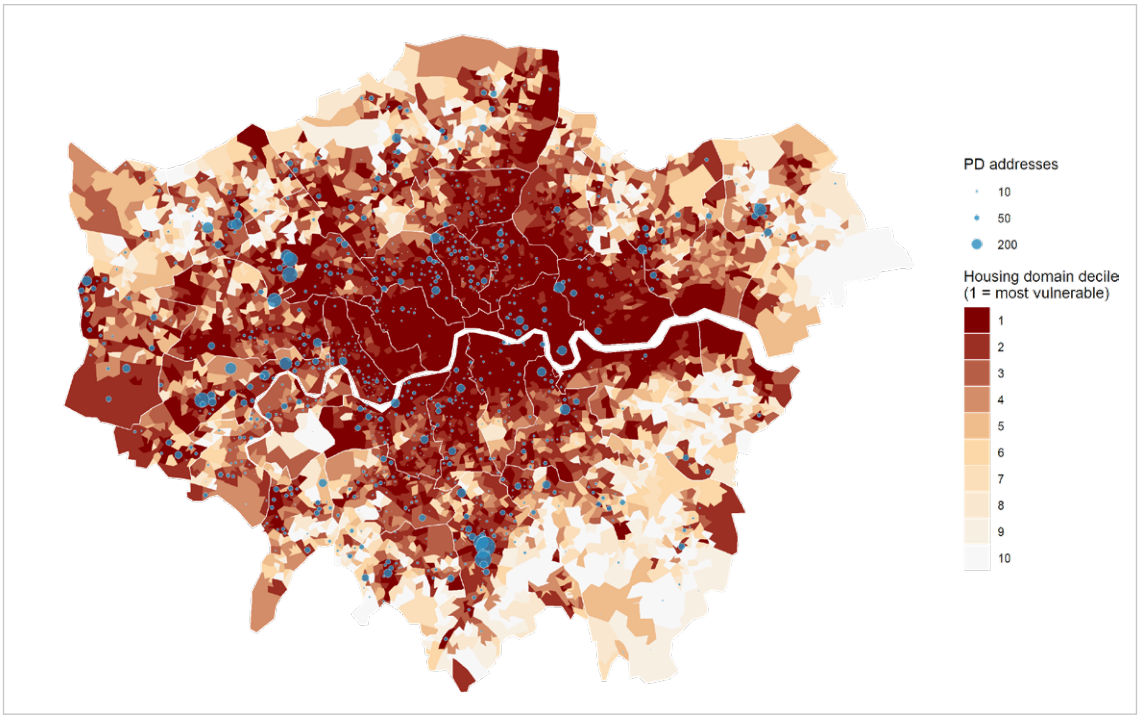


Figure 7: Housing related heat vulnerability and location of PDR housing in London

EPC data on floorspace

As noted above, we were able to link the addresses of over 12,000 of our identified PDR homes to EPC data containing details of the total internal floorspace and number of habitable rooms for those housing units. Although some degree of caution needs to be applied to the absolute figures from this data, the comparisons it allows do demonstrate important differences between types and locations of PDR housing and trends over time in relation to space standards.

Table 7 shows, for schemes given prior approval from 2013–19 before the regulations required compliance with NDSS, the average floorspaces by type of PDR conversion and compliance with NDSS had these applied according to our assumptions. This shows that agricultural to residential schemes tend to be a much larger floorspace than the various commercial-to-residential schemes, with office-to-residential schemes the smallest and even the average internal floorspace beneath the recommended absolute minimum of 37m^2. The total number of light industrial unit conversions is quite small, but all other categories have high numbers to support comparisons. Even without NDSS being required by the regulations, a strong majority of agricultural-to-residential schemes were complying with these and providing generous floorspace for residents. Although residential quality is about much more than just total internal floorspace, this does suggest there may be higher quality housing in agricultural-to-residential conversions than the various commercial-to-residential schemes.

Table 7: EPC floorspace data by type of scheme

	Mean average floorspace m²	Median average floorspace m²	Number of units	Number assumed compliant with NDSS	% Compliant	% non compliant
Agri to resi	168.43	147	889	769	86.5%	13.5%
Light ind to resi	78.91	57	39	16	41.0%	59.0%
Office to resi	32.69	34	10191	3615	35.5%	64.5%
Retail / SG to resi	56.87	50	833	297	35.7%	64.3%
Storage / dist to resi	95.40	62.6	124	65	52.4%	57.6%
Total	61.92	49	12076	4762	39.4%	60.6%

Table 8 does the same analysis by size of scheme for those given prior approval 2013–19, using our own categories for scheme size. This appears to show a correlation between the overall number of residential units being created and the average scheme size and compliance with NDSS with small minor schemes (1–5 residential units) showing the largest average floorspace and being most likely to comply with NDD and the large major schemes (over 100 residential units) having the smallest average floorspace and being least likely to comply with NDSS. Again, although housing quality is about much more than just internal floorspace, this does also suggest that there may be particular problems associated with large-scale conversion schemes, in particular those schemes producing over 100 flats.

Table 8: EPC floorspace data by size of scheme

	Mean average floorspace m²	Median average floorspace m²	Number of units	Number assumed compliant with NDSS	% Compliant	% non compliant
Small minor	100.51	67	2844	1664	58.5%	61.5%
Large minor	57.34	50	1887	717	38.0%	62.0%
Small major	51.85	48	2772	985	35.5%	64.5%
Medium major	47.69	44	3579	1197	33.4%	66.6%
Large major	39.59	35	994	199	20.0%	80.0%
Total	61.92	49	12076	4762	39.4%	60.6%

Table 9 illustrates the same analysis in relation to floorspace and the deprivation of the area in which the conversion is located, utilising our quintile classification for LSOAs for schemes given prior approval from 2013–19. This shows that when regulatory control over space standards does not apply, we see the smallest sized units on average and the least likelihood of compliance with NDSS in PDR conversions located in the most deprived neighbourhoods and the largest schemes and likelihood of meeting the NDSS standards in the least deprived locations. This suggests there may be an equalities issue with poorer quality housing being concentrated in more deprived places.

Table 9: EPC floorspace data by LSOA deprivation of scheme

Deprivation quintile	Mean average floorspace m^2	Median average floorspace m^2	Number of units	Number assumed compliant with NDSS	% Compliant	% non-compliant
1	47.82	43	2288	663	29.0%	71.0%
2	49.49	44	2593	799	30.8%	69.2%
3	59.47	48	2543	945	37.2%	62.8%
4	78.72	55	1995	982	49.2%	50.8%
5	75.95	58	2657	1373	51.7%	49.3%
Total	61.92	49	12076	4762	39.4%	60.6%

Government required that PDR schemes comply with NDSS after April 2021, having announced this in September 2020 so that given there may be some influence from an announcement even before it comes into effect and given that schemes can spend some weeks through the prior approval process we might consider 2020–21 transitionary years between the 2019–19 position of NDSS compliance not being required and the 2022–23 position of it applying. We therefore looked at the average recorded floorspace sizes for schemes created during these different time period, and our assumed compliance with NDSS. Table 10 shows the results.

We did dip sample those in the 2022–23 category which did not appear compliant with NDSS using our methodology. This showed that in some cases this was due to which standard had been applied (in particular whether a one-bedroom flat had the 37 or 50m^2 standard applied) and a number where the submitted floorplans during prior approval showed compliance but the EPC data does not (in many cases this was just missed and is likely to the accuracy of EPC data, but it is also possible in some cases implemented schemes do not exactly comply with floorplans). There were some cases, however, where the standard does not seem to have been applied, raising questions about planners assessing this during the prior approval process and awareness around this (in some focus groups held as part of this research there was discussion as to whether the regulations just required 37m^2 or if the

other NDSS standards applied at all). For our purposes here, the average floorspaces and the comparison between periods in relation to NDSS compliance is perhaps more useful than any single figure for NDSS compliance.

Table 10: EPC floorspace data by year group of prior approval for scheme

2013–19 schemes					
	2013 mean average floorspace m²	**2013 median average floorspace m²**	**2013 number of units**	**2013 number assumed compliant with NDSS**	**2013 % Compliant**
1 Room (37 sqm standard)	25.32	22	2218	219	9.9%
2 Room (50 sq m standard)	43.75	43	4527	1143	25.2%
3 Room (61 sq m standard)	64.73	62	3584	1987	55.4%
4 Room (74 sq m standard)	90.99	85	699	476	68.1%
5 Room (90 sq m standard)	121.06	114	347	264	76.1%
6 Room (103 sq m standard)	155.86	145	244	222	91.0%
7 Room+ (116 sq m standard)	258.09	228.56	457	451	98.7%
All in year group / total	61.92	49	12076	4762	39.4%
2020–21 schemes					
	2020 mean average floorspace m²	**2013 median average floorspace m²**	**2020 number of units**	**2020 number assumed compliant with NDSS**	**2020 % Compliant**
1 Room (37 sqm standard)	25.19	23	191	22	11.5%
2 Room (50 sq m standard)	44.35	43	599	160	26.7%
3 Room (61 sq m standard)	66.32	64.45	374	219	58.6%
4 Room (74 sq m standard)	96.76	90	113	93	82.3%
5 Room (90 sq m standard)	115.57	107.5	110	82	74.5%
6 Room+ (103 sq m standard)	156.5	148	55	46	83.6%
7 Room+ (116 sq m standard)	237.56	223.5	164	159	97.0%
All in year group / total	79.32	54	1606	781	48.6%

2022-23 schemes					
	2022 mean average floorspace m²	**2013 median average floorspace m²**	**2022 number of units**	**2022 number assumed compliant with NDSS**	**2013 % Compliant**
1 Room (37 sqm standard)	37.55	33	11	5	45.5%
2 Room (50 sq m standard)	46.96	44	121	36	29.8%
3 Room (61 sq m standard)	64.68	60	115	56	48.7%
4 Room (74 sq m standard)	95.65	92	52	39	75.0%
5 Room (90 sq m standard)	119.17	112.5	42	34	81.0%
6 Room+ (103 sq m standard)	155.99	149.475	44	40	90.9%
7 Room+ (116 sq m standard)	242.82	219	104	104	100.0%
All in year group / total	113.77	80	489	314	64.2%

The average total floorspace appears to have risen considerably between 2013–19 and 2022–23 and our assumed rate of NDSS compliance similarly rises. However, as Table 10 also suggests, there are differences between housing of differing numbers of habitable rooms. To test whether the space standards regulation had effect on the sizes of conversions created through PDR, we compared units built before the regulation (2013–2019), during a transition period (2020–2021) and after the regulations took effect (2022+). Regression models were fitted for floorspace and NDSS compliance, using interaction terms to assess how the effect of the regulatory period varying depending on number of habitable rooms. The models accounted for clustering within schemes.

Table 11 presents the percentage change in floorspace and the odds of NDSS compliance comparing 2013 with 2022. This shows that only one habitable room conversions had a significant increase in floorspace, with a mean increase of 49.8% and had increased odds of being NDSS compliant after the regulations came into effect (OR 7.6). These results show that the regulation's effect was not even across all conversion sizes. It was concentrated in one-bedroom units (studios) which was by far the category that had the poorest compliance with the standards before 2021. No comparable change was found for larger conversions nor during the transition period.

These estimates are based on units with EPC data which was not available for all PDR conversions. For the newer schemes, the small sample size is reflected in the width of the confidence intervals (see also Figure 8), however the same pattern was found independently in both models which supports this being a real effect of the space regulations.

Table 11: Change in floorspace and National Described Space Standard (NDSS) compliance for PDR housing units by number of habitable rooms, comparing 2022 with 2013.

Room number	Increase in floor space (95% CI)	P value	NDSS compliance (95%CI)	P value
1 Room	49.8% (21%–85.3%)	<0.0001	7.61 (1.42–40.67)	0.018
2 Room	6.3% (–1.9%–15.1%)	0.136	1.25 (0.67–2.34)	0.476
3 Room	–1.6% (–9%–6.4%)	0.688	0.76 (0.47–1.24)	0.272
4 Room	6.8% (–1.3%–15.6%)	0.102	1.41 (0.69–2.84)	0.344
5 Room	–0.1% (–9.2%–10%)	0.985	1.34 (0.57–3.11)	0.501
6 Room+	0.3% (–6.7%–7.8%)	0.94	1.5 (0.52–4.36)	0.458

Increase in floor space shown as percentage change in mean floor area (m^2), NDSS compliance shown as odds ratios and 95% CI.

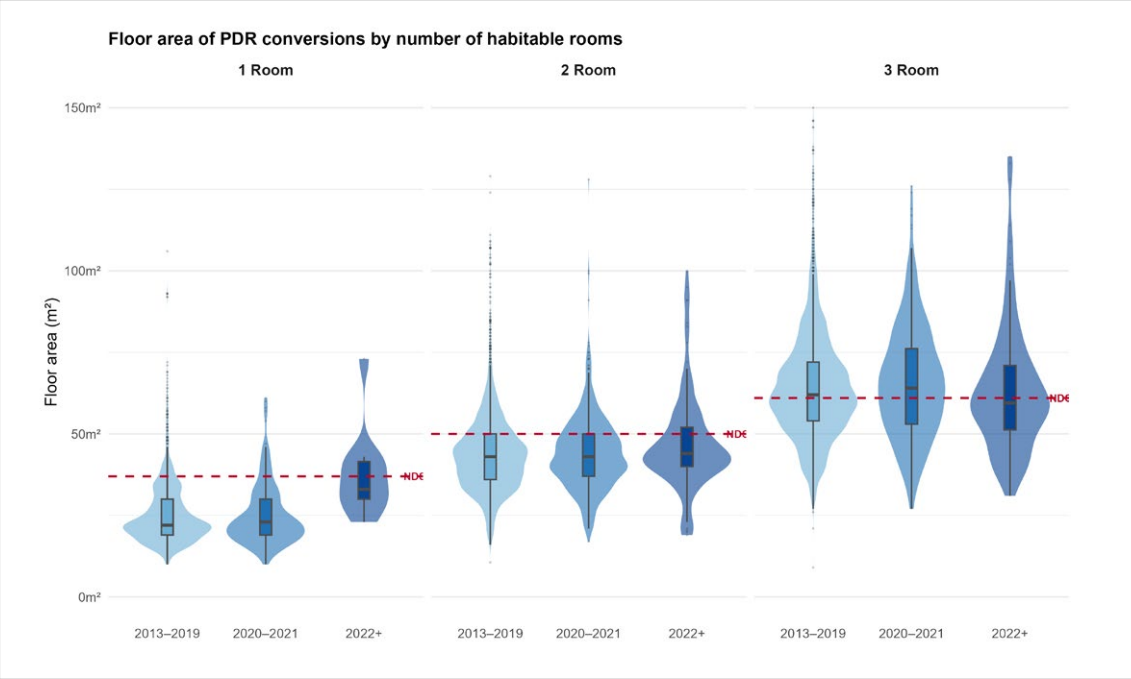


Figure 8: Floor area of PDR conversions by number of habitable rooms and regulatory period

Overall, this suggests that the introduction of the minimum space standards through the 2021 amendments to the regulations has had a significant positive impact on the size of the housing being produced through PDR at the smallest end of the scale: studio flats. With the caveats about accuracy notwithstanding, the EPC floorspace data so suggest serious issues with a lack of space in flats produced through PDR prior to this. Although we have both total floorspace and number of habitable room data for 12,076 housing units, we had the floorspace alone for 57,196 PDR homes. The smallest total floorspace according to that data is a flat of just 7m^2 in total, which was in a large office-to-residential conversion we know to be in TA/EA use. The data set shows 16,485 flats below 37m^2, 28.8% of those we have this data for, of which 4,765 are below 25m^2.

Previous research suggests the significant negative health and wellbeing impacts this can have, and lack of space and overcrowding came-up frequently in our own research as a problem reported by residents (see Work Package 2 below). Overcrowding involves more than just the absolute space available (also involving the number of people occupying the space and arguably subjectively also the way they utilise the space) but increasing the absolute space available to residents in this way may have positive benefits particularly if the impact has been greatest for those with the least amount of space overall.

Mortality among residents of permitted development housing in England: descriptive results

The results below describe the linked deaths on their own terms: counts by year of occurrence, sex, age band, cause group and development size. No denominators are used in this section, so these figures are counts rather than mortality rates and do not by themselves support comparison with other populations.

A total of 2,148 deaths occurred among residents of PDR housing between 2013 and 2024, of which 1,300 (60.5%) were male and 848 (39.5%) female (Table 12; Figure 9). Annual deaths roughly tripled over the period, from around 100 a year in 2013 and 2014 to a peak of 303 in 2022, with 284 in 2023 and 258 in 2024. Deaths stepped up markedly in 2020 (229, from 159 in 2019), and 1,308 deaths (60.9%) occurred in the five years 2020 to 2024. This rise should not be read as a mortality trend: the PDR housing stock grew substantially over the period, the 2020 to 2022 counts include the COVID-19 pandemic years, and deaths in 2013 to 2015 include deaths at addresses linked from the year the relevant permitted development policy came into force, before most conversions had completed, so the early years describe the increase in the number of PDR residents rather than resident mortality.

The proportion of deaths that were male ranged from 54.0% (2014) to 65.1% (2023) across the period. Death rates will be calculated in a separate analysis after the estimation of person-time lived in each type of development that is required for the estimation of rates.

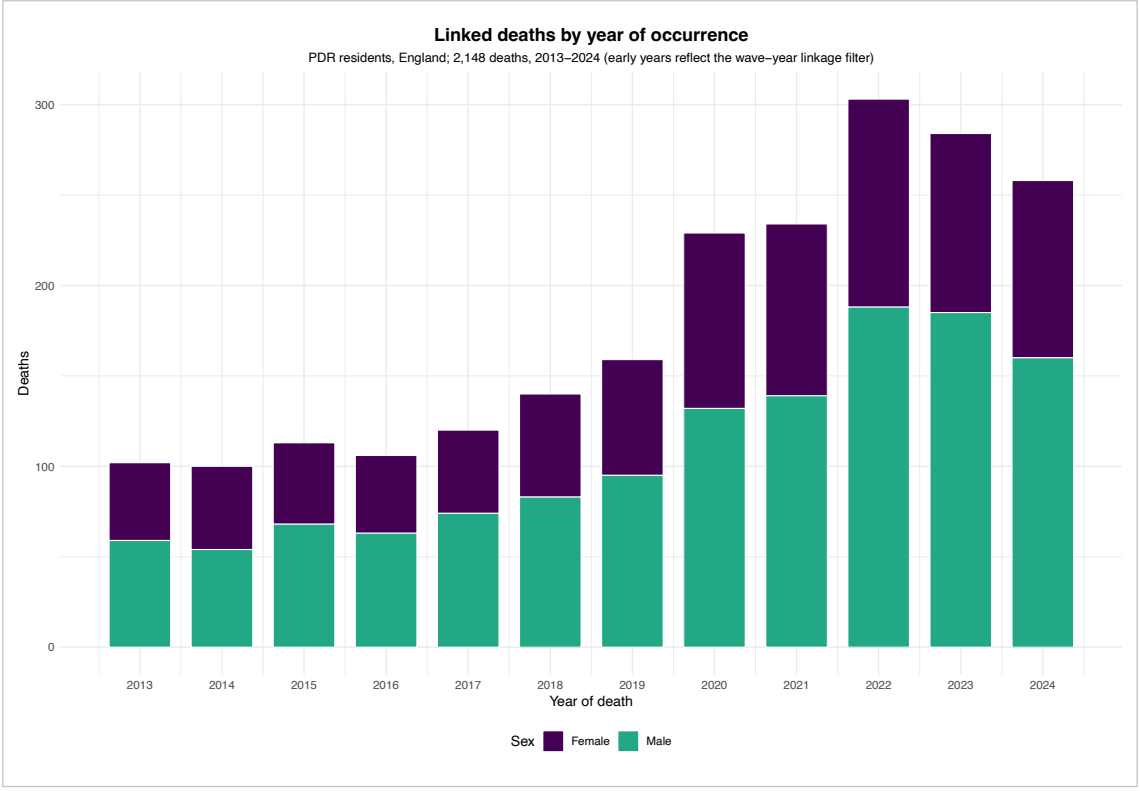


Figure 9: Linked deaths by year of occurrence and sex, 2013 to 2024.

Table 12: Deaths among residents of PDR housing by calendar year of occurrence and sex, England, 2013 to 2024

Year	Male	Female	Total	% male	Cumulative
2013	59	43	102	57.8%	102
2014	54	46	100	54.0%	202
2015	68	45	113	60.2%	315
2016	63	43	106	59.4%	421
2017	74	46	120	61.7%	541
2018	83	57	140	59.3%	681
2019	95	64	159	59.7%	840
2020	132	97	229	57.6%	1,069
2021	139	95	234	59.4%	1,303
2022	188	115	303	62.0%	1,606
2023	185	99	284	65.1%	1,890
2024	160	98	258	62.0%	2,148

Deaths in 2013 to 2015 include deaths at addresses linked from the policy-wave year onwards, before most conversions completed; they describe the linkage, not resident mortality.

The age distribution of deaths differed by sex (Table 13; Figure 10). The median age band at death was 70 to 74 for males and 75 to 79 for females. Over half of male deaths occurred before age 75 (740 of 1,300; 56.9%), compared with just under half of female deaths (399 of 848; 47.1%); overall, 1,139 deaths (53.0%) occurred under age 75. Around one in three deaths (699; 32.5%) occurred at ages 25 to 64. Male deaths were spread across the working and older ages, with more than 80 deaths in every age band from 50 to 54 upwards; female deaths were concentrated at older ages, peaking in the 85 to 89 and 90 and over bands. There were 39 deaths (1.8%) of children under five and very few deaths at ages 5 to 19.

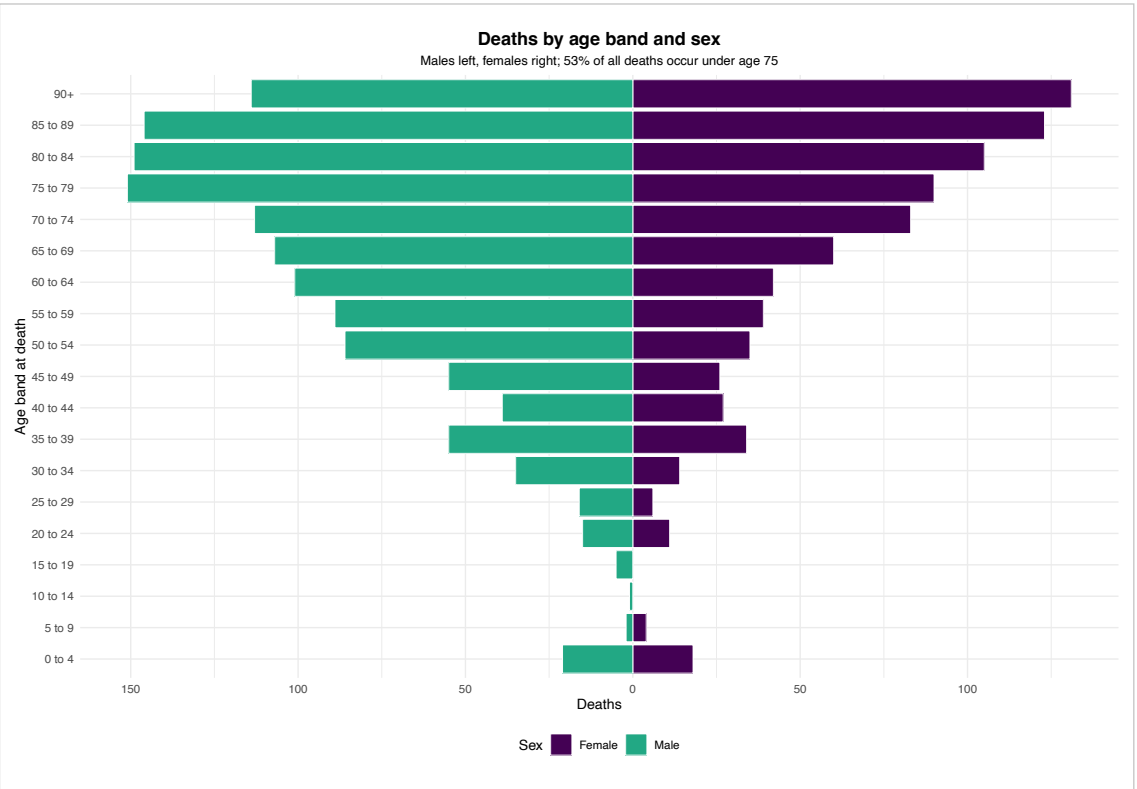


Figure 10: Deaths by age band at death and sex, all ages, 2013 to 2024.

Table 13: Deaths by age band at death and sex, all ages, 2013 to 2024

Age band	Male	Female	Total	% of all deaths
0 to 4	21	18	39	1.8%
5 to 9	2	4	6	0.3%
10 to 14	1	0	1	<0.1%
15 to 19	5	0	5	0.2%
20 to 24	15	11	26	1.2%
25 to 29	16	6	22	1.0%
30 to 34	35	14	49	2.3%
35 to 39	55	34	89	4.1%
40 to 44	39	27	66	3.1%
45 to 49	55	26	81	3.8%
50 to 54	86	35	121	5.6%
55 to 59	89	39	128	6.0%
60 to 64	101	42	143	6.7%
65 to 69	107	60	167	7.8%
70 to 74	113	83	196	9.1%
75 to 79	151	90	241	11.2%
80 to 84	149	105	254	11.8%
85 to 89	146	123	269	12.5%
90+	114	131	245	11.4%

Median age band at death: males 70 to 74, females 75 to 79. Deaths under 75: males 740 of 1,300 (56.9%), females 399 of 848 (47.1%).

ONS classified all 1,139 deaths under age 75 into ten cause groups defined by the ICD-10 codes of its avoidable mortality definition, plus a residual "Other" group containing every death under 75 outside the named groups (Table 14; Figure 11). The named groups sum to 786 deaths (69.0% of under-75 deaths); the residual group holds the remaining 353 deaths (31.0%). The largest named groups were diseases of the circulatory system (223; 19.6%), neoplasms (195; 17.1%) and alcohol-related and drug-related deaths (164; 14.4%). Deaths from intentional self-harm (47), injuries (35), COVID-19 (35), diseases of the respiratory system (55), infectious diseases (16), assault (10) and events of undetermined intent (6) made up the remainder. Self-harm, assault and undetermined intent together accounted for 63 deaths (5.5% of deaths under 75).

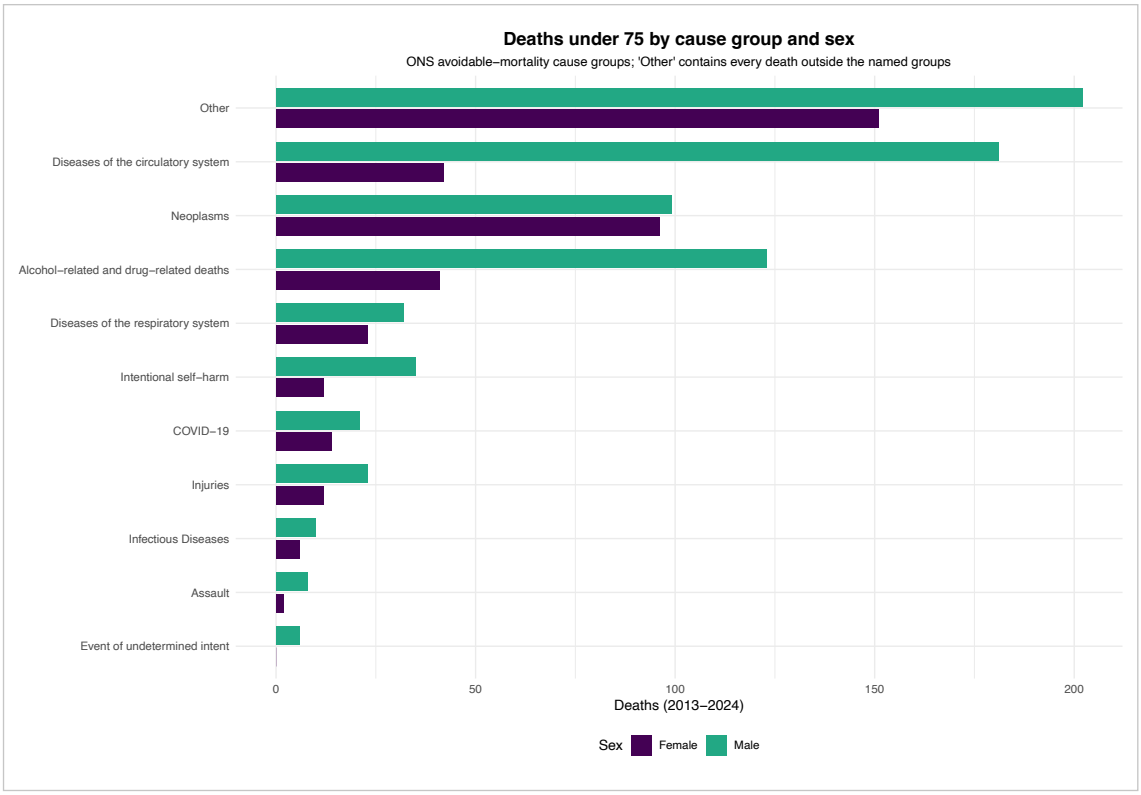


Figure 11: Deaths under age 75 by cause group and sex, 2013 to 2024.

Table 14: Deaths under age 75 by cause group and sex, 2013 to 2024

Cause group (ONS avoidable mortality definition)	Male	Female	Total	% of under-75 deaths
Other	202	151	353	31.0%
Diseases of the circulatory system	181	42	223	19.6%
Neoplasms	99	96	195	17.1%
Alcohol-related and drug-related deaths	123	41	164	14.4%
Diseases of the respiratory system	32	23	55	4.8%
Intentional self-harm	35	12	47	4.1%
COVID-19	21	14	35	3.1%
Injuries	23	12	35	3.1%
Infectious diseases	10	6	16	1.4%
Assault	8	2	10	0.9%
Event of undetermined intent	6	0	6	0.5%
All named avoidable groups (subtotal)	538	248	786	69.0%
All deaths under 75	740	399	1,139	100%

Named groups use the ICD-10 codes of the ONS avoidable mortality definition; every other death under 75, including deaths from avoidable causes outside the named groups, is coded to "Other". The named-group subtotal is therefore a lower bound on avoidable deaths and the under-75 total (1,139) an upper bound (see Limitations).

The cause pattern differed markedly by sex. Among deaths under 75, males accounted for 181 of the 223 circulatory deaths and 123 of the 164 alcohol-related and drug-related deaths, and for 35 of the 47 deaths from intentional self-harm; neoplasm deaths were near-equal by sex (99 male, 96 female). Alcohol-related and drug-related deaths made up 16.6% of male deaths under 75 (123 of 740) and 10.3% of female deaths under 75 (41 of 399). Over time, the alcohol-related and drug-related share of under-75 deaths rose from 10% in 2013 to 2015 to 13% in 2016 to 2019 and 16% in 2020 to 2024, while the circulatory share fell from 27% to 18% (Figure 12). All 35 COVID-19 deaths occurred in 2020 to 2024.

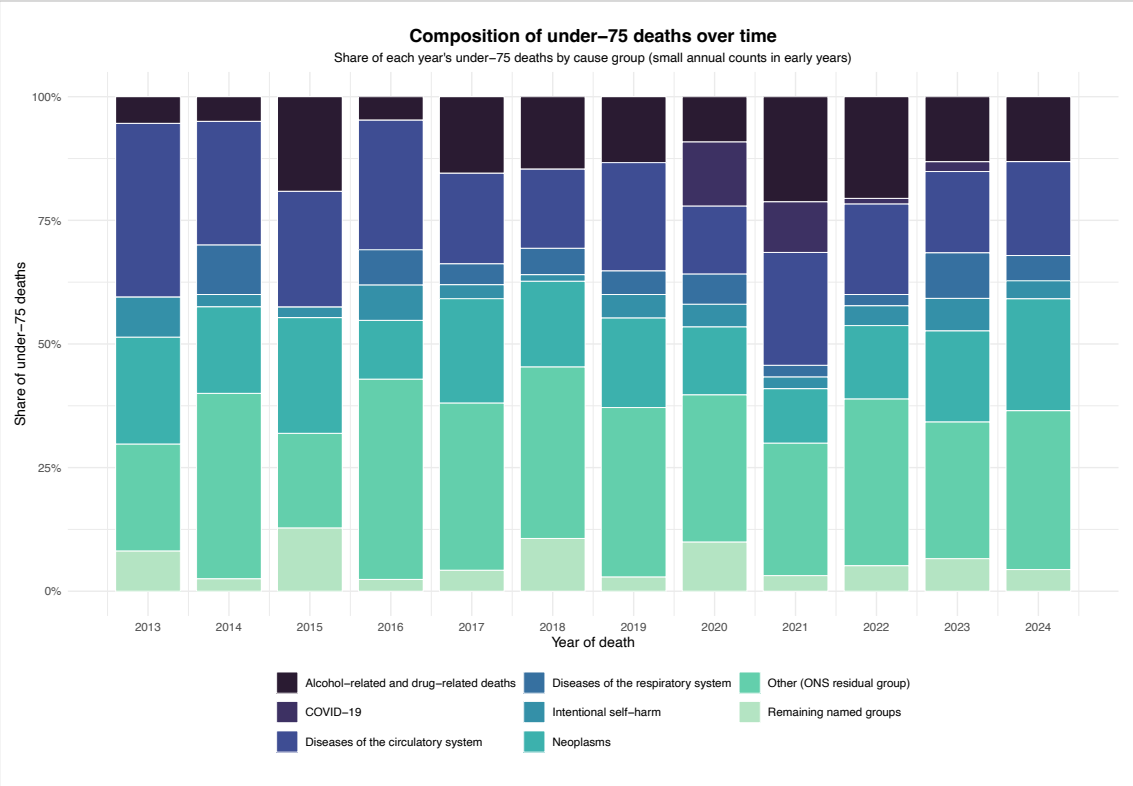


Figure 12: Cause composition of deaths under age 75 by year of occurrence.

Qualitative work in this project had suggested concerns about deaths from external causes (deaths caused by accidents, violence, or external circumstances rather than internal physiological or disease processes) in large PDR developments. Across all ages, 61 deaths met the ONS definition of suicide: 8 occurred at large major developments (schemes of 100 or more dwellings) and 53 at all other developments (Table 15). The equivalent splits were 6 and 42 for intentional self-harm, 2 and 9 for assault, and 2 and 4 for events of undetermined intent. The suicide total (61) exceeds the sum of the self-harm and undetermined-intent counts (54) because those rows use the narrower code ranges of the avoidable mortality definition (X66 to X84 and Y16 to Y34), which exclude the drug- and alcohol-poisoning codes (X60 to X65 and Y10 to Y15) that the suicide definition includes; in the cause classification used in Table 14 and Table 15, those poisoning deaths are counted under alcohol-related and drug-related deaths.

Whether these counts are high or low relative to the person-time lived in each type of development will be addressed in the comparative analysis reported separately.

Table 15: Suicide and violent-cause deaths by development size, all ages, years 2013 to 2024 combined

Cause	Large major developments (100+ dwellings)	All other developments	Total
Suicide (ONS definition)	8	53	61
Intentional self-harm	6	42	48
Assault	2	9	11
Event of undetermined intent	2	4	6

The intentional self-harm, undetermined-intent and assault rows use the ICD-10 ranges of the ONS avoidable mortality definition (X66 to X84; Y16 to Y34; X86 to Y09 and U50.9), which assign intentional drug and alcohol poisonings to the alcohol-related and drug-related group. Suicide (ONS definition) comprises intentional self-harm at ages 10 and over (X60 to X84) and events of undetermined intent at ages 15 and over (Y10 to Y34); it therefore includes the poisoning codes X60 to X65 and Y10 to Y15 and overlaps, but is not the sum of, the other rows. Counts include all ages, unlike Table 14.

Limitations

These are counts of linked deaths, not mortality rates, and four features of the data shape their interpretation. First, ONS advised that the linked counts are likely to be an undercount: address information on death certificates is often supplied by informants and frequently omits flat numbers, and address quality in both datasets limited matching. Second, deaths in 2013 to 2015 were included from the year the relevant permitted development policy came into force rather than the date of each conversion, so early-year counts may include deaths that preceded genuine occupancy. Third, deaths are counted by year of occurrence, whereas routinely published national mortality statistics use year of registration, which limits direct comparison. Fourth, the cause table exhausts all deaths under 75 across its groups, so the residual "Other" group is not a defined cause of death: it contains non-avoidable deaths together with any deaths from avoidable causes outside the ten named groups. An exact count of avoidable deaths therefore cannot be formed: the named-group total (786) is a lower bound, on the assumption that ONS applied the definition's age restrictions as well as its ICD codes when populating the named groups, and all deaths under 75 (1,139) is an upper bound that holds regardless. Judgements about whether mortality in this population is higher or lower than expected require the modelled person-time denominator and will be made in a comparative analysis to be reported separately.

Case study: Connected Bradford

A total of 974 people were identified as living in PDR addresses in this local authority area. Of these, 51 had multiple PDR addresses making the determination of their index date problematic and 20 had no GP registration dates and were excluded. Furthermore, 313 did not have at least 6 months of follow up at either side of their index date and were also excluded resulting in a sample of 590 residents for analysis. Figure 13 shows the flow diagram.

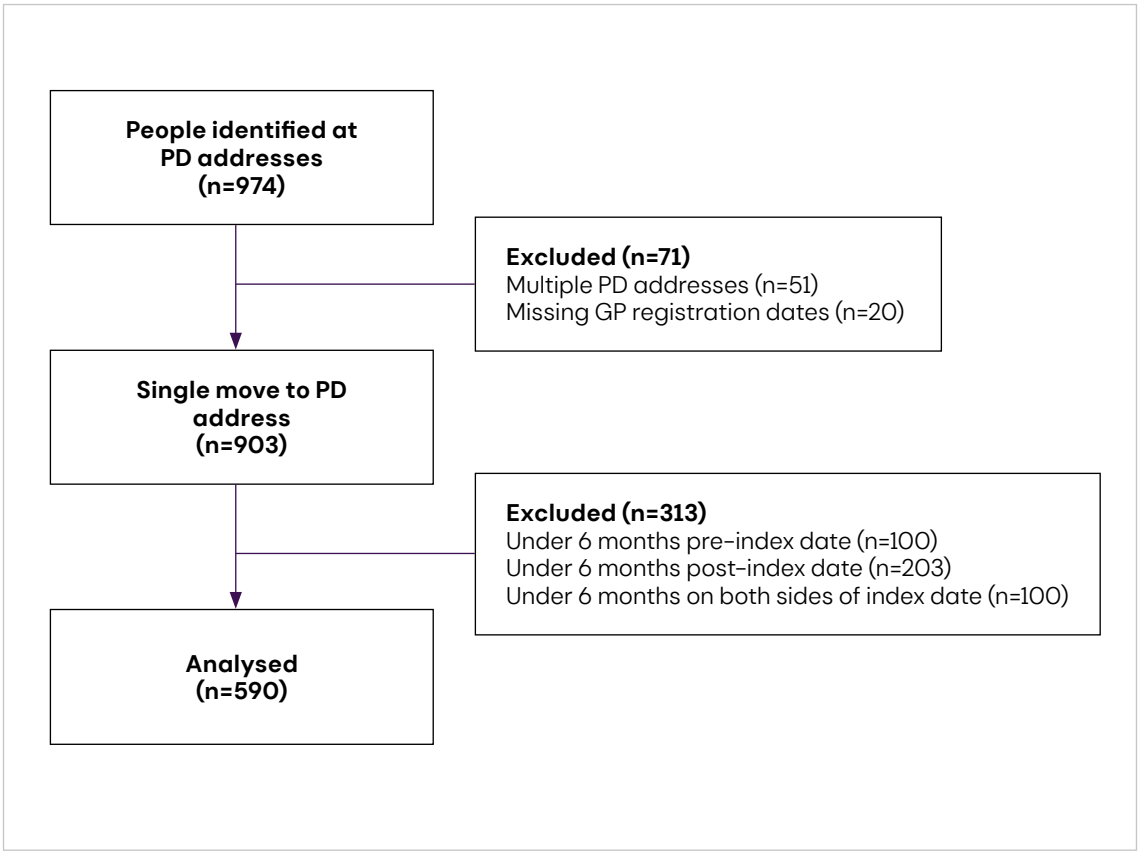


Figure 13: Flow diagram of the Connected Bradford Permitted Development case study

Description of the sample

Basic characteristics of the sample are provided in Table 16. Overall, the sample was comprised by mainly males, aged 45.6±19.5 and predominantly white.

Table 16: Basic demographic characteristics of the studied sample

Variable	Value
n	590
Female	271 (45.9%)
Age (years)	45.6±19.5
Observation period (years)	25.2±14.3
Ethnicity	
White	376 (63.7%)
Asian	88 (14.9%)
Black	21 (3.6%)
Multiple	3 (0.5%
Other	102 (17.3%)

Values are n(%) for categoric samples and mean±standard deviation for continuous variables.

Primary analysis

The mean pre/post window length was 5.24 years on each side of the index date (median= 4.52). In the pre-index window, the mean number of attended primary care appointments was 19.2 (median=10), corresponding to a rate of 4.07 appointments per person-year. In the post-index window, the mean number of attended primary care appointments was 29.2 (median= 14), mean rate of 5.73 appointments per person-year. The unadjusted comparison showed this difference to be statistically significant (p<0.0001). In the adjusted mixed-effects model, moving into PDR housing was associated with a 49.9% increase in the rate of primary care appointments (rate ratio 1.499[1.464-1.535], Table 17) after adjusting for window length and the proportion of each window overlapping with the COVID-19 pandemic. In the sensitivity analysis, the estimated effect was unchanged (1.497[1.449-1.543]) which indicates that the main result was not driven by the subgroup whose index date was imputed from the property conversion approval date.

Table 17: Rate ratios for GP appointment numbers following transition into PDR housing: Pre-post analysis.

	Whole Sample (n=590)		Sensitivity analysis (n=326)	
	RR (95% CI)	p value	RR (95% CI)	p value
Intercept	1.703 (1.512–1.917)	<0.0001	2.229 (1.947-2.552)	<0.0001
Post vs Pre	1.499 (1.464–1.535)	<0.0001	1.497 (1.449–1.543)	<0.0001
COVID overlap	1.655 (1.541–1.777)	<0.0001	1.448 (1.312–1.598)	<0.0001

Values are rate ratios (RR) and 95% confidence intervals

Secondary analysis

The interrupted time series analysis modelled appointment counts by year relative to the index date. An unadjusted line plot showing the mean primary care contacts per person per year relative to index date is shown in Figure 14.

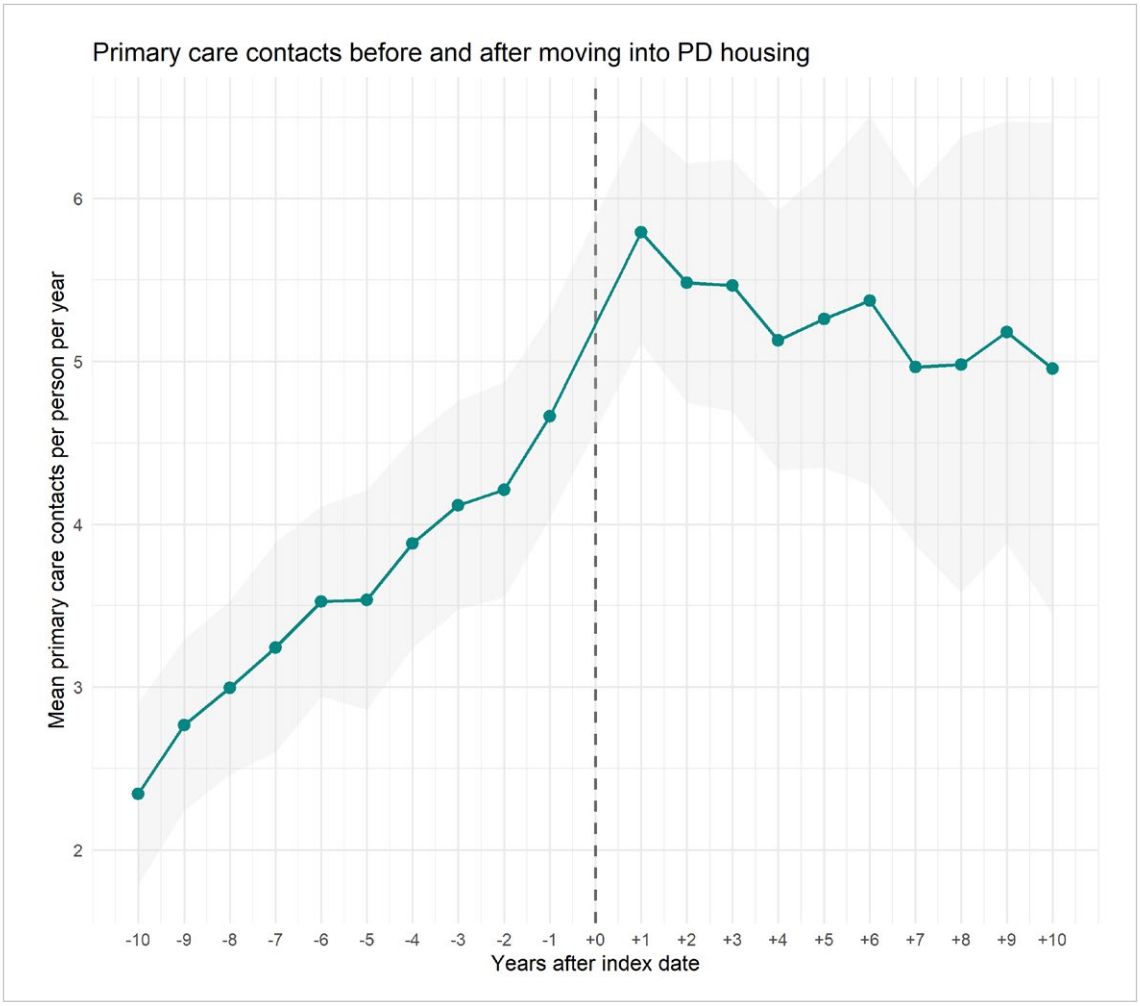


Figure 14: Mean Primary Care contact per person by year relative to index date.

In the main cohort (n=590), moving to PDR housing was associated with an increase in appointment rate in adjusted models (RR:1.081 [1.041–1.122]) alongside an increasing trend already present before the move (RR: 1.077 (1.071–1.083)), consistent with secular changes as people use more healthcare services as they age. The COVID-19 pandemic was independently associated with an increase in appointment rate (RR: 1.061 (1.030–1.093)). The pattern was consistent in the sensitivity analysis (Table 18).

Table 18: Rate Ratios for primary care appointments by year relative to PDR housing transition: interrupted time series analysis

	Whole Sample (n=590)		Sensitivity analysis (n=326)	
	RR (95% CI)	**p value**	**RR (95% CI)**	**p value**
Intercept	2.345 (2.075–2.650)	<0.0001	2.504 (2.171–2.887)	<0.0001
Pre PDR trend per year	1.077 (1.071–1.083)	<0.0001	1.057 (1.049–1.065)	<0.0001
Change post PDR move	1.081 (1.041–1.122)	<0.0001	1.205 (1.147–1.266)	<0.0001
COVID period	1.061 (1.030–1.093)	0.0001	1.214 (1.168–1.262)	<0.0001

Morbidity

Among the Connected Bradford PDR resident's asthma was the most commonly recorded condition, present in 18% of the population, followed by hypertension and diabetes (Figure 15). As described in the methods section, the prevalence reflects the proportion of the population with at least one matching coded term recorded, so these figures describe how widespread each condition is across the population.

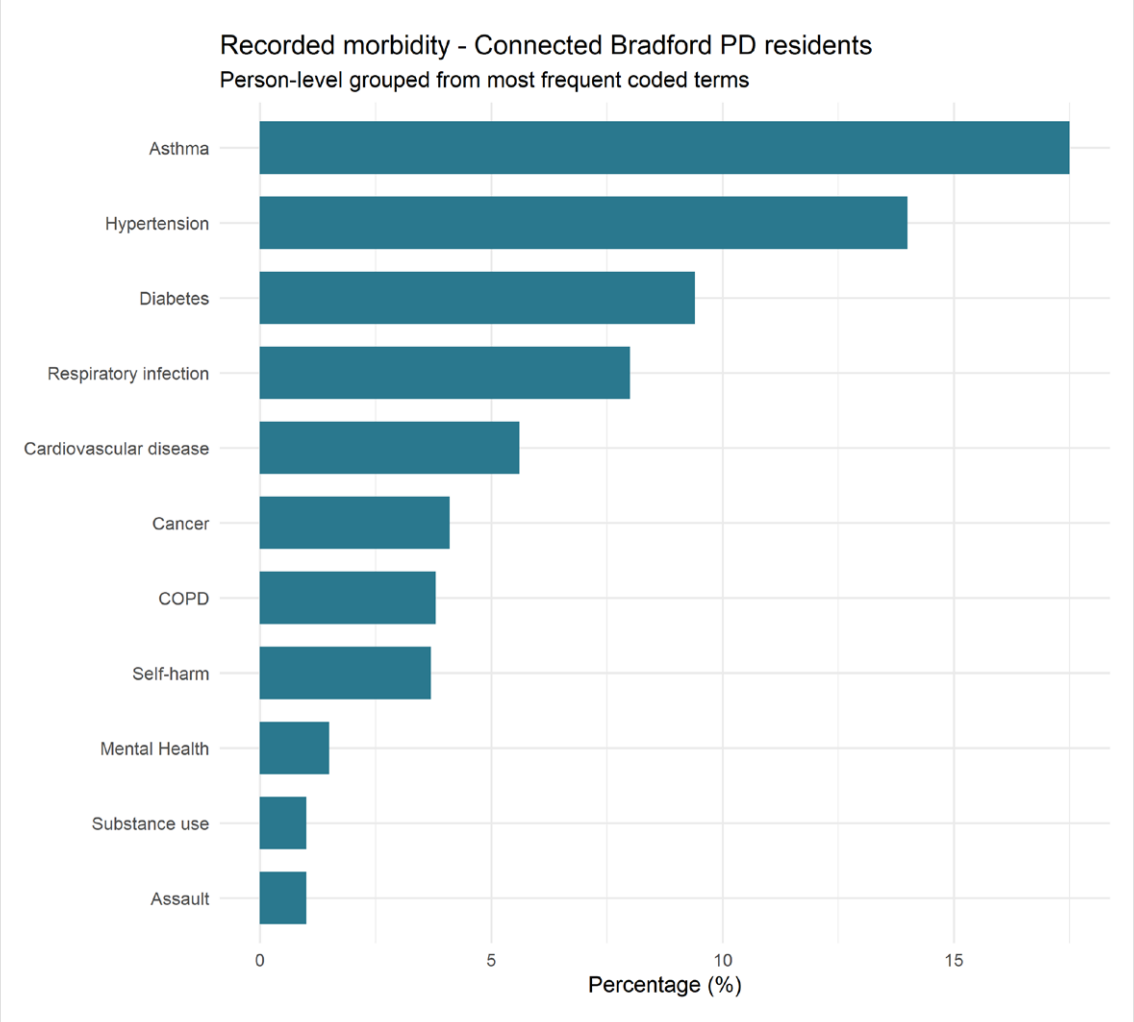


Figure 15: Recorded morbidity – Connected Bradford PDR residents

Limitations

There are several limitations to both analyses. First, primary care records were not designed for research purposes, so they carry imprecisions such as coding inconsistencies or incomplete registrations that are expected when working with real-world electronic health records. We defined index date using the change of address registered in the GP record and that data was then linked to a UPRN using an address-matching approach. The UPRN was not attached to the clinical record natively, hence the move-in dates that predate the year of approval of a given PDR conversion. The sensitivity analysis aimed to account for this fact but does nor remove uncertainty in the cohort as a whole. Furthermore, people might move without changing their address in their GP record which is also something to take into consideration.

The within-person design aimed to remove confounding characteristics that are stable within a person, but it is still sensitive to variables that change systematically over the same period as the move to a PDR address such as the pre-existing rise in appointments that reflect aging and secular trends and the COVID-19 pandemic. The models used included terms intended to account for these factors, though age itself was not modelled directly. Moving to a different house can also lead to an increase in primary care contacts not associated with the quality of the housing itself such as re-registering at a new practice, getting to know the new GP, updating tests, etc. A comparison group of people moving to non-PDR housing would help disentangle those differences. Finally, the outcome captures all attended primary care appointments of any staff role and by telephone or in person. This is a single setting case study of the Bradford PDR population that illustrates the type of individual-level analysis the original national linkage was intended to support.

Overall, results show a statistically significant increase in primary care contact associated with recorded transition into PDR housing. This increase was not attenuated when restricting the analysis to the subgroup with imputed index date.

Conclusions

The location and land-use analyses show that around four out of ten residents of PDR housing live within a short distance of a land use which can be categorised as incompatible with residential occupation, including industrial manufacturing, waste disposal, vehicle repair and nightclubs. These “bad neighbour” uses are the ones that would be closely scrutinised before permission is granted under full planning permission, given their potential for noise pollution, air pollution and other nuisance. Agricultural conversions, on the other hand, are isolated from essential services instead of being exposed to incompatible neighbouring land uses.

Access to basic amenities such as GP surgeries and primary schools is also a standard consideration under full planning permission. PDR development does not impose such requirements allowing these conversions to proceed regardless of how far they are from services residents will need.

The location of the conversions in industrial and commercial areas also suggest potential exposure to external environmental pollution. Regardless of the type of conversion, in London more than half of PDR addresses are within 100 metres of a commercial cooking outlet. Retail conversions were the closest, with a median distance of 38 m and 58.9% within 50m which is in line with their previous use. Outside London, similar proportions were seen only for office and retail conversions. Location close to major roads could also be a concern. Nearly half of London PD addresses were within 50m of a motorway or A road compared with 28.8% in the rest of England. This was reflected by analysis of monitored levels of daily $PM_{2.5}$.The median annual mean $PM_{2.5}$ concentration was 7.9µg m^{-3}, around 1.6 times the WHO annual guideline. Daily concentrations ranged from 0.5 to 62.4 µg m^{-3}, seemingly driven by locational proximity to sources of air pollution.

There was also locational concerns in relation to heat vulnerability: across England, 25.3% of PDR addresses were located in the 10% most heat-vulnerable LSOAs. The breakdown by domain shows that this is driven by the built and outdoor environment rather than the characteristics of the population.

Matching the address list to EPC data on floorspace and number of habitable rooms, where available, suggested a large quantum of extremely small housing had been developed under PDR: 16,485 units which could be under 37m^2 total internal floorspace were identified. Compliance with space standards seemed to be lower and average unit sizes seemed to be smaller for commercial than agricultural-to-residential conversions, those located in more deprived neighbourhoods and those located in larger sized schemes. There is evidence to suggest the 2021 regulatory changes to the GPDO have led to a significant increase in space standards and compliance with NDSS for studio flats.

The ONS-linked mortality data describes for the first time, the pattern of deaths among this population. Of particular interest, over half of the deaths occurred before age 75 and the share of alcohol and drug related deaths rose between 2013-2024. These are counts and not rates. This analysis does not establish whether mortality risk among PDR residents is elevated relative to the general population, analysis of which is ongoing and will be reported in a later publication.

The Connected Bradford case study offers a clearer signal of change in primary care contact following a person moving into a PDR conversion. Residents showed a statistically significant 49.9% increase in primary care contact after moving into PDR housing in the primary analysis, after adjusting for window length and time overlapping with the COVID-19 pandemic. A smaller but significant increase was also seen in the interrupted time series analysis (8.1% in the whole sample, 20.5% in the sensitivity analysis). This estimate considers a pre-existing yearly trend before estimating the change at the point of the move. The primary analysis reflects overall pre/post difference without that adjustment. While this analysis has limitations that warrant some caution in interpretation as described in detail above, it constitutes a signal that needs to be investigated further.

Taken together, WP1 findings show that PDR housing is disproportionately located in areas with poor conditions and that its residents show an increase in healthcare use following their move, evidence of a population facing worse conditions across several independent measures.



Work Package 2: Resident perspectives of living in permitted development housing

Introduction and specific objectives

WP2 explored the lived experiences of residents living in housing created through PDR in England, including their demographics and self-reported health and wellbeing. While WP1 quantified associations between PDR housing and health outcomes using linked administrative datasets, many important dimensions of health and wellbeing cannot be captured through routine health records alone. Everyday experiences of housing, including sleep quality, thermal comfort, mental wellbeing, perceptions of safety, opportunities for social interaction, and residents' ability to adapt their living environment, are important determinants of health but remain largely invisible within administrative data.

To address this evidence gap, WP2 adopted a mixed-methods design comprising a large-scale national survey, in-home semi-structured interviews along with environmental assessments, and focus groups. Together, these methods provided detailed evidence on residents' experiences of their homes and how characteristics of the indoor environment, building design and neighbourhood context influence health, wellbeing, comfort and everyday life.

The work package complemented the epidemiological analyses undertaken in WP1 by capturing self-reported health, health-related behaviours and lived experiences that cannot be measured through NHS or mortality data alone.

The analysis was informed by the socioecological THRIVES framework,[97] which recognises that health is shaped through interactions between individuals and their physical, social and economic environments. Drawing on concepts from the psychological meanings of home and health equity literature, this framework provided a lens for understanding how housing conditions are embodied through everyday lived experiences and how residents' agency, social circumstances and wider environmental contexts shape health and wellbeing. This perspective enabled examination of both the immediate residential environment, indoor environmental quality including daylight, ventilation, thermal comfort, noise, space, and damp, and broader determinants such as housing security, neighbourhood conditions, access to amenities and green infrastructure, and residents' capacity to adapt their homes to support comfort, wellbeing and health.

Primary data were collected through a national survey of residents living in PDR housing, followed by in-home semi-structured interviews and environmental assessments with a stratified sample of participants. To ensure that the perspectives of populations often under-represented in housing research were included, focus groups were also conducted with residents living in temporary and emergency accommodation within PDR conversions, in partnership with third-sector organisations who helped recruit eligible participants.

The survey generated quantitative evidence on residents' demographic characteristics, housing conditions, health, wellbeing and health-related behaviours, while interviews and environmental assessments, and focus groups provided richer insights into residents' experiences of living in PDR housing. Collectively, these complementary methods enabled triangulation with findings from WP1 and WP3, providing a more comprehensive understanding of the pathways through which PDR housing influences health and informing subsequent recommendations for policy and practice.

97. Pineo, H. 2022 Towards healthy urbanism: inclusive, equitable and sustainable (THRIVES)–an urban design and planning framework from theory to praxis. *Cities & health*, *6*(5), 974-992. Available at: **https://doi.org/10.1080/23748834.2020.1769527**

Specific Objectives

WP2 was designed to address the following objectives:

- To characterise the demographic profile, self-reported health, wellbeing and health-related behaviours of residents living in PDR housing through a national questionnaire survey and compare these findings with national datasets, including the English Housing Survey and Census data.
- To identify health needs and wellbeing outcomes that are not captured through routine healthcare datasets, including mental health, subjective wellbeing, sleep quality, thermal comfort, safety perceptions and non-hospital-treated health conditions.
- To examine residents' experiences of the indoor environment, including daylight, ventilation, overheating, cold, damp, mould, noise, space, privacy and the suitability of the home for everyday activities such as sleeping, cooking, working, studying and social interaction.
- To investigate how residents perceive the relationship between housing conditions and their physical health, mental wellbeing and daily lives, including the influence of housing tenure, affordability, neighbourhood characteristics and access to local services and green infrastructure.
- To explore residents' adaptive behaviours and their capacity to modify their homes to improve comfort, health and wellbeing, including barriers to implementing environmental adaptations.
- To capture the perspectives and experiences of residents living in temporary and emergency accommodation within PDR conversions through focus groups, ensuring that the needs and priorities of vulnerable and hard-to-reach populations were represented.
- To undertake in-home environmental assessments alongside interviews to document observable housing conditions and triangulate residents' reported experiences with objective assessments of the dwelling environment.
- To integrate findings with Work Packages 1 and 3 to improve understanding of the mechanisms linking PDR housing characteristics, environmental exposures and health outcomes, and to identify practical interventions and policy recommendations to improve the quality of existing and future PDR housing.

These objectives addressed the following research questions:

- **RQ2.1:** What health needs of populations living in PDR housing cannot be identified through administrative health datasets?
- **RQ2.2:** Which characteristics of PDR housing do residents perceive as disruptive or supportive for daily activities related to sleep, diet, work, study, social interaction and caring responsibilities?
- **RQ2.3:** How do residents perceive indoor environmental comfort, and in what ways do they modify their home environment to reduce discomfort and support health and wellbeing?

Methods

This WP adopted a mixed-methods design combining a large-scale survey, semi-structured at-home interviews, and focus groups to examine the health and wellbeing impacts of housing created through PDR in England. The integration of quantitative and qualitative approaches enabled both breadth and depth in understanding residents' lived experiences.

The online survey was developed using established instruments, prior research, and pilot study findings,[98] alongside input from multiple stakeholder groups. It captured key domains including demographics, physical and mental health, wellbeing, and housing conditions . Survey items were selected to enable comparison with national statistics in England. To maximise inclusivity, the survey was translated into the seven most commonly spoken languages in England (after English) and was also made available in paper format. Participants were recruited between March 2024 and April 2025 postal invitations sent to addresses identified through a PDR sampling framework. Participants received a £20 voucher. Recruitment was stratified by area deprivation, with oversampling in the most deprived quintiles to improve representativeness. Eligibility criteria included being aged 18 or over and residing at an address matching the sampling framework. Where discrepancies in postcode data arose, participants were contacted to confirm eligibility. Additional data cleaning procedures included the removal of duplicate or fraudulent responses and exclusion of responses completed in under 2.37 minutes (lowest 2.5th percentile). A total of 9,828 postcards were sent out, from which 1,029 eligible participants completed the survey (eligible response rate: 10.5%)Quantitative survey data were analysed using R and QGIS.

98. Pineo, H., Clifford, B., Eyre, M., & Aldridge, R. W., 2024. Health and wellbeing impacts of housing converted from non-residential buildings: A mixed-methods exploratory study in London, UK. *Wellbeing, Space and Society*, *6*, 100192. Available at: **https://www.sciencedirect.com/science/article/pii/S2666558124000101**

To complement the survey, semi-structured interviews were conducted with residents living in converted dwellings. The semi-structured interview guide was developed based on a pilot study and refined with input from the research project advisory groups. It was designed to explore residents' subjective experiences in depth. A relatively large qualitative sample (n=75) was employed to capture diverse experiences across building types and geographic contexts, enhancing policy relevance. Participants were recruited from survey respondents who expressed interest in follow-up research. Of 706 individuals who volunteered between June 2024 and June 2025, 75 interviews and in-home assessments were completed following eligibility screening and attrition. Interviews were conducted by trained researchers using a flexible protocol covering themes identified in the literature, including light, noise, space, and neighbourhood context, while allowing emergent issues to surface. Participants received a £20 voucher. All interviews were conducted with informed consent, and data were anonymised. Home assessment forms were analysed alongside photographs taken during home visits. Plans of the visited buildings were also downloaded from planning portals and used to provide additional context for the interview analysis.

In addition, six focus groups were conducted between July 2024 and February 2025 with residents of temporary and emergency accommodation in PDR conversions across four local authority areas in England: Bristol, Croydon, Harlow, and Harrow. These were delivered in collaboration with third-sector organisations supporting residents, who assisted with recruitment, logistics, and safeguarding. A total of 36 participants took part, with 33 completing a demographic questionnaire. Participants received a £40 voucher. Focus groups were facilitated using visual and textual prompt materials illustrating home, building and neighbourhood conditions known to affect health. Participants identified key issues through interactive activities, which informed subsequent discussions.

All study procedures received ethical approval from University College London. A distress protocol was implemented to support participants where needed. Qualitative data from interviews and focus groups were transcribed and analysed using Interpretive Phenomenological Analysis (IPA) and thematic analysis (respectively), aided by NVivo software. This approach enabled systematic identification of recurring themes while retaining sensitivity to participants' lived experiences. Two researchers reviewed the coding to ensure consistency and agreement.

Findings

This section draws together findings on residents' demographics and lived experiences of PDR housing. It draws on the three complementary strands of data collection described above: survey, interviews and focus groups. The lived experience findings are grouped thematically, first covering the overall perceptions of the PDR housing, its location, shortage of space and overcrowding, daylight and issues with windows, safety and security, noise, and finally thermal comfort.

Who are the residents of PDR housing and what is their self-reported mental health?

Residents of PDR housing in our sample are youngn, with a mean age of 36.0 years (SD: 11.9), 56.3% were under 35. The survey sample is also ethnically diverse relative to the national population (53.9% White (n=555), 21.6% Asian (n=222) and 11.8% Black). Educational level and employment were high, 78.5% had a bachelor's degree or higher (n= 809) and 68.8% (n=708) were employed. PDR households were most frequently single-person (37.3%, n=380) or 2-person households (43.6%, n=449), and 77.1% of households (n=793) had no children.

Most residents rented their home (72.8%, n=749) of whom 165 (22.0%) were on housing benefit. A private landlord or letting agency was the most common landlord (n=647) followed by council or local authority (n=100). A total of 88 survey respondents reported living in temporary or emergency accommodation across 45 unique PD schemes. Applying our survey response to our broader set of identified PDR housing, we estimate that approximately 5,528 housing units (95% CI: 4,347–6,709) within PD schemes across England are used for TA/EA. Considering the mean household size of 2.395 occupants in such accommodation (in our sample), we estimate that 13,241 people (95% CI: 10412–16069) are living in PD housing under TA/EA in England. Among TA/EA residents, 38.6% (n=34) had lived in their accommodation for less than 12 months. A further 26.1% (n=23) reported living there for between one and three years, while 27.3% (n=24) had stayed between three and five years. The remaining five residents (5.7%) had lived in their dwelling for more than five years. From our focus groups, it was often mothers with children in this accommodation for extended time periods.

Residents reported experiencing several housing issues in our survey, and these were grouped into four domains. Safety and security (five items, including difficulty locking doors or windows and concerns about fire safety), damp and structural (six items including damp, mould and leaky roofs), noise and pollution (five items including noise from neighbours and pest infestations) and space and light (three items including shortage of space and inadequate lighting). A total of 76.5% respondents reported at least one housing issue and more than half (56.3%) reported issues across more than one domain which suggests housing issues in PD dwellings cluster across different areas of the home. Analysing the number of individual issues, we found that 23.1% of PDR respondents reported five issues or more.

We measured mental wellbeing using the Warwick–Edinburg Mental Wellbeing Scale (WEMWBS), a validated questionnaire where scores range from 14 (lowest) to 70 (highest possible wellbeing)[99]. The mean wellbeing score in PD residents in our survey was 46.8 (95% CI 46.4–47.2). For comparison, the mean score of the England general population is 50.5 (95% CI 50.1–50.9) as recorded in the 2024 Health Survey for England. The difference of 3.7 points (95% CI 3.1–4.5) was statistically significant in all age groups under 65 years old. It also exceeded the minimum detectable change established by the WEMWBS (3 points)[100] which suggests the gap between PD residents and the general population represents a meaningful difference in wellbeing.

WEMWBS scores can also serve as a proxy for probable depression. Using a validated threshold of 41 or below,[101] 22% of PDR residents fell within the range of probable depression. We examined whether specific housing problems (noise, space insufficiency and thermal discomfort) were associated with poor mental health outcomes. PD residents that reported these issues had significantly higher odds of probable depression and lower wellbeing scores compared to those who did not, after adjusting for age, education level, ethnicity, employment, living with children, tenure and income (Figure 16).

99. Tennant R, Hiller L, Fishwick R, et al. 2007 The Warwick–Edinburgh Mental Well–being Scale (WEMWBS): development and UK validation. *Health Qual Life Outcomes. 5(1):63. Available at:* **https://doi.org/10.1186/1477–7525–5–63**
100. University of Warwick. WEMWBS: 14–item vs. 7–item scale. Available from: **https://warwick.ac.uk/fac/sci/med/research/platform/wemwbs/about/wemwbsvsswemwbs/**
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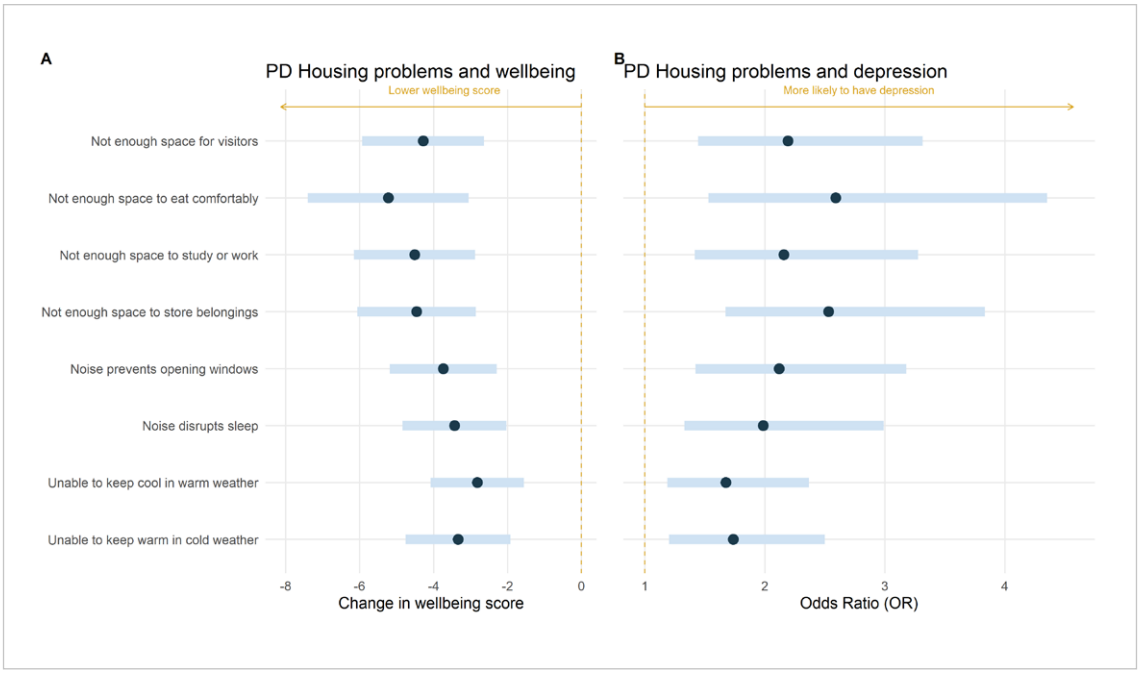


Figure 16: Associations between self-reported housing problems and mental health outcomes in PD residents. A) Change in WEMWBS score. Values are Beta coefficients B) Odds of probable depression. Values are Odds Ratios. Space sufficiency and noise items were measured on a 5-point Likert scale. For space items, estimates represent respondents who disagreed or strongly disagreed that their home provided adequate space for daily activities compared to those who agreed or strongly agreed and strongly agreed. For noise items, estimates represent residents who agreed or strongly agreed that noise prevented them from opening windows or disrupted their sleep compared to those who strongly disagreed or disagreed. Thermal comfort items were measured as yes/no questions. Estimates represent residents who reported being unable to keep cool in warm weather or warm in cold weather.

We also analysed if housing characteristics were associated with these outcomes. Results differed by outcome. Residents in office conversions reported lower wellbeing scores compared to those in agricultural conversions. No significant association was found with depression. Residents living in medium major schemes had lower wellbeing scores than those living in smaller schemes, but this did not translate to increased odds of depression. Living in a studio was associated with both lower wellbeing scores and increased odds of probable depression, compared to residents in non-studio flats (Figure 17).

No significant associations were found with year of approval and either outcome. However, these null findings need to be interpreted with caution. The large majority of our survey respondents lived in schemes approved 2013–19 (80.9%). While this reflects the composition of the PDR housing stock in England, it leaves insufficient variation to reliably detect differences between approval periods. The lack of association with depression compared to wellbeing scores can also be partly explained by this. Depression is a binary variable built from a continuous measure which reduces statistical power and associations might go undetected in a sample of this size. The association between office conversions and lower wellbeing score also needs to be interpreted with caution.

The number of survey respondents living in agricultural conversions and used as reference was low (n=36, 3.6%), resulting in wide confidence intervals (CI) (Figure 17). Odds ratio for depression were consistent in direction but due to the wide CI we are unable to draw conclusions. These findings should be confirmed in larger studies with better representation of non-office conversion residents.

Specific characteristics such as dwelling type, noise, thermal comfort and sufficient space seem to play a role in residents' wellbeing and highlight the need for minimum space and amenity standards that adequately protect the mental health of residents. Full results of these findings are currently being prepared for publication in a peer-reviewed journal.

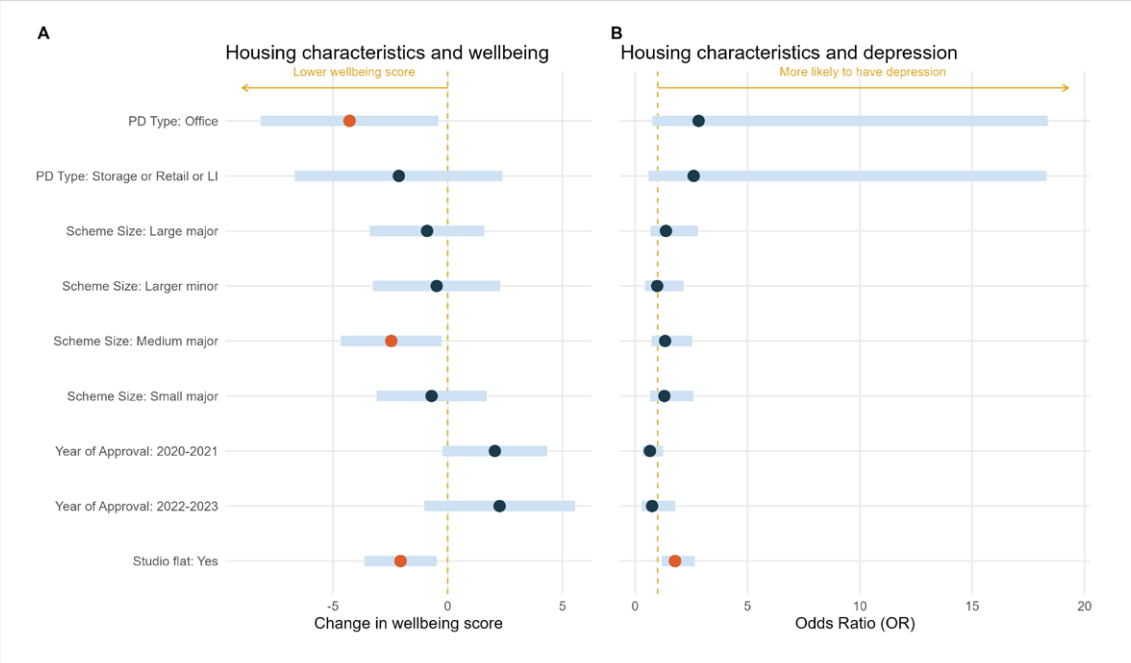


Figure 17: Associations between housing characteristics and mental health outcomes in PD housing residents. A) Changes in WEMWBS mental wellbeing score (linear regression coefficients) and B) Odds of probable depression (logistic regression odds ratios). Models are adjusted for age, education level, ethnicity, employment status, living with children, tenure and income. Reference categories are Agricultural conversions (PD_type), small minor (Scheme_size) and 2013-2019 (Year of Approval). Bars represent 95% CI and red dots indicate statistically significant associations ($p<0.005$)

Residents' Overall Perceptions of PDR Housing

Residents' experiences of struggling in poor housing conditions were not uncommon across PDR dwellings, but were particularly prevalent in TA and EA. There were a range of experiences between residents of PDR converted housing, which could be connected to tenure. However, the difficulties that residents of PDR converted housing faced presented as a spectrum of harm. For example, residents living in privately rented accommodation faced the same overall issues as those living in TA or EA, but often the difficulties were felt less acutely. Regardless of tenure, the findings suggest that specific features of deregulated conversions are also likely to affect the degree of harm involved.

Temporariness, undesired permanence and uncertainty emerged as central features of PDR living, with some variation across tenures. TA/EA residents may be placed in PDR housing as they await a social housing allocation with no control over their dwelling. Residents of privately rented or owned flats in PDR buildings had other reasons for feeling that they could not move, such as inability to afford better accommodation. Residents of TA / EA reported a reluctance to unpack, whereas residents living in PRS accommodation spoke of an unwillingness or inability to decorate their dwellings, both of which undermined their sense of their dwelling as a home.

For those living in TA and EA interviewed as part of the focus groups (FG), we found that living in poor quality deregulated conversions created a steady stream of negative signals that translated into feelings of being less important or undeserving of a 'proper' home. These perceptions arose through repeated interactions with building management, service providers such as security, and the local authority. During these interactions residents would find themselves being ignored or deprioritised. Although residents regularly voiced acute needs or problems with their accommodation, they described being *"shut down"* and treated as though their situation was hopeless *"and even funny"*. One resident described a feeling of being *"unwanted ... everyone's trying to get rid of you"*. This marginalisation was experienced as contributing towards depression, often leaving residents feeling as though *"you're nobody"* (FG).

In their accounts of inaction, delays and poor repairs, residents offered their interpretations for the persistence of *"terrible"* conditions as further evidence of the marginalisation residents' in PDR conversions. We identified two central problems. First, the unsuitability of the conversions and second, the tendency of this type of converted housing to attract a poor type of landlord or management. One resident described *"battling a landlord who doesn't care"* as *"really depressing"* (FG). However, where properties were privately rented or managed directly by the local authority the situation was often just as bad, with residents frequently reporting a sense that the local authority *"don't help, they don't support us or nothing, nothing at all"* (Int). Residents of privately rented accommodation interviewed (Int) spoke of different – but connected – issues, in particular reporting feeling grateful to have somewhere to live in a hostile and expensive private rental market and so were more willing to bear the varied problems raised by PDR converted housing. One example of this was an interviewee who had recently moved into a privately rented PDR conversions said *'I will be happier to leave. But, I mean, you never know what the next one will be like'* (Int).

Location of the PDR conversions

The PDR conversions that we heard about in the survey, focus groups, and interviews were often in unsuitable locations, either in very busy and noisy town centre locations or isolated in non-residential areas. The former presented numerous risks relating to crime, noise, and pollution, whereas the non-residential locations presented the same risks in addition to difficulty accessing transport, amenities and services whilst also engendering feelings of being ignored or excluded by local services that reinforced both the material and symbolic dimensions of the marginalisation that they experienced (FG). One owner -occupier reflected upon their dwelling's location, saying *"it's not in a very nice sort of position is it. It's more like an industrial area isn't it really, and we kind of thought it might be developed when we bought it, but nothing round here really"* (Int). These patterns are consistent with the wider findings of this project and other research, which has linked negative health and wellbeing outcomes to a lack of control over one's living environment, prolonged periods of housing precarity, and poor build quality and repairs.[102]

Shortage of space and overcrowding

The findings point to several material differences between PDR converted dwellings and the general housing stock, which are likely harming health and wellbeing. These are: high dwelling density, limited internal space (particularly for conversions that took place before 2021), lack of outdoor space, and location in non-residential areas; all of which are more common in PDR conversions which do not have to meet most planning standards.

In overcrowded and small PDR units, everyday activities such as cooking were constrained by noise and smells reaching other occupants of the same dwelling. One resident of a PDR conversion in Croydon described this, saying *"sometimes you get up early to cook. They can smell [the food] because they're in the same room"* (FG).

Survey respondents' own assessments of their homes reflected these constraints. Between roughly half and three-quarters of respondents strongly agreed or agreed that their home offered sufficient space for different everyday functions. Space for eating comfortably was rated most favourably (73.8%, n=759), followed by space for visitors (61.4%, n=632), while space for studying or working (55.3%, n=569) and for storing essential belongings (55.9%, n=575) were rated less favourably. Perceptions of space sufficiency were consistently higher among owner-occupiers than among renters and TA/EA residents.

102. Watts, B., & Blenkinsopp, J. 2022. Valuing Control over One's Immediate Living Environment: How Homelessness Responses Corrode Capabilities. *Housing, Theory and Society*, *39*(1), 98–115. Available at: **https://doi.org/10.1080/14036096.2020.1867236**

Overall, 168 households (15.5%) in the survey were classified as overcrowded. Within this group, nearly a quarter (21.4%, n=36) were TA/EA residents, and almost 60% (59.8%, n=101) rented from a private landlord. Overcrowding varied markedly by tenure: 6.3% (n=14) of homeowners were overcrowded, compared with 15.4% (n=90) of renters not receiving housing benefit and 31.5% (n=52) of renters receiving housing benefit. Among the smaller number of respondents living in conversions approved between 2020 and 2023, 25.3% (n=23) of those from the 2020–2022 period were overcrowded, suggesting that overcrowding is a problem that has persisted beyond the 2021 amendments to the GPDO, which has increased the absolute space in dwellings but cannot manage the number of people living in each unit.

Perceptions of insufficient space were a significant concern extending well beyond households which classify as overcrowded. Over one in six PDR households surveyed were overcrowded (16.4%) (using the persons per room method to define this, as opposed to subjective impressions of having sufficient space for common activities), compared with a national average of 4.4%, with gradients in reported difficulty across tenure type, particularly amongst those living in TA/EA. Similar patterns were observed with shortage of space for storage and to study / work, suggesting that the impact of space insufficiency extends beyond floor area to one's broader quality of everyday domestic life. The proliferation of undersized and overcrowded units, combined with a surfeit of single person dwellings provided by PDR, has amplified concerns over overcrowding and space insufficiency, particularly the impact these factors have on mental health and wellbeing.[103]

Smaller dwellings are often perceived to be well-suited to some groups, particularly younger, single residents who may value location or being able to live alone over space.[104] Indeed, one interviewee expressed a desire *for "something small so I could focus on my work. I didn't want to get too comfortable"* (Int). However, the survey findings point to a more complex reality. Although the population living in PDR converted housing is comparatively young, ethnically diverse and highly educated, insufficient space and overcrowding was experienced as a hardship rather than a choice, and space constraints appeared as a material burden rather than an aspirational trade-off.

103. King's College London. 2015. No Space like Home? Small Domestic Properties, Compensatory Urbanism and Housing Futures in English Cities at: **https://www.kcl.ac.uk/research/no-space-like-home** .
104. Kichanova, V., Size Doesnt Matter: Giving a Green Light to Micro-Homes at **https://www.adamsmith.org/research/size-doesnt-matter-giving-a-green-light-to-micro-homes** .

Daylight, windows and ventilation

Windows, ventilation and cooling were another major concern for residents of PDR conversions. Such issues related closely to the nature of PDR conversions, which necessarily involve commercial buildings such as offices being transformed into housing with very few, if any, changes being made to the facade or fenestration.[105] Windows were problematic in multiple ways, including crime, pests, and overheating or heat escape (FG). Interviewees pointed to a lack of control over windows as a particularly pernicious part of the problems they posed, with one interviewee saying of his windows: *"[t]here's a lovely amount of sunlight that comes in in the day but we can't manage it, we're not in control of it. We can't close the blinds"* (Int). Evidence from the survey reinforces the accounts of residents in the focus groups and interviews. Natural light and ventilation were markedly poorer in PDR conversions than in comparable housing delivered through the planning system. 72% of the PDR units surveyed were single aspect, compared with 29.5% of units delivered through full planning permission. Some PDR units developed before 2020 had no windows at all.

Among survey respondents living in studio units (n=288), the majority (93.9%, n=214) were in office-to-residential conversions, and 84.2% had been built between 2013 and 2019. Of these studio residents, 10.5% (n=24) reported having no windows at all in their accommodation. Among those with a window, 10.7% (n=21) had no or only a partial outside view, and 16.4% (n=32) could not open their window, or could only open it partially, often owing to locked fittings or landlord-installed restrictors. A further 8.2% (n=16) could not cover their window, and 40.4% (n=80) reported having no trickle vent, with an additional 14.4% (n=28) unsure whether one was present.

Among respondents not living in a studio unit (n=782), 51.3% (n=401) lived in one-bedroom accommodation and 38.4% (n=300) in two-bedroom accommodation. The large majority (82.5%, n=645) lived in accommodation where the kitchen and living room shared a single, open-plan space; within this group, 3.7% (n=24) had no window at all in the open-plan area. Among those with a window, when asked whether they could open at least one window in the kitchen/lounge, 5.0% (n=31) reported that it offered a restricted or no outside view, 6.2% (n=38) reported that it could not be opened fully, and 7.6% (n=47) could not cover it with curtains, blinds or shutters.

105. Madeddu, Manuela, and Ben Clifford. 2022. The Conversion of Buildings to Housing Use: Englands Permitted Development Rights in Comparative Perspective. *Progress in Planning* 171: 100730. Available at: **https://doi.org/10.1016/j.progress.2022.100730**.

Close to 40% (39.6%, n=245) reported having no trickle vent, and a further 8.9% (n=55) were unsure whether one was present. In bedrooms within these open-plan dwellings, the large majority (92.6%, n=597) had a window; of these, visibility was obstructed in 13.8% of cases (n=41), 14.6% (n=46) could not be fully opened, and 10.9% (n=22) could not be covered. A trickle vent was present in fewer than half of these bedrooms (47.8%, n=308).

Among residents in non-open-plan dwellings (n=119), 23.5% (n=28) had no kitchen window, 9.2% (n=11) had no living room window, and 5.0% (n=6) had no bedroom window. Where present, kitchen windows offered an outside view in 73.9% of cases (n=88) and could be opened in 93.3% (n=86); 82.2% (n=74) could be covered. Just over half (51.1%, n=37) had a trickle vent, and 7.8% (n=7) were unsure whether one existed. In living rooms, 84.0% (n=100) of windows could be opened, 82.2% (n=74) offered an outside view, and 87.8% (n=79) could be covered, though only 40.3% (n=48) had a trickle vent — an equal proportion had none, and a further 9.2% (n=11) did not know. Bedroom windows in non-open-plan dwellings offered outside visibility in 84.0% of cases (n=100), could be covered in 86.6% (n=103), and could be fully opened in 86.6% (n=103); trickle vents were the least common feature here, present in only 37.8% (n=45) of cases.

Taken together, these findings identify windows as a significant and recurring problem within PDR conversions, pertaining to thermal comfort, ventilation, safety, daylight, damp, noise and pollution. These deficiencies are closely related to the type and quality of windows typically installed in non-residential buildings, poorly suited to residential use. Extrapolating the survey's finding that 2.6% (n=27) of respondents had no windows at all in their dwelling to a national scale, using the figure of 73,008 conversions delivered between 2015 and 2020 (MHCLG data), suggests that up to 1,898 households in PDR housing may lack any windows.. Considerably larger numbers of residents have windows that do not open, or only partially open, do not lock, or are positioned too high on walls or ceilings to provide any outside view.

These issues can be linked to multiple health and wellbeing outcomes, including poor ventilation causing respiratory issues.[106] Ventilation in PDR conversions was frequently found to be inadequate, with mechanical ventilation and trickle vents often required (but not provided) to substitute for operable windows. This substitution was of particular concern given that insufficient ventilation is highly predictive of damp and mould.[107]

106. Kelly, Frank J., and Julia C. Fussell. 2019. Improving Indoor Air Quality, Health and Performance within Environments Where People Live, Travel, Learn and Work. *Atmospheric Environment* 200: 90–109. Available at: **https://doi.org/10.1016/j.atmosenv.2018.11.058**.
107. MHCLG, DHSC and UKHSA (2026) Understanding and addressing the health risks of damp and mould in the home. Available at: **https://www.gov.uk/government/publications/damp-and-mould-understanding-and-addressing-the-health-risks-for-rented-housing-providers/understanding-and-addressing-the-health-risks-of-damp-and-mould-in-the-home--2**

Safety and security

The findings from the survey, interviews, and the focus groups suggest a preponderance of safety and security issues raised by PDR conversions. In particular, the emergence of security guards as figures wielding arbitrary authority within PDR conversions, whose imposition of rules and restrictions harm residents' sense of safety and belonging in their homes (FG). One interviewee described the lack of safety, combined with the lack of concern shown by building management as follows: *"It's not safe at all. Every time we try to talk to the office, they just try to push you away"* (Int). The survey findings showed that safety concerns were a significant concern for a residents. 44.4% of residents (n=457) reported feeling very safe when alone in their dwelling. 39.7% (n=409) reported only feeling fairly safe, whilst 3.4% (n=35) felt very unsafe and 0.5% (n=5) reported that they could not be home alone due to safety concerns. Perceptions of safety were consistently poorer amongst residents of rental and TA/EA accommodation than those in owner-occupied housing (Survey).

We were told that on our focus groups that when residents raised serious concerns around maintenance and building safety, the response from building management was frequently inadequate, ranging from no response at all to a temporary fix, usually only after very long delays. Whilst waiting for issues to be resolved, residents' health was often harmed or serious incidents occurred, including fires. One resident recalled how *"the fire brigade did inform the Council quite a while [ago], they said it is not safe, and they never take it seriously"* (FG). At another PDR conversion from an industrial to residential use, rubbish accumulated due to fly-tipping by non-residents. The lack of response from the building managers was experienced as dehumanising, despite the fact that residents *"complained a lot because they left us like animals"* (FG). However, it was not just building management who ignored residents. More concerning for residents was being ignored by the police, which left people feeling that nobody would respond to a dangerous situation. One resident called the police about safety concerns and recalled being met with laughter, *"the police, they laugh, they say oh, that place, we know that"*. In this way, residents were aware that the police appeared to stereotype their building. Poor quality PDR conversions were apparently well known to emergency services due to the frequency of calls. One resident observed that *"it's calmed down a bit now, but you know the police and ambulance were at that building every day for different things"*. Another resident of the same PDR scheme, echoed this, noting that *"the police have been called there so often. In the end, they don't care"*. The resident believed that this pattern encouraged further crime, since *"they knew they could get away with stuff down there"* (FG).

Security guards and managers in PDR conversions, particularly those that were used for TA/EA, were described by residents as occupying a problematic role somewhere between an external threat and a prison warden.. Residents described security guards enforcing arbitrary rules not contained within tenancy agreements, such as prohibiting children playing in corridors, whilst neglecting to intervene in far more serious situations such as incidents of domestic violence. Crime was reportedly enabled in TA/EA settings both through a concentration of large numbers of people with complex needs and vulnerabilities who were poorly supported, as well as through the isolated location of the PDR conversions away from the norms and passive surveillance typical of residential areas. When the police stopped responding to calls from these locations, residents felt that this emboldened criminality, despite the presence of on-site security guards, who often felt more akin to prison guards than protectors.

Noise

Road traffic noise was the most commonly reported source of disturbance among residents of PDR conversions, with 19.9% of people rating it as very or extremely disturbing, while only 8.8% reported not hearing it at all. Noise from neighbours (18.8%, n=193) and from construction (16.8%, n=173) were also frequently identified as highly annoying. Aircraft noise was, by contrast, the least problematic source. Only 6.4% (n=60) rated it as very or extremely bothersome, and 19.5% (n=201) reported not hearing it at all. Overall, more than a third of respondents (36.1%, n=261) agreed or strongly agreed that outdoor noise caused them, or someone in their household, trouble sleeping (Survey). The effects of living with constant traffic noise were summarise by one interviewee, who said: *"I can't switch off ... although I've lived here for six years it hasn't numbed it out"* (Int).

Thermal comfort

Beyond the negative effects of unsuitable locations, discussed above, PDR conversions were found to be distinctly problematic with extreme overheating. Overheating was described by interviewees as so *"unbearable"* that residents avoided going home or cooking (FG, Int). Many of the dwellings surveyed were studios consisting of a single room with a toilet and a shower built into the corner, at times housing three or four people. Such dwellings were likely to have single aspect windows, meaning that light and warmth could enter the flat readily but achieving adequate ventilation and cooling proved difficult without a cross breeze (FG).

Overheating in PDR conversions posed significant challenges for parents and caregivers. Some parents reported that the only viable solution for their children's safety was to stay out of the dwelling. One resident living as part of a large family in an overcrowded dwelling explained *"I can't cook or if I'm cooking, I know it's gonna be even hotter in the house"* (Int). The findings link overheating and poor ventilation to the fact that the PDR conversions were not originally designed to be dwellings, and that high levels of density to maximise developer profits mean that many units are single aspect and often lack operable windows. These are issues that could be readily addressed through proper planning scrutiny.

Survey findings reinforced these accounts. Keeping comfortable in hot summer weather was problematic for 45.4% (n=467) of respondents, while 25.3% (n=260) could not keep comfortably warm during cold winter weather. To manage heat, residents commonly used internal blinds or shutters (46.1%, n=466) and portable fans (37.1%, n=375). 23.7% (n=244) of respondents could not open more than one window at a time to create a cross-breeze. Limited window access appeared to be a particular driver of thermal discomfort among studio dwellers: 43.2% (n=48) of those with only one window reported difficulty staying cool in summer, and among studio dwellers who could not keep comfortably cool, 14.4% (n=15) reported that their window could not be opened, or could only be partially opened, and 6.3% (n=7) reported being unable to cover it. External environmental factors also shaped ventilation practices. Over a third of respondents (36.1%, n=374) agreed or strongly agreed that outside noise prevented them from opening windows for cooling or ventilation, while 22.2% reported the same difficulty owing to outdoor air pollution.

Conclusions

WP2 demonstrates that the health and wellbeing implications of PDR housing are experienced through overlapping features of the home, building and neighbourhood. Survey respondents were predominantly young, highly educated and employed renters. Despite the health advantages of their youth, education and employment status, they experienced multiple wellbeing and housing issues. Housing problems were widespread: 76.5% reported at least one issue and 56.3% reported problems across more than one domain. Mental wellbeing was lower than in the general English population, with 22% scoring within the range for probable depression; insufficient space, noise and thermal discomfort were associated with poorer mental health. These problems were especially acute for residents in temporary and emergency accommodation, who often experienced prolonged insecurity, overcrowding, poor management and limited control over their homes.

Qualitative findings reinforce the survey evidence, showing how inadequate space, restricted windows, poor ventilation, overheating, noise, safety concerns and unsuitable locations can disrupt everyday activities and undermine residents' sense of home, agency and belonging. Together, these findings add a lived-experience dimension to the wider study. They complement WP1 evidence on location and healthcare use and provide context for WP3 measurements of indoor environmental quality, identifying plausible pathways through which PDR housing may affect health and contribute to health inequalities. Overall, WP2 highlights the importance of housing quality, security and planning oversight alongside housing supply.



Work Package 3: Environmental conditions inside permitted development housing and modelling potential improvements

Introduction and specific objectives

Background

People spend around 90% of their lives indoors, a figure which may be higher for vulnerable individuals. Ensuring good indoor environmental quality (IEQ), including thermal, visual, acoustic and air quality conditions, is therefore vital. Socially and economically disadvantaged communities are the most affected by environmental hazards and extreme events, including those caused by ongoing and future climate change.[108] Building design and operation can modify human exposures to outdoor and indoor environmental hazards, thus affecting health and wellbeing. Indoor environments may create, exacerbate or reduce health inequalities, inequities and injustices, but further research is needed to fully understand such impacts.[109]

108. CCC, 2026. A Well-Adapted UK, The Fourth Independent Assessment of UK Climate Risk (CCRA4-IA). Available at: **https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/**
109. Ucci, M. and Mavrogianni, A., 2024. Health inequalities and indoor environments: research challenges and priorities. Buildings and Cities, 5(1), pp.662–674. Available at: **https://doi.org/10.5334/BC.514**

This is particularly the case for PDR housing. Until recently, data on the indoor environmental performance of PDR housing was scarce. WP3 addressed this evidence gap by employing a quantitative approach combining indoor environmental monitoring and modelling. WP3 builds on WP1 (housing-health data linkage), WP2 (exploration of lived experiences of PDR residents), and findings of past studies on the impact of location, original building design characteristics and the quality of the PDR conversion design on indoor environmental quality, which are briefly summarised below.

The location of many PDR homes in non-residential neighbourhoods may negatively affect indoor environmental quality through the ingress of outdoor air pollution and noise. Several studies highlighted PDR conversions situated in unsuitable locations, such as areas with high traffic volumes, near factories, waste transfer stations, or within industrial estates.[110, 111] We now have further evidence on this from Work Package 1 of this project. The original design characteristics of the building types commonly converted under PDR may also pose constraints to achieving good indoor environmental quality. For example, many office or commercial buildings feature single-aspect spaces, large glazing surfaces, non-operable or tinted windows that remain after the conversion.[112, 113]

The quality of the PDR conversion is also important. Alongside common PDR resident concerns about the surrounding environment (pollution, noise, crime or vandalism), interviews and surveys of London PDR residents identified significant issues with poor window systems, including non-operable windows.[114] This may result in inadequate ventilation, which could increase the concentration of internally generated pollutants, damp, mould, odours, poor daylight access and overheating. Many PDR developments tend to meet only the minimum thermal performance requirements set out in Building Regulations for material change of use. For example, the average energy rating of small and large PDR developments in London is C, which is higher than the median rating of D for all London dwellings, but lower than the median of B achieved in new London dwellings approved via standard planning routes.[115] The absence of double glazing in some PDR homes may also cause noise issues.

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110. Clifford, B., Canelas, P., Ferm, J., Livingstone, N., Lord, A. and Dunning, R., 2020. Research into the quality standard of homes delivered through change of use permitted development rights. Available at: **https://assets.publishing.service.gov.uk/media/5f159de5e90e075e90a720dc/Research_report_quality_PDR_homes.pdf**
111. Marsh, R., Chang, M. and Wood, J., 2022. The relationship between housing created through Permitted Development Rights and health: a systematic review. Cities & Health, 6(4), pp.833–852. Available at: **https://doi.org/10.1080/23748834.2020.1833281**
112. Clifford, B., Canelas, P., Ferm, J., Livingstone, N., Lord, A. and Dunning, R., 2020. Research into the quality standard of homes delivered through change of use permitted development rights. Available at: **https://assets.publishing.service.gov.uk/media/5f159de5e90e075e90a720dc/Research_report_quality_PDR_homes.pdf**
113. Marsh, R., Chang, M. and Wood, J., 2022. The relationship between housing created through Permitted Development Rights and health: a systematic review. Cities & Health, 6(4), pp.833–852. Available at: **https://doi.org/10.1080/23748834.2020.1833281**
114. Pineo, H., Clifford, B., Eyre, M. and Aldridge, R.W., 2024. Health and wellbeing impacts of housing converted from non-residential buildings: A mixed-methods exploratory study in London, UK. Wellbeing, Space and Society, 6, 100192. Available at: **https://doi.org/10.1016/j.wss.2024.100192**
115. Chng, I., Reades, J. and Hubbard, P., 2024. Planning deregulation as solution to the housing crisis: The affordability, amenity and adequacy of Permitted Development in London. Environment and Planning A: Economy and Space, 56(3), pp.961–978. Available at: **https://doi.org/10.1177/0308518X231209982**

Previous studies, as outlined above, have examined the indoor environmental quality and energy performance of PDR housing using qualitative approaches, administrative data, small samples or case studies. To enhance our understanding of indoor environmental exposures in PDR housing and the role of building characteristics, WP3 collected high-resolution indoor hygrothermal and air quality monitoring data, combined with building and occupant questionnaire surveys in a sample of 47 PDR homes. Based on survey data, WP3 further developed archetypes of PDR housing, and quantified current and future thermal and air pollutant exposures using building performance modelling, including the impact of PDR-specific interventions aiming to improve indoor environmental quality.

Specific objectives

WP3 was designed to address the following objectives:

- To carry out detailed indoor hygrothermal and air quality monitoring, building and occupant surveys in a large sample of PDR homes capturing at least one heating season and one non-heating season.
- To integrate findings with WP1 and WP2 to improve understanding of the mechanisms linking PDR housing characteristics, environmental exposures and health outcomes and, together with stakeholders, to co-create retrofit interventions tailored to PDR homes that could be applied to improve indoor environmental conditions.
- Based on the survey data, to develop archetypes of PDR housing, including original building function, geometry, construction and conversion type/age, and building fabric characteristics (with a focus on building envelope thermal efficiency).
- To model indoor environmental conditions and associated exposures in PDR archetypes, for baseline conditions and following retrofit interventions, under the current and future climate.
- To provide indoor exposure estimates to WP4 to quantify health impacts.

These objectives addressed the following research questions (RQ):

- **RQ3.1:** What are the exposure levels to indoor excess heat/cold and air pollutants of populations living in PDR housing?
- **RQ3.2:** How do these levels compare against exposure levels experienced across the English housing stock?[116]
- **RQ3.3:** What retrofit strategies need to be implemented to improve indoor environmental conditions in PDR housing, now and in the future?

116. Our analysis of this is still ongoing and this will be discussed in detail further in a separate upcoming paper

Methods

Overview

WP3 combined indoor environmental monitoring, building surveys and resident questionnaires with building performance modelling to examine indoor conditions in PDR housing and assess potential improvements. Monitoring and surveys provided evidence of conditions currently experienced in occupied homes and informed the development of archetypes, i.e. simplified models of typical PDR homes. These models were used to explore how building characteristics, household activities and climate influenced indoor temperature, relative humidity and pollutant concentrations. Several interventions aiming to improve the performance of PDR housing were then assessed. The quantification of indoor environmental exposures before and after interventions provided a basis for the health impact assessment in WP4.

Indoor environmental monitoring and surveys

Case study selection and recruitment

Participants were recruited through the wider project survey of residents living in PDR homes across England, undertaken under WP1 and WP2. Postal invitations and monetary incentives generated approximately 1,000 WP2 survey responses. Eligible respondents were subsequently invited to participate in in-depth monitoring of their homes and a more detailed WP3 questionnaire survey. The monitoring sample was selected to capture variation in building conversion age and type, tenure, and household characteristics, while remaining feasible within the time and cost requirements of intensive fieldwork.

Fifty-five homes were initially recruited, exceeding the original target of 50. Eight were subsequently excluded because it was found that they were not converted into residential properties under PDR, residents moved out early, or contact was lost. The final sample comprised 47 valid case studies. Most were in Greater London and southern England, with additional sites in Northampton, Bristol, Leeds and Ipswich, as shown in Figure 18. The geographical distribution of the participating homes reflected the predominantly urban concentration of PDR housing.



Figure 18: Locations of PDR homes recruited for the fieldwork study across England (on a Google Maps base layer)[117]

Fieldwork and environmental measurements

Monitoring took place for varying periods between June 2024 and September 2025, with the intention of covering both heating and non-heating seasons, wherever possible. Each home received two or three visits, depending on the monitoring period length. The monitoring equipment was installed during the initial site visit, when the building survey and one resident questionnaire were also completed. Interim visits, where required, allowed battery replacement, equipment checks and collection of further qualitative information. Equipment was removed and final information collected during the final visit. Site visit participants received additional monetary incentives after the initial and final visits.

An Eltek AQ210 monitor was installed in the main living area of each home to measure air temperature,[118] relative humidity, fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), carbon monoxide (CO) and carbon dioxide (CO2) at five-minute intervals. A HOBO MX1102 logger recorded air temperature,[119] relative humidity and CO2 in the main sleeping area at ten-minute intervals. SKC UMEx 100 passive samplers[120] were used to measure formaldehyde concentrations over one week in the main living area.[121]

117. Google, 2026. My Maps. Available at: **https://www.google.com/maps/d/u/0/edit?hl=en&mid=1L9WR4Bjks4B6TjNpFzcBlhxk6fgyquc&ll=52.609634248257876%2C-0.8592823000000078&z=7**
118. Eltek, 2026. Environmental Monitoring Systems. Available at: **https://www.eltekdataloggers.co.uk/**
119. Onset, 2026. Data Loggers. Available at: **https://www.onsetcomp.com/**
120.
121. SKC, 2026. UMEx 100 Passive Samplers. Available at: **https://www.skcltd.com/products2/passive-samplers/umex-100-formaldehyde.html**

Building surveys recorded dwelling geometry, dimensions, construction, glazing and ventilation provision (Figure 19). Seasonal occupant questionnaires, administered in summer and winter, collected information on thermal, visual and acoustic comfort, perceived air quality, household habits and activities (such as window opening and other ventilation practices, clothes washing and drying). The questionnaires provided contextual evidence of how residents used their homes, rather than continuous records of every action. Participants provided separate written consent for environmental monitoring, questionnaires, building surveys and photography. The study received prior approval from the UCL Research Ethics Committee, and the collected data were anonymised.

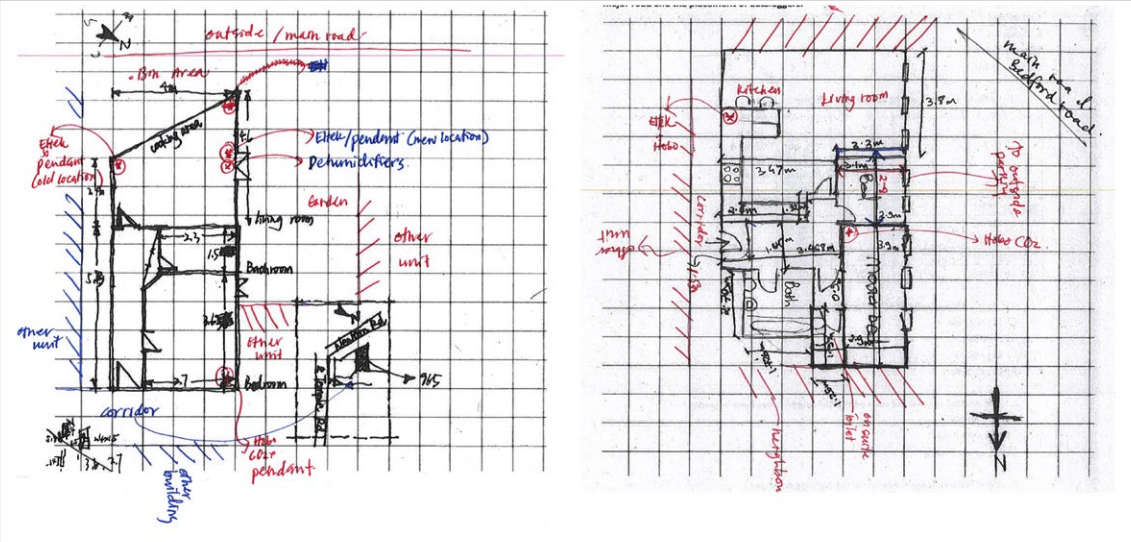


Figure 19: Examples of hand-drawn sketches used during site surveys to record flat layouts, key building features and monitoring equipment locations

Monitoring quality assurance

Monitored data were processed using a predefined quality assurance protocol. Eltek units were co-located in the lab with reference instruments for $PM_{2.5}$ and with NO_2 diffusion tubes to assess accuracy and systematic bias. Measurements were aligned by timestamp and, where required, aggregated to ten-minute intervals. Readings outside instrument ranges, physically inconsistent values and prolonged repeated readings indicative of equipment malfunction were treated as missing. $PM_{2.5}$ observations recorded at relative humidity equal to or higher than 85% were excluded. Hourly and daily summaries were retained only when at least 75% of expected observations were valid, reducing the influence of incomplete records. The monitoring was used both to describe indoor conditions in the case study homes and to assess the plausibility of subsequent model assumptions.

Archetype development and stock coverage

The building surveys established the physical basis for developing archetypes broadly representative of the English PDR stock. Archetype selection began by grouping the 47 valid PDR case studies with monitoring and survey data. The initial classification considered:

- development scale;
- original building construction age;
- building conversion type and period;
- building geometry;
- building thermal characteristics and glazing ratio;
- dwelling size and layout;
- ventilation configuration.

Table 19: Initial set of 20 distinct PDR dwelling types and variations.

Dwelling category	Conversion period	Number of variants
Agricultural or storage conversion	2013–19 and 2020–21	2
Retail conversion	2013–19 and 2020–21	2
Office-to-flat conversion	2020–21	1
Office-to-student hall conversion	2020–21	1
Office-to-house conversion	2013–19	1
Office-to-MVHR only flat	2013–19	1
Office-to-stack-ventilated flat	2013–19	1
Office-to-dual-aspect flat	2013–19	4
Office-to-single-aspect flat	2013–19	7

This approach aimed to preserve the main sources of variation observed across the monitored sample while producing a manageable number of models for simulation and testing a range of measures to improve indoor environmental quality. An initial set of 20 candidate types was identified, including agricultural/storage and retail conversions, alongside a larger group of office conversions shown in Table 19. Among the office conversions, two dated from 2020–21 and the remainder from 2013–19. These captured differences between single- and dual- aspect PDR dwellings and less common configurations, including mechanically ventilated, stack-ventilated and student accommodation. The remaining office cases consisted of office conversions with unique characteristics. Although this initial classification captured the diversity of the monitored sample, modelling 20 separate types would have limited the feasibility of systematic testing.

The candidate types were, therefore, consolidated into a final set of seven archetypes, guided by the availability of equivalent variables in the PDR AddressBase and linked 3DStock data: The PDR AddressBase dataset was compiled principally by matching housing schemes from local planning authority planning databases (prior approval data) with the Glenigan construction monitoring database,[122] and with Ordnance Survey AddressBase records.[123] The resulting dataset contained 77,421 individual PDR properties in England, with conversion information, addresses and Unique Property Reference Numbers (UPRNs). Records were linked by UPRN to UCL's 3DStock model,[124] combining Ordnance Survey and Valuation Office Agency (VOA) data with separately sourced domestic Energy Performance Certificates (EPCs).

Table 20: Archetype-defining and secondary model parameters, as identified through the linkage of records between the PDR AddressBase and the 3DStock model.

Parameter	Variable role	Key categories / predominant variations	Wider-stock availability (PDR AddressBase, 3DStock model)
Conversion type	Primary	Office, retail, agricultural, storage	95%
Total floor area	Primary	<50 m^2, 50–100 m^2, >100 m^2	41 – 78%
Building fabric thermal insulation level (EPC rating)	Primary	High (A–B), medium (C–D), poor (E–G)	41 – 78%
Wall construction	Secondary	Brick, system-built	15 – 34%
Glazing ratio	Secondary	Normal, more than typical	12 – 18%
Ventilation mode	Secondary	Natural	15 – 33%

As shown in Table 20, conversion type, total floor area and overall building thermal insulation level were selected as the main defining characteristics. Conversion type was available for about 95% of PDR stock records in the PDR AddressBase, while completeness for floor area and thermal insulation information ranged from about 41% to 78%. Secondary variables, including wall construction, glazing ratio, and ventilation type, were less complete. As a result, wall construction and glazing ratio were treated as secondary model parameters and varied within each archetype to broaden the conditions represented. Most monitored homes were naturally ventilated, and the 3DStock data available also indicated natural ventilation was predominant. The same was, therefore, applied to the archetypes. Overall, around one quarter of addresses lacked a linked EPC. No information was provided on internal dwelling layouts, room configurations, or occupant behaviour.

122. Glenigan, 2026. Glenigan Data Practices. Available at: **https://www.glenigan.com/data-practices/**
123. Ordnance Survey, 2026. AddressBase data products and support. Available at: **https://www.ordnancesurvey.co.uk/products/addressbase**
124. Evans S, Liddiard R, Steadman P., 2017. 3DStock: A new kind of three-dimensional model of the building stock of England and Wales, for use in energy analysis. *Environ Plan B Urban Anal City Sci. 44(2):227–55. Available at:* **http://doi.org/10.1177/0265813516652898**

Table 21 summarises the key characteristics of the seven archetypes:

- Archetypes S and S+ represent office conversions to small flats with moderate and high building fabric thermal insulation, respectively. Two geometries within each size group, S1/S2, captured layout differences.
- M and M+ represent office conversions to medium-sized flats with the same insulation distinction. Two geometries within each size group, M1/M2, captured layout differences.
- Archetype A represents a large agricultural conversion,
- R represents a medium-sized retail conversion, and
- L represents an office conversion to student accommodation, all of moderate insulation levels.

The representativeness of the archetypes was estimated from the combined prevalence of conversion type, floor area and insulation characteristics in the available stock data. The seven archetypes covered an estimated 82.4% of the dwelling combinations that could be identified using the available conversion type, floor area and insulation data. The representativeness attributed to each of the archetypes is shown in Table 21. Among monitored office conversions, 16 case studies were represented by archetype S, five by S+, seven by M and five by M+. Archetypes A, R and L were linked to one case study each. The remaining case studies in the sample each represented less than 3% of the wider stock data available or could not be quantified reliably. Figures 20 and 21 illustrate the contrasting building types represented by the different conversion type categories.



Figure 20: Images (a), (b), and (c) show examples of office-to-flat conversion buildings that could each contain any of the types represented by Archetypes S, S+, M, and M+.



Figure 21: Examples of (a) Archetype A – agricultural conversion, (b) Archetype R – retail conversion, and (c) Archetype L – office-to-student hall conversion.

Table 21: Classification of PDR housing archetypes and associated simulation variants.

Archetype ID	Geometry ID	Conversion type	Total floor area band (m^2)	Overall building fabric thermal insulation	Variants	% Stock represented
A	A	Agricultural	150–200	Moderate	Wall construction: brick-, stone-, timber- clad Floor level: ground, middle, top Orientation: north, south, east, west	4.4%
R	R	Retail to flat	50–100	Moderate	Wall construction: brick-clad, system built Floor level: ground, middle, top Glazing ratio: 20%, 50%, 80% Orientation: north, south, east, west	2.4%
S	S1, S2	Office to small-sized flat (bedsit or 1-bed flat)	< 50	Moderate		30.2%
S+				High		5.3%
M	M1, M2	Office to medium-sized flat (1-bed or 2-bed)	50–100	Moderate		31.6%
M+				High		5.5%
L	L	Office to student hall	100–150	Moderate		3.0%

Model development and climate inputs

Models were developed in DesignBuilder,[125] a building simulation software package that uses the EnergyPlus calculation engine.[126] The model accounted for air movement through windows and gaps in the building, and for moisture absorbed and released by building materials. Internal gains were assigned separately to occupants, equipment, lighting and moisture-generating activities. The models representing office-to-flat conversions accounted for overshadowing from adjacent buildings by positioning massing blocks of comparable height and scale about 20 m away. Four orientations and three floor levels (ground, middle, and top) provided 12 spatial combinations within each block-of-flats model, as illustrated in Figure 22.

Simulations used CIBSE weather files for the London climate zone.[127] Test Reference Year (TRY) files represented typical annual conditions and supported assessment of typical annual indoor conditions. Design Summer Year (DSY) represented warmer weather conditions for overheating assessment. The annual simulations used the UK Climate Projections 2018 (UKCP18) 2030s high-emissions (50th percentile), 2050s medium-emissions (50th percentile), and 2080s high-emissions (50th percentile) scenarios to approximate the current climate, a 2 °C global warming, and a 4 °C global warming scenario, respectively.

125. DesignBuilder Software Ltd., 2026. DesignBuilder. Available at: **https://designbuilder.co.uk/**.
126. DOE, 2024. EnergyPlus. Available at: **https://energyplus.net/**
127. CIBSE, 2026. CIBSE Weather Data. Available at: **https://www.cibse.org/knowledge-research/weather-data/**

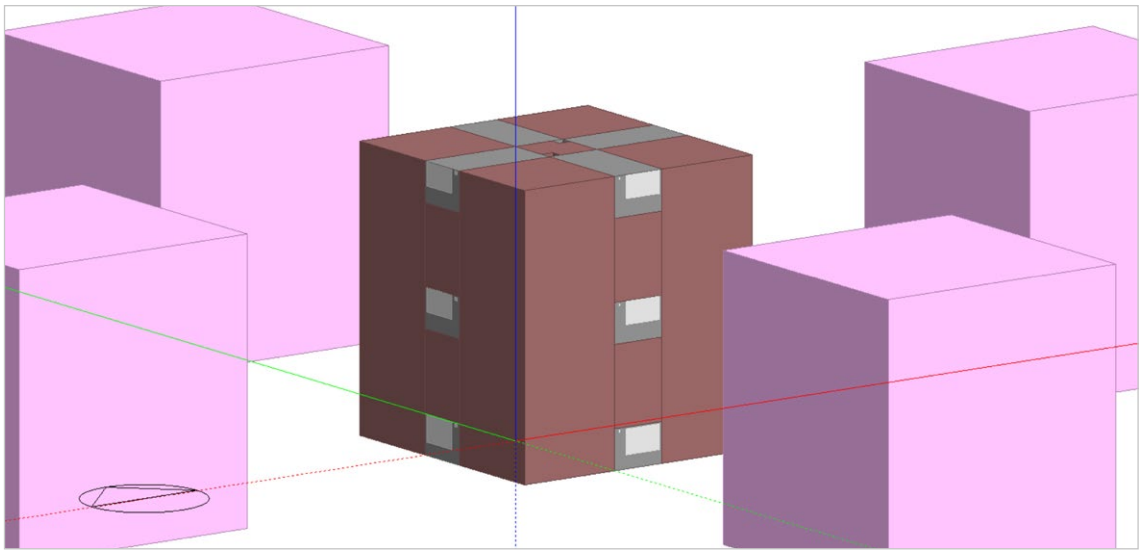


Figure 22: 3D view of the DesignBuilder model, showing the PDR flat locations in a block assessed across different floors and orientations.

Building fabric and baseline operational assumptions

Both thermally heavyweight masonry and lightweight system-built constructions were considered across thermal insulation levels. The high, moderate and low insulation specifications described in Table 22 were used. Glazing ratios of 20%, 50% and 80% represented variations observed during fieldwork. Poor building fabric airtightness was assumed, recognising that building envelope improvements during conversion may not achieve the performance of purpose-built newbuilds. This assumption was supported by a sensitivity analysis comparing modelled results under different airtightness levels with monitored conditions in office-to-flat conversions with similar building-fabric thermal characteristics, with the poorer airtightness assumption producing a closer match.

Table 22: Building element U-value according to overall insulation level.[128]

	Wall (W/m^2K)	Roof (W/m^2K)	Floor (W/m^2K)	Glazing (W/m^2K)
High thermal insulation level*	0.30	0.18	0.25	1.60
Medium thermal insulation level	0.50	0.27	0.48	2.0
Low thermal insulation level	0.70	0.35	0.70	3.0

*For reference, the latest Approved Document L specifies the following U-values for newbuilds: 0.26 W/m^{2K} for walls, 0.16 W/m2K for roofs, 0.18 W/m2K for floors, 1.6 W/m2K for windows.[129]

128. HM Government, 2018. Approved Document L1B: Conservation of Fuel and Power in Existing Dwellings (2010 edition incorporating 2018 amendments). Available at: **https://webarchive.nationalarchives.gov.uk/ukgwa/20190213060753/https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l**
129. HM Government, 2026. Approved Document L: Energy and greenhouse gas emissions. Available at: **https://www.gov.uk/government/publications/approved-document-l-2026**

Under baseline ventilation controls, windows were simulated to open between 8 am and 11 pm from May to September when the dwelling was occupied, indoor air temperature reached at least 22 °C, and outdoor air temperature was lower than indoor temperature.[130] Windows were assumed to open to 25% of their maximum opening area. Windows remained closed overnight, reflecting the observations made during the survey about security concerns, and during the heating season under this baseline schedule. Internal doors were represented as 50% open, allowing airflow between rooms.

Two baseline mechanical extraction scenarios were considered: (i) operating during cooking and bathroom-use periods, and (ii) inactive. The latter represented systems that were unavailable, non-operational or unused. Maximum extract rates were set at 0.030 m^3/s in the cooking area and 0.015 m^3/s in the bathroom.[131] Heating used a 19 °C setpoint and 16 °C setback. These modelling assumptions were retained following sensitivity testing and comparison with monitored indoor temperatures in case study homes with characteristics similar to those of the modelled bedsit. Two occupancy scenarios represented (i) a single person working away from home and (ii) two people working from home, providing contrasting occupancy durations, exposure conditions and associated heat, moisture and pollutant generation. The selected household sizes reflected those of most PDR case study participants. $PM_{2.5}$ and NO_2 were simulated using the EnergyPlus generic contaminant model.[132]

Background pollutant sources were assumed constant, a simplification that does not account for local spatiotemporal variation but is better suited for comparison purposes. As most case studies were located in London and southern England, average urban pollution levels informed outdoor concentration assumptions. NO_2 was set at 0.011 ppm (representative of the 2024 urban roadside annual average)[133] and $PM_{2.5}$ at approximately 7 $\mu g/m^3$ (representative of the 2024 urban background annual average).[133] Indoor particulate sources represented cooking, showering and, in a separate scenario, tobacco smoke. NO_2 was represented as outdoor-sourced due to the prevalence of electric cookers among PDR homes. The model accounts for the gradual removal (via deposition) of pollutants from indoor air using fixed values of 0.39 h^{-1} for $PM_{2.5}$ and 0.00024 m^3/s for NO_2.[134]

130. CIBSE, 2017. TM59: Design methodology for the assessment of overheating risk in homes. Available at: **https://www.cibse.org/knowledge-research/knowledge-portal/technical-memorandum-59-design-methodology-for-the-assessment-of-overheating-risk-in-homes/**
131. HM Government, 2021. Approved Document F: Ventilation. Volume 1: Dwellings. London. Available at: **https://assets.publishing.service.gov.uk/media/61deba42d3bf7f054fcc243d/ADF1.pdf**
132. DOE, 2024. EnergyPlus. Available at: **https://energyplus.net/**
133. DEFRA, 2024. *Modelled background pollution data: $PM_{2.5}$* and NO_2 annual mean. Department for Environment, Food and Rural Affairs, London. Available at: **https://uk-air.defra.gov.uk/data/pcm-data**
134. Wang Y, Petrou G, Symonds P, Hsu SC, Milner J, Hutchinson E, et al., 2025. Investigating the impacts of home energy retrofit on the indoor environment through co-simulation: A UK case study. *Journal of Building Engineering. 100:111794. Available at:* **http://doi.org/10.1016/J.JOBE.2025.111794**

Evaluation against monitored conditions

The plausibility of the S1 model was assessed before wider application by comparing simulated and monitored distributions of temperature, relative humidity, $PM_{2.5}$, and NO_2 with case studies of similar characteristics, as well as the wider naturally ventilated office-to-flat conversions. A direct, home-by-home comparison was not undertaken because the theoretical models were designed to represent typical dwelling types and household scenarios, rather than replicate the exact characteristics of specific monitored homes. These influences were explored through contrasting scenarios, including operational patterns, and pollutant- and moisture- generation sources.

Evaluation used the S1 geometry under the 2030s TRY file for London, with heavyweight construction and moderate thermal insulation. The summer period was defined as May to September, and the heating season as October to April. The central tendencies and spreads of the monitored and modelled distributions were compared, and plausibility was judged by broad agreement in distributions and seasonal patterns. An initial calibration exercise was undertaken for one dwelling archetype, using monitored data to inform adjustments to selected model inputs and improve agreement with observed indoor conditions. Despite these adjustments, modelled relative humidity during the heating season remained lower than monitored levels, indicating that the simulations did not fully capture the higher relative humidity levels observed across the reference monitored PDR homes.

Parametric simulations and output analysis

The selected assumptions formed the basis for exploring how different building fabric, glazing, occupancy, extract ventilation and climate characteristics affect indoor conditions. Six annual baseline sets of simulations covered $PM_{2.5}$ variations with and without smoking and NO_2 variations with and without extraction. As shown in Table 23, each batch combined two occupancy scenarios, four fabric variations, three glazing ratios, and six weather files, producing 144 iterations (864 across the six batches). The simulations ran on UCL's Myriad high-performance computing facility. Modelling output was averaged across the 12 combinations of orientation and floor level. Seasonal means, medians, and 5th, 25th, 75th, and 95th percentiles were calculated for indoor operative temperature, relative humidity, and pollutant concentrations. These highlighted differences in indoor environmental conditions across scenarios and guided the selection of worst-case scenarios for testing potential improvements. The seasonal statistics describe different aspects of the simulated distributions, i.e. means and medians summarise typical conditions, while lower and upper percentiles describe the spread. Averaging across dwelling positions before calculating these statistics also means that spatially localised peaks may be smoothed out in the reported distributions.

Table 23: Baseline simulation batch characteristics.

Batch ID	Simulation period	Key batch characteristics	Variants	Iterations
1	Annual	$PM_{2.5}$, no smoking, with exhaust fan schedule	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
2	Annual	$PM_{2.5}$, with smoking, with exhaust fan schedule	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
3	Annual	NO_2, with exhaust fan schedule	Activity scenarios (2), building fabric characteristics (4), glazing percentage (3), weather files (6)	144
4	Annual	$PM_{2.5}$, no smoking, no exhaust fan	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
5	Annual	$PM_{2.5}$, with smoking, no exhaust fan	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
6	Annual	NO_2, no exhaust fan	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144

Seasonal screening of retrofit interventions

The screening utilised adverse baseline characteristics, including high occupancy, smoking and high insulation, as identified through the annual baseline runs. A staged assessment first screened interventions under adverse conditions, then tested the annual performance of packaged interventions against baseline scenarios. Two 14-day periods from the 2050s weather files were selected: 22 July – 4 August from the DSY1 weather file, representing warm summer conditions, and 18–31 December from the TRY weather file, representing humid and cold winter conditions. The screening retained a 50% glazing ratio and two building fabric variations, i.e., lightweight system-built and heavyweight masonry. Its purpose was to identify promising combinations for more extensive testing, with annual simulations subsequently examining whether their performance remained favourable under different household, building fabric and climate assumptions.

The interventions tested were informed by a workshop held on 29th September 2025 with housing and planning professionals, public health specialists and PDR residents. The measures addressed the following categories:

- solar gains (external/internal shading and solar window film);
- natural ventilation (daytime/nighttime window opening variations);
- internal airflow (doors open 24/7 or closed during moisture- and pollutant-generating events);
- mechanical air extraction (continuous or timed operation during moisture- and pollutant- generating events);
- background ventilation using trickle vents.

Measures were tested individually and in combinations, producing output from 672 iterations in total.

Selected retrofit intervention packages

Four packages were selected to address different priorities, as no single combination performed best across all outcomes: packages A and B target overheating, package C targets winter moisture, and package D targets air pollutants. As shown in Table 24, annual testing compared them with baseline reference scenarios without and with extraction (O1 and O2, respectively). Reference scenarios otherwise shared the same underlying building, operational, occupancy and climate assumptions.

The interventions adopted by each package are summarised below:

- **A. Overheating control with external shading** – summer daytime and nighttime ventilation, open internal doors, continuous air extraction, external louvre and side fins.
- **B. Overheating control with internal shading** – summer daytime and nighttime ventilation, open internal doors, continuous extraction, and high-reflectance internal blinds.
- **C. Winter moisture control** – summer daytime ventilation with scheduled heating season ventilation, internal door closure and scheduled extraction during moisture- or contaminant- generating events and high-reflectance internal blinds.
- **D. Pollutant control** – summer daytime ventilation, trickle ventilation, open internal doors, continuous extraction and high-reflectance internal blinds.

The indoor environmental output per package was assessed for $PM_{2.5}$ with and without smoking and for NO_2. Each batch was tested under 144 variations, totalling 2,592 runs. Table 24 presents each batch's characteristics.

Table 24: Batch run characteristics of the intervention packages and their variations.

Batch ID	Simulation period	Key batch characteristics	Additional batch characteristics	Variants	Iterations
O1 a	Annual	$PM_{2.5}$, with smoking	Summertime/ daytime ventilation only, internal doors open, exhaust fan off, baseline internal blinds	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
O1 b		$PM_{2.5}$, no smoking			144
O1 c		NO_2, smoking not modelled			144
O2 a	Annual	$PM_{2.5}$, with smoking	Summertime/ daytime ventilation only, internal doors open, exhaust fan on schedule, baseline internal blinds	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
O2 b		$PM_{2.5}$, no smoking			144
O2 c		NO_2, smoking not modelled			144
A a	Annual	$PM_{2.5}$, with smoking	Summertime/ day+night ventilation, internal doors open, exhaust fan on 24/7, external louvres and side fins	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
A b		$PM_{2.5}$, no smoking			144
A c		NO_2, smoking not relevant			144
B a	Annual	$PM_{2.5}$, with smoking	Summertime/ day+night ventilation, internal doors open, exhaust fan on 24/7, high-reflectance internal blinds	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
B b		$PM_{2.5}$, no smoking			144
B c		NO_2, smoking not modelled			144
C a	Annual	$PM_{2.5}$, with smoking	Summertime/ daytime ventilation, heating season/ scheduled ventilation, scheduled extract fan operation, internal door closed during moisture/ contaminant generating events, high-reflectance internal blinds	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
C b		$PM_{2.5}$, no smoking			144
C c		NO_2, smoking not modelled			144
D a	Annual	$PM_{2.5}$, with smoking	Summertime/ daytime ventilation+trickle vent, internal doors open, exhaust fan on 24/7, high-reflectance internal blinds	Activity scenarios (2), building fabric (4), glazing percentage (3), weather files (6)	144
D b		$PM_{2.5}$, no smoking			144
D c		NO_2, smoking not modelled			144

Design-stage cross ventilation provision

Cross ventilation was tested separately by introducing a 1 m² window on the wall opposite the existing opening of the single-aspect S1 flat geometry. This represented an opportunity during conversion design or substantial refurbishment, rather than retrofit. Annual testing used the same underlying conditions and parametric variations as the baseline models to assess the effect of providing an alternative airflow path.

Quality assurance

As discussed earlier, the model underpredicted heating season relative humidity compared with the monitoring data, warranting caution when interpreting moisture-related findings. Quality assurance checks also led to corrections to aspects of the $PM_{2.5}$ generation and removal input. Selected baseline simulations were repeated to assess the implications before completing the revised simulation set. In non-smoking scenarios, the corrections reduced mean concentrations by approximately 27% in summer and 18% in winter. Changes were smaller in smoking scenarios, with corresponding reductions of 9% and 1% in means. These corrections did not affect the remaining modelled variables. Despite the issues highlighted above, the selected reruns suggested that the relative performance of the scenarios is likely to remain broadly consistent following the $PM_{2.5}$ input corrections.

Findings

Overview

This section presents site observations, monitoring findings from 47 PDR homes and modelling of indoor environmental conditions and air quality. The modelling explores how potential improvements in a small bedsit influence selected indoor environmental conditions. Modelled temperatures in this section refer to operative temperature, which accounts for both air temperature and the temperatures of surrounding surfaces.

Fieldwork findings

Site observations

Observations made during the case study visits identified a series of factors that may adversely affect indoor environmental quality, and occupant health and wellbeing. Selected photos in Figure 23 below illustrate examples of crowded spaces that lack adequate storage space, windows often blocked by furniture or appliances, and sleeping areas very near cooking or other indoor pollution-generating activities. Figure 24 shows examples of office-to-residential PDR conversions with damp and mould problems.

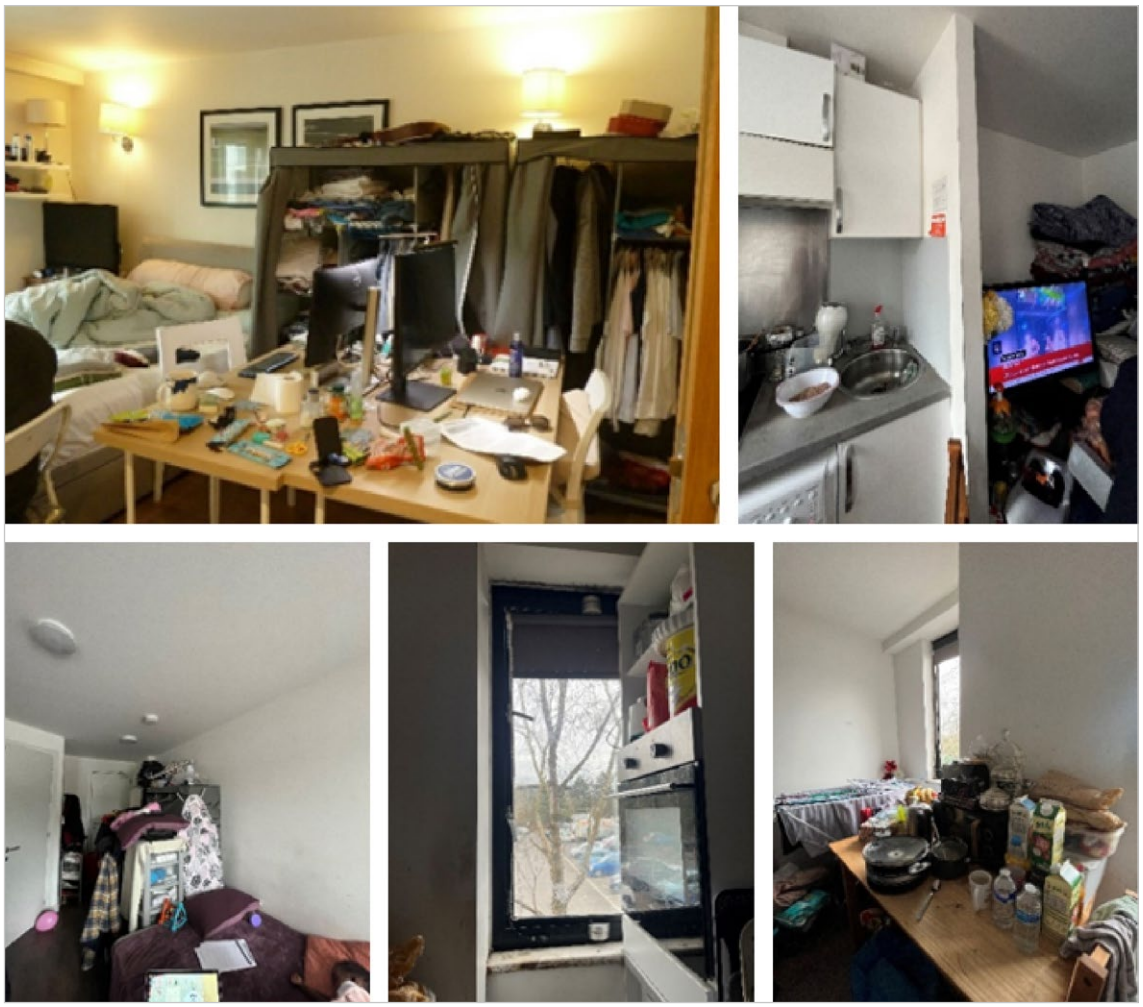


Figure 23: Photos of surveyed PDR homes: inadequate living space.



Figure 24: Photos of surveyed PDR homes: damp and mould.

Windows that could not be opened were observed in the office-to-residential conversions, shown in Figure 25. One flat in this development had a U-shaped, open-plan layout, with a fixed window in the living area at one end and a sleeping area at the other, as shown in Figure 26 (left image). The sleeping area had no windows of its own or direct access to daylight from the living-area window. An office-to-flat conversion in another development also had a windowless bedroom, separated from the main living area by glazed double doors also shown in Figure 26 (right image). However, the planning drawings showed this flat as an open-plan bedsit, rather than a one-bedroom flat with an enclosed, windowless bedroom.



Figure 25: Photos of surveyed PDR homes: lack of operable windows



Figure 26: Photos of surveyed PDR homes: windowless bedrooms.

Security and privacy concerns due to street-level windows were also recorded during the surveys. Residents in temporary accommodation were reluctant to open the window widely due to the risk of theft by outsiders accessing belongings positioned near the window, as shown in Figure 27. The absence of access to private amenity spaces, such as balconies, roof terraces or private gardens, was reported in many of the surveyed homes.



Figure 27: Photos of surveyed PDR homes: security and privacy concerns.

Residents' perceptions

Residents' responses to seasonal questionnaires highlighted some level of thermal discomfort in both seasons. In summer, 62% of respondents (n=47) rated thermal conditions in their homes as slightly, moderately, or very uncomfortable, and 70% (n=47) reported frequently feeling warm or hot. During the heating season, 43% (n=44) reported feeling slightly, moderately, or very uncomfortable, with 23% (n=44) reporting frequently feeling cool or cold. Perceived humidity was also a concern, with approximately 40% of respondents rating conditions as slightly humid to humid throughout the year. Of those, a greater proportion described conditions as moderately humid or humid during the heating season, i.e. 33% compared with 17% in the summer.

Moisture-related problems were reported in both seasons but were more widespread during the heating season. Condensation on windows or walls was reported in 30% of homes during the summer compared with 80% during the heating season (n=44). Responses to questions on room-specific problems indicated mould in 55% of homes in summer (n=47) and 73% during the heating season (n=44). Residents attributed the presence of mould to inadequate ventilation, rooms without windows or openable windows, ineffective extract fans, bath leaks, rain penetration, and inadequate insulation or heating.

Stuffiness was reported by 51% of respondents in summer (n=47) and 42% during the heating season (n=43). Overall, indoor air quality was rated below average or worse by 26% in summer (n=46) and 33% during the heating season (n=42). Dissatisfaction with air movement affected 60% and 48% of respondents, respectively (n=47 and n=42). Residents commonly opened windows for fresh air and odour removal, where possible, but reported fixed, non-opening windows, ineffective or non-functioning bathroom extract fans, and security or privacy concerns restricting ventilation. Together with site observations, these accounts highlight constraints on residents' ability to manage indoor environmental conditions.

Monitored data findings

Monitored data from 47 PDR homes showed substantial variation in indoor air temperature, relative humidity, CO_2, CO, $PM_{2.5}$, and NO_2. Based on the monitoring, the main concerns were high summer temperatures, cold conditions during the heating season, high humidity in some properties, and elevated concentrations of certain pollutants. The graphs below illustrate the monitored indoor environmental conditions across seasons, dwelling types, and rooms. The dashed reference lines, summarised in Table 25, provide context for interpreting the monitored conditions. Comparisons with pollutant guidelines are indicative, as the seasonal summaries presented here do not match the annual, 24-hour, or 8-hour averaging periods specified by those guidelines.

Table 25: Reference values used to interpret the monitored indoor conditions.

Variable	Reference values	Source and interpretation
Temperature	18 – 26 °C	CIBSE Guide A,[135] CIBSE TM59,[136] UKHSA Keeping warm and well,[137] UKHSA Supporting vulnerable people in hot weather[138]
Relative humidity	40 – 60%	CIBSE TM40[139]
CO_2	1000 – 1500 ppm	HSE[140]
CO	3.5 ppm 8.7 ppm	WHO 24-hour mean[141] DEFRA maximum daily running 8-hour mean[142]
$PM_{2.5}$	5 µg/m^3 15 µg/m^3 20 µg/m^3	WHO annual mean[141] WHO 24-hour[141] DEFRA annual mean[142]
NO_2	5.3 ppb 13.3 ppb 21.3 ppb	WHO annual mean[141] WHO 24-hour mean[141] DEFRA annual mean[142]

The World Health Organisation (WHO) values are health-based recommendations. CIBSE and HSE provide practical guidance on indoor conditions and ventilation, while UKHSA provides public health guidance on how environmental conditions affect health. The statutory outdoor air pollutant limits reported by DEFRA do not apply directly to indoor conditions in the monitored homes. Future work will address adaptive thermal comfort criteria, in addition to the static threshold mentioned earlier.

135. CIBSE, 2015. Guide A: Environmental design, at: **https://www.cibse.org/knowledge-research/knowledge-portal/guide-a-environmental-design-2015/**
136. CIBSE, 2017. TM59: Design methodology for the assessment of overheating risk in homes, at: **https://www.cibse.org/knowledge-research/knowledge-portal/technical-memorandum-59-design-methodology-for-the-assessment-of-overheating-risk-in-homes/**
137. UKHSA, 2026. Keeping warm and well: staying safe in cold weather, at: **https://www.gov.uk/government/publications/keeping-warm-and-well-staying-safe-in-cold-weather/top-tips-for-keeping-warm-and-well-this-winter?**
138. UKHSA, 2024. Supporting vulnerable people before and during hot weather: social care managers, at: **https://www.gov.uk/government/publications/hot-weather-and-health-supporting-vulnerable-people/supporting-vulnerable-people-before-and-during-hot-weather-social-care-managers-staff-and-carers**
139. CIBSE, 2020. CIBSE TM40 – Health and wellbeing in building services, at: **https://www.cibse.org/knowledge-research/knowledge-resources/engineering-guidance/cibse-technical-memoranda-tm/tm40-health-and-wellbeing-in-building-services/**
140. HSE, 2026. Using CO2 monitors – Ventilation in the workplace, at: **https://www.hse.gov.uk/ventilation/using-co2-monitors.htm**
141. WHO, 2021. WHO global air quality guidelines: Pparticulate matter ($PM_{2.5}$ and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. 1–360 at: **https://www.who.int/publications/i/item/9789240034228**
142. DEFRA, 2023. National air quality objectives and European Directive limit and target values for the protection of human health at: **https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update_20230403.pdf**

Figure 28 shows that high summer indoor temperatures affected many homes. In 14 of the 46 homes with available temperature data, at least one room exceeded 26°C for at least a quarter of the monitored time. These were various sizes and layouts of office-to-flat conversion. Of these 14 homes, six also had average summer temperatures above 26°C in at least one monitored room. Site 631, a single-aspect, one-bedroom office conversion with extensive glazing, was particularly warm, with living and bedroom area summer averages of 28.9°C and 27.3°C, respectively. Overall, bedrooms were cooler than living areas.

Cold conditions were also common during the heating season, with 23 of 32 homes experiencing temperatures below 18°C for 5% or more of the monitored time in at least one room. This included examples from office-to-residential, retail-to-residential and agricultural-to-residential conversions. Seven of these homes experienced seasonal averages of 18°C or lower. Particularly cold conditions occurred at sites 292, 645 and 212, comprising one retail and two office conversions, all with average temperatures of under 16°C and falling below 10°C during the coldest 5% of the recordings.

Figure 29 shows the distribution of living area relative humidity. Seasonal averages exceeded 60% in seven of 30 homes during the heating season and four of 44 homes during the summer. This included various types of office-to-flat, a retail-to-flat and an agricultural-to-house conversion. Sustained periods of high indoor relative humidity may increase the risk of surface condensation and create conditions favourable to damp and mould growth, particularly on cold surfaces.[143] In nine homes, relative humidity exceeded 60% for a quarter or more during the heating season monitored period. Sites 292 (retail-to-flat), 212 (office-to-one-bed) and 645 (office-to-two-bed) combined cold conditions with heating season average levels of 64-72%.

The living area CO_2 concentrations shown in Figure 30 were generally higher during the heating season than in summer. This may reflect reduced window opening during colder weather, although differences in occupancy and other ventilation practices could also contribute. Concentrations exceeded 1,500 ppm for approximately 5% or more of the monitored time in 8 of 44 homes in summer and 13 of 40 during the heating season. These were various types of office-to-flat and the retail-to-flat conversion. Site 1209, a single-aspect bedsit, had a heating season average of approximately 1,650 ppm, with the highest 5% of recorded concentrations reaching over 2,500 ppm. During the site visit, it was established that the occupancy was four people, indicating insufficient ventilation for the number of people present, as well as overcrowding.

143. WHO, 2009. *WHO guidelines for indoor air quality: dampness and mould. Copenhagen: WHO Regional Office for Europe. Available at:* **https://www.who.int/publications/i/item/9789289041683**

As shown in Figure 31, CO concentrations were generally low, with no seasonal average above the WHO 24-hour reference value of 3.5 ppm. Site 1209 was the only home where summer concentrations exceeded this value for about 5% of the monitored time, with the highest 5% of readings above 5.8 ppm. No combustion source or smoking was reported in this home, thus, the source of the elevated CO remains uncertain. Across homes and seasons, CO concentrations were generally well below the legally binding outdoor reference value of 8.7 ppm for the maximum daily eight-hour mean,[144] however, shorter peaks cannot be ruled out.

For $PM_{2.5}$, shown in Figure 32, more homes recorded averages above the WHO guideline values and the statutory annual outdoor air limit than for CO and NO_2. Summer averages exceeded the WHO annual guideline value of 5 µg/m^3 in 40 of 42 homes, and the DEFRA statutory annual limit for outdoor air in England of 20 µg/m3 in 12 of 42 homes. During the heating season, mean concentrations were above the WHO guideline values in all 36 homes, and above the DEFRA values in 10 of 36 homes. Particularly high summer $PM_{2.5}$ averages were recorded at sites 570 and 474, reaching approximately 107 and 109 µg/m^3, respectively. Site 570, a single-aspect, one-bedroom flat, also had a high heating season average of 73 µg/m^3. Site 474 was an office-to-student-hall conversion where the sensor was placed in the flat's shared common room, potentially capturing emissions from cooking and other shared activities.

144. DEFRA, 2023. National air quality objectives and European Directive limit and target values for the protection of human health, at: **https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update_20230403.pdf**

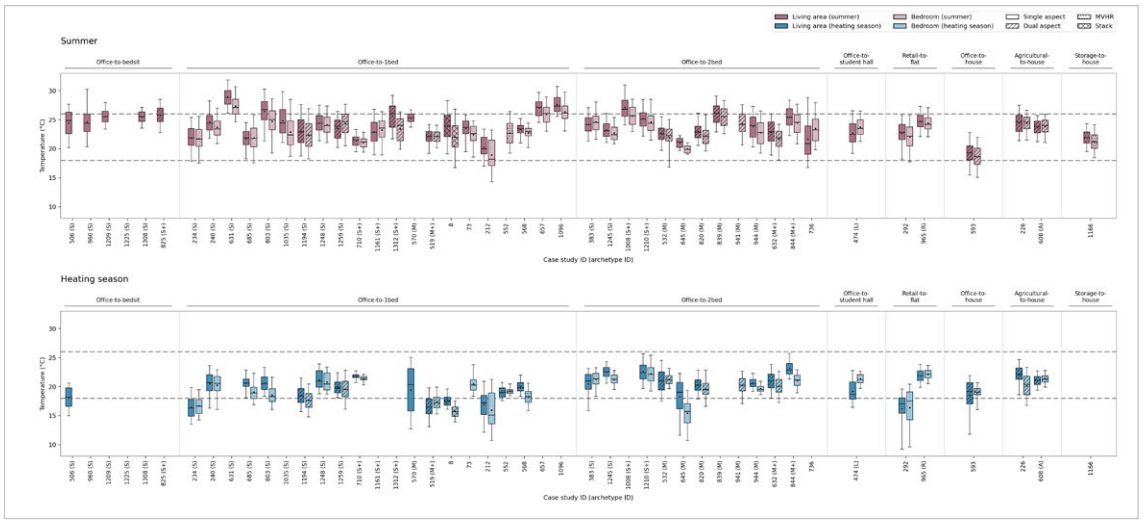


Figure 28: Seasonal dry-bulb temperature distributions in living areas and bedrooms, grouped by conversion and dwelling type.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Blank positions indicate unavailable data. Dashed lines mark the 18 °C cool-temperature and 26 °C high-temperature reference values.

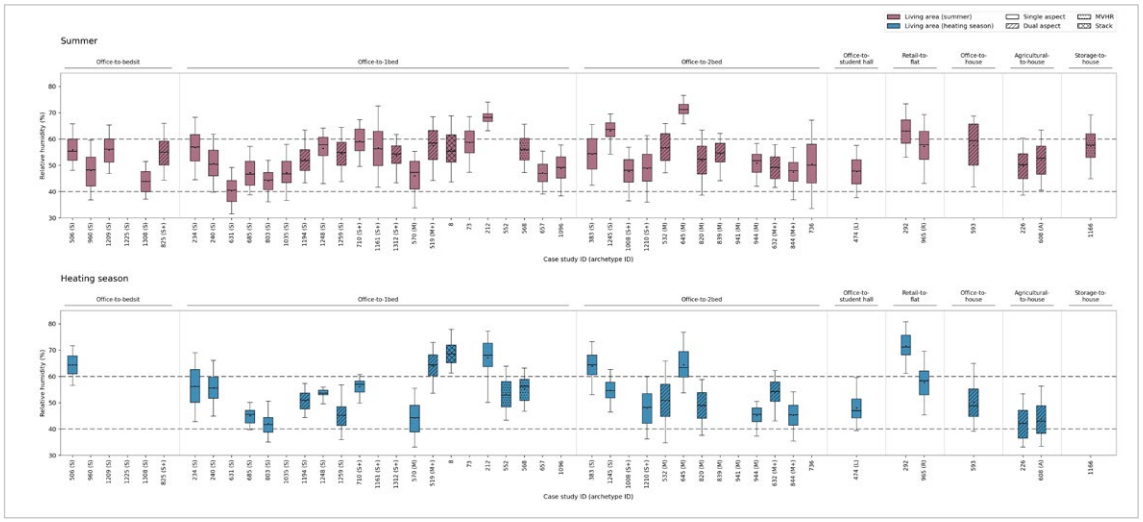


Figure 29: Seasonal relative humidity distributions in living areas, grouped by conversion and dwelling type.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Blank positions indicate unavailable data. Dashed lines mark the 40% lower and 60% higher relative humidity reference values.

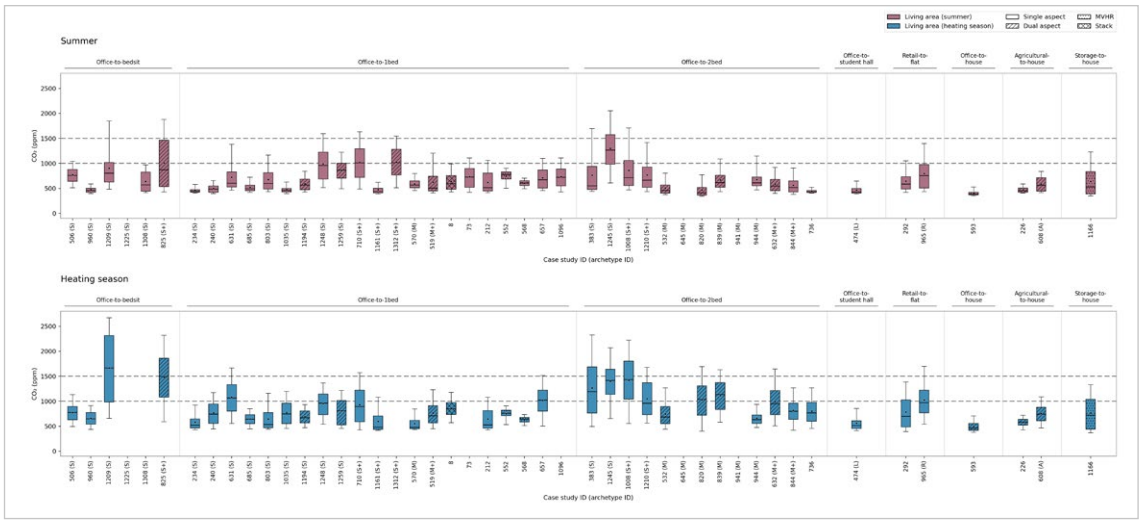


Figure 30: Seasonal CO_2 concentration distributions in living areas and bedrooms, grouped by conversion and dwelling type.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Blank positions indicate unavailable data. Dashed lines mark the 1,000 ppm lower and 1,500 ppm upper CO_2 reference values.

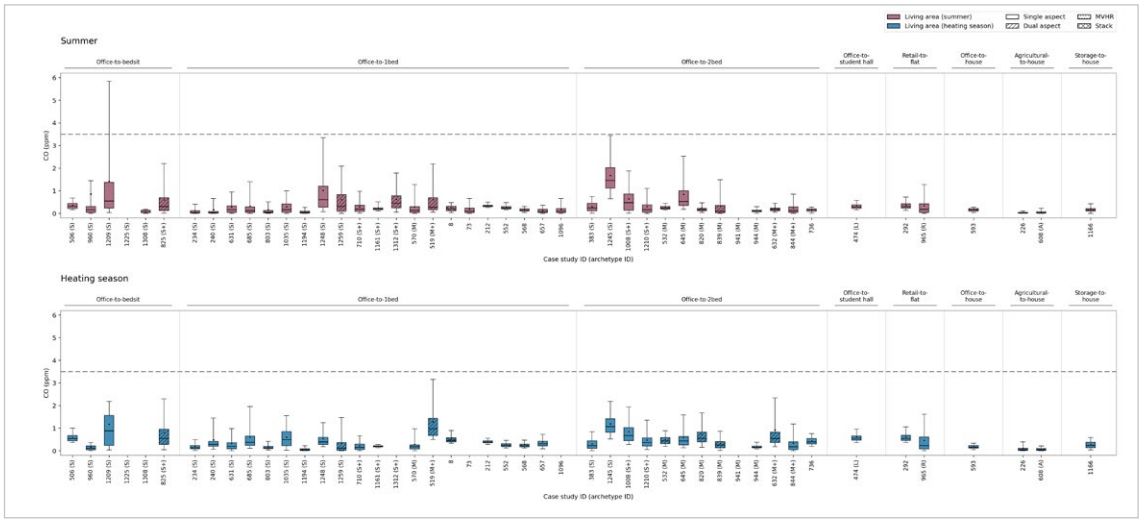


Figure 31: Seasonal CO concentration distributions in living areas, grouped by conversion and dwelling type.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Blank positions indicate unavailable data. The dashed line marks the 3.5 ppm CO reference value for a 24-hour period. The corresponding 8-hour reference value of 8.7 ppm lies above the plotted range. These reference values provide context alongside the distributions of 10-minute recordings.

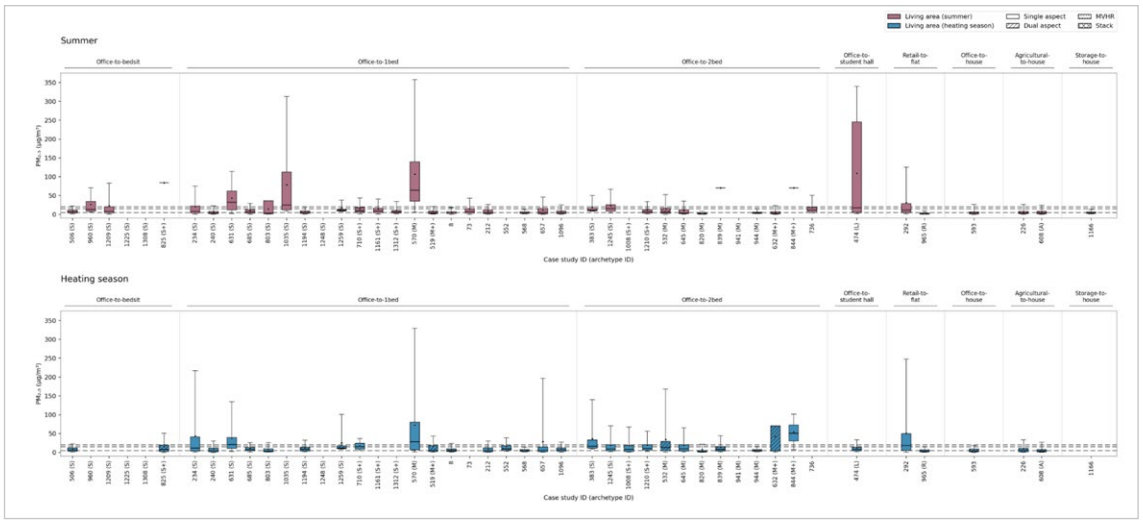


Figure 32: Seasonal $PM_{2.5}$ concentration distributions in living area, grouped by conversion and dwelling type.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Blank positions indicate unavailable data. Dashed lines mark the annual mean reference values of 5 and 20 µg/m3 and the 24-hour mean reference value of 15 µg/m^3. These reference values provide context and are not directly comparable with the distributions of 10-minute recordings.

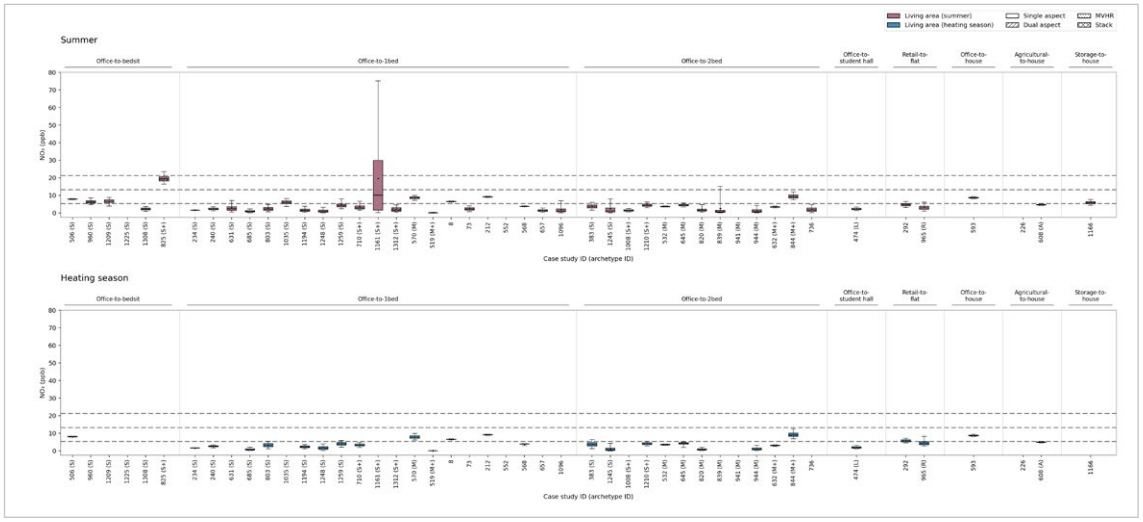


Figure 33: Seasonal NO_2 concentration distributions in living area, grouped by conversion and dwelling type.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Blank positions indicate unavailable data. Dashed lines mark the annual mean reference values of 5.3 and 21.3 ppb and the 24-hour mean reference value of 13.3 ppb. These reference values provide context and are not directly comparable with the distributions of 10-minute recordings.

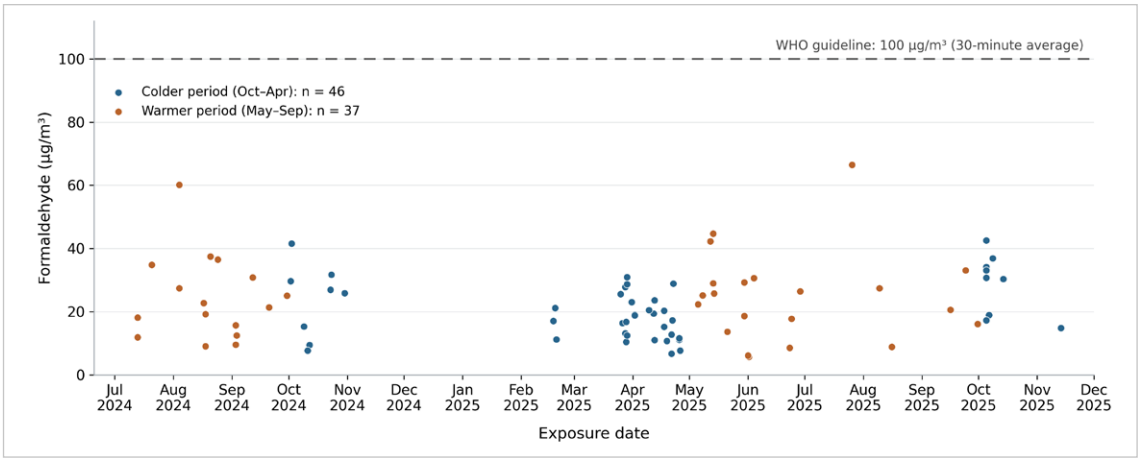


Figure 34: Formaldehyde concentrations from 47 PDR homes, with each dot representing the average concentration per exposure period. The dashed line indicates the WHO guideline of 100 µg/m^3 average over 30 minutes, shown for reference

As shown in Figure 33, fewer homes recorded seasonal averages above the recommended values for NO_2 than for $PM_{2.5}$. Average NO_2 exceeded the 5.3 ppb WHO annual guideline value in 12 of 43 homes in summer and seven of 28 homes during the heating season. Sites 1161 (located in Crawley) and 825 (located in Croydon), both office conversions, experienced high summer averages of approximately 19.6 ppb. No seasonal averages exceeded the 21.3 ppb statutory annual outdoor air limit.

In addition to longitudinal monitoring, a total of 83 passive sampler measurements were analysed from 47 PDR homes – 36 homes were sampled twice and 11 once. Each measurement represents the average formaldehyde concentration over a typical exposure period of approximately one week. Figure 34 shows that concentrations ranged from 6–67 µg/m^3 and varied considerably between homes and sampling periods. All sample averages were below the WHO reference value of 100 µg/m^3. This guideline applies to 30-minute averages and, thus, sampling over several days cannot rule out shorter-term exceedances. The higher concentrations observed in some homes during warmer periods could in part reflect increased release from indoor materials at higher temperatures,145 potentially offsetting the benefits of increased summertime ventilation.

Overall, the monitored conditions indicated some variation between dwelling groups. Bedsits (studio flats) tended to have higher summer temperatures. Houses tended to have lower living area CO_2 and $PM_{2.5}$ than flats, along with lower heating season relative humidity. Single-aspect flats generally had higher summer living area temperatures and $PM_{2.5}$ than dual-aspect homes, while homes with enclosed kitchens had slightly lower $PM_{2.5}$ than those with open-plan kitchens.

145. CPSC, 2016. *An update on formaldehyde (Publication 725, 2016 revision). U.S. Consumer Product Safety Commission. Available at:* **https://www.cpsc.gov/s3fs-public/An-Update-On-Formaldehyde-725_1.pdf**

However, several groups contained very few homes, and these patterns could also reflect differences in dwelling size and occupant activities, among other parameters. Indoor environmental performance should be assessed across several indicators and in the context of each home's characteristics and use. This broader perspective can help explain differences between PDR homes.

Modelling findings

The results presented in this section concern geometry S1, representing a small single-aspect bedsit (studio flat) converted from a previous office building. The findings cover typical-year (TRY) and warmer-summer (DSY1) London weather files for the 2030s, used here to approximate current conditions, and the projected climates for the 2050s and 2080s. Unless otherwise stated, the reported ranges cover both weather file types, and baseline or intervention scenarios with and without extraction. The results are aggregated across 24 building fabric and household combinations, rather than presented for individual homes.

Determinants of environmental performance across baseline simulation variations

The S1 baseline simulations showed that no single combination of building features and household conditions performed best across air temperature, relative humidity and air quality. The findings below are conditional on the underlying assumptions utilised in the simulations:

- **Summer temperature:** Higher thermal insulation, smaller windows covering 20% of the external wall area and switched-off extract fans were associated with higher indoor temperatures. Larger windows were linked to lower summer temperatures, potentially because the same 25% opening factor creates a greater opening area, allowing more ventilation. However, larger windows can also admit more heat, particularly on south- and west-facing facades. Two-person, working-from-home households were slightly warmer on average.
- **Heating season relative humidity:** Higher insulation levels were associated with lower relative humidity, while two-person, working-from-home households generally experienced higher relative humidity levels.
- **$PM_{2.5}$:** Concentrations were higher with smaller windows and switched-off extract fans, with the highest levels occurring in two-person households with smoking.
- **NO_2:** Average concentrations were slightly higher with two-person occupancy, larger windows and scheduled air extraction rather than no air extraction. More opportunities to open windows may have contributed to higher summer NO_2 by allowing more outdoor pollution indoors.

Baseline performance and the impact of design-stage cross ventilation provision

The modelling indicated that small, single-aspect studio flats already face summer overheating risk under the 2030s climate scenarios. This risk increases as the climate warms. Figure 35 shows that allowing an opening on the opposite side of the home to allow cross ventilation reduced indoor summer temperature and indoor $PM_{2.5}$ concentrations but did not improve every modelled environmental variable. At the same time, NO_2 concentrations were slightly higher.

In the 2030s, average summer operative temperatures were 24.6–25.2°C. Higher-end temperatures (95th percentiles) reached 29.8–30.5°C. By the 2080s, summer averages rose by around 2.4°C and higher-end temperatures by more than 3°C. Differences between TRY and DSY were relatively small, and both indicated increasing indoor temperatures under future climates.

Cross ventilation lowered average summer temperatures compared with equivalent single-aspect homes by about 1.2°C and 1.8°C under the 2030s and 2080s DSY weather files, respectively. This finding highlights the importance of providing opportunities for airflow through the home during the conversion design. However, cross ventilation alone may not prevent overheating, particularly in future climates.

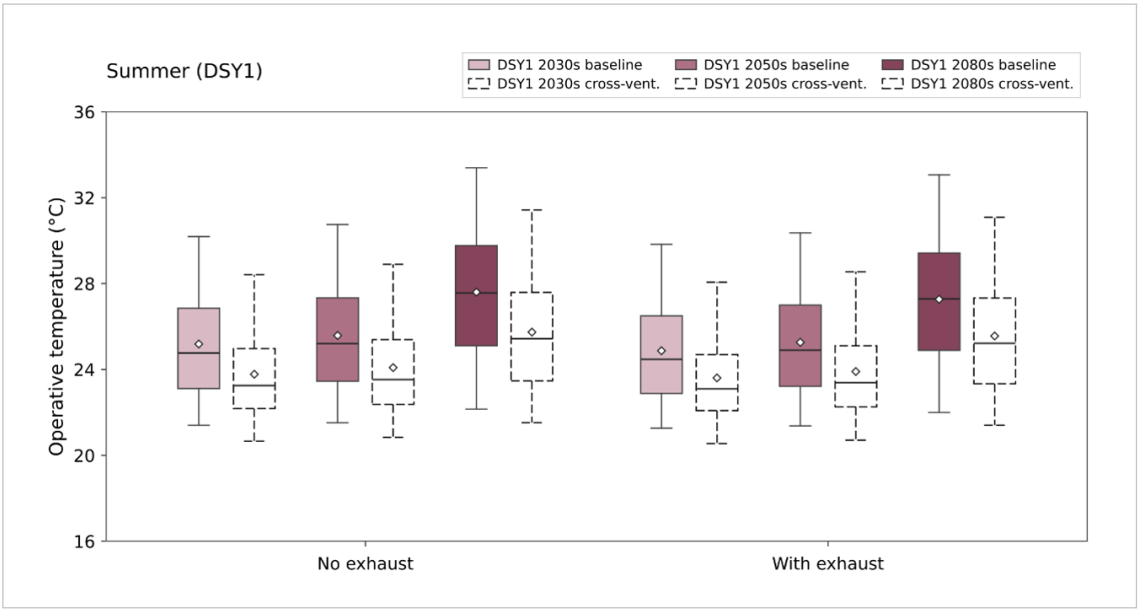


Figure 35: Summer operative temperatures for baseline (coloured boxes) and cross-ventilated (dashed boxes) scenarios, with and without exhaust ventilation, for the 2030s, 2050s and 2080s, under the DSY1 weather files.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

Figure 36 shows average heating-season relative humidity, which was 45–48% in the 2030s and tended to decline under future climates. Cross ventilation increased relative humidity by around 2.5–4% in summer across the two exhaust scenarios and three timescales. This was accompanied by lower indoor temperatures and thus does not necessarily mean the air contained more moisture. In addition, the model underestimated heating season relative humidity, and averaging can conceal humid conditions in individual flats.

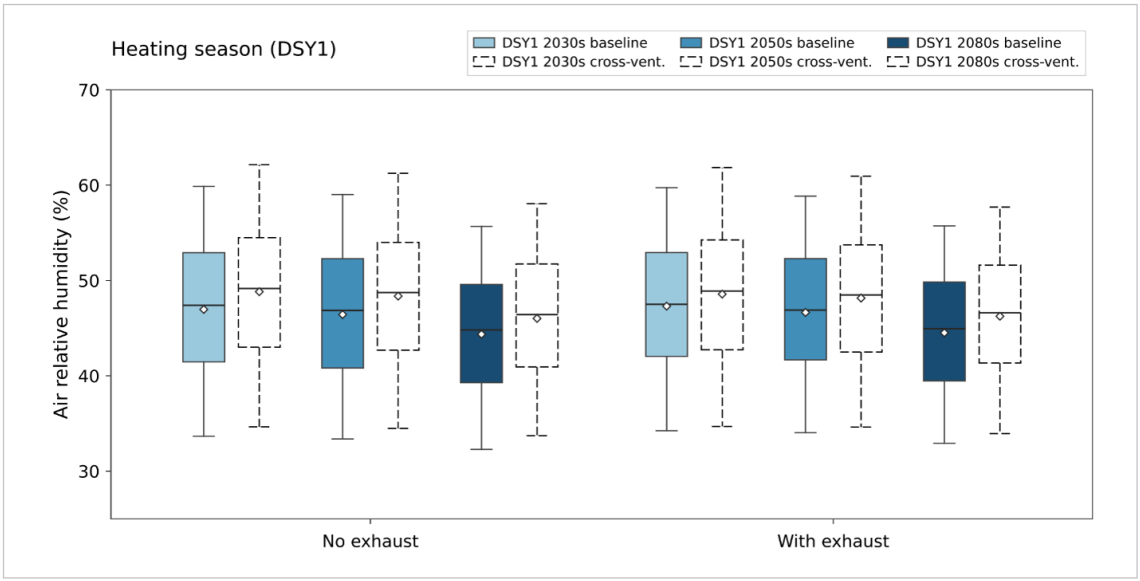


Figure 36: Heating season air relative humidity for baseline (coloured boxes) and cross-ventilated (dashed boxes) scenarios, with and without exhaust ventilation, for the 2030s, 2050s and 2080s, under the DSY1 weather files.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

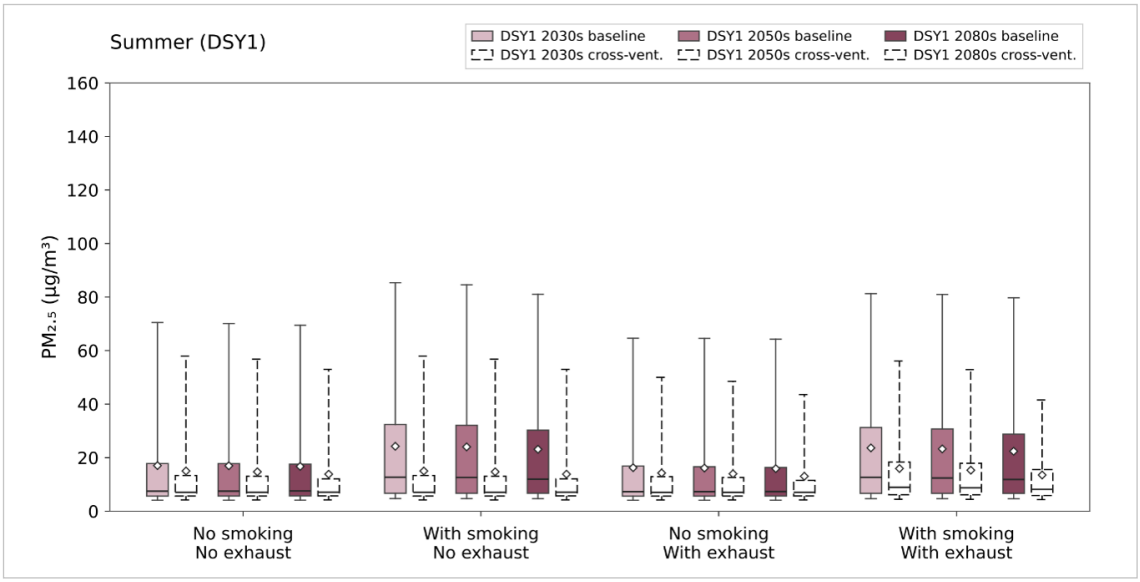


Figure 37: Heating Summer $PM_{2.5}$ concentrations for baseline (coloured boxes) and cross-ventilated (dashed boxes) scenarios, with and without exhaust ventilation and smoking, for the 2030s, 2050s and 2080s, under the DSY1 weather files.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

$PM_{2.5}$ was consistently higher during the heating season and with smoking. Figure 37 shows that average summer concentrations were approximately 22–25 µg/m^3 with smoking and 16–17 µg/m3 without. Heating season concentrations ranged from 32–36 µg/m3 without smoking and 50–56 µg/m3 with smoking. Scheduled exhaust operation reduced $PM_{2.5}$ concentrations across scenarios, by approximately 3–5% in summer and 8–11% during the heating season. In summer, cross ventilation reduced concentrations significantly, i.e. by approximately 12–40% across scenarios, with larger reductions occurring under smoking scenarios.

Figure 38 shows summer NO_2 concentrations, which changed little between the 2030s, 2050s, and 2080s but were approximately 6.5% higher with summer cross ventilation. Increased airflow allows more outdoor NO_2 to enter the home, which also explains why winter NO_2 concentrations were approximately 20% lower than summer concentrations during the heating season.

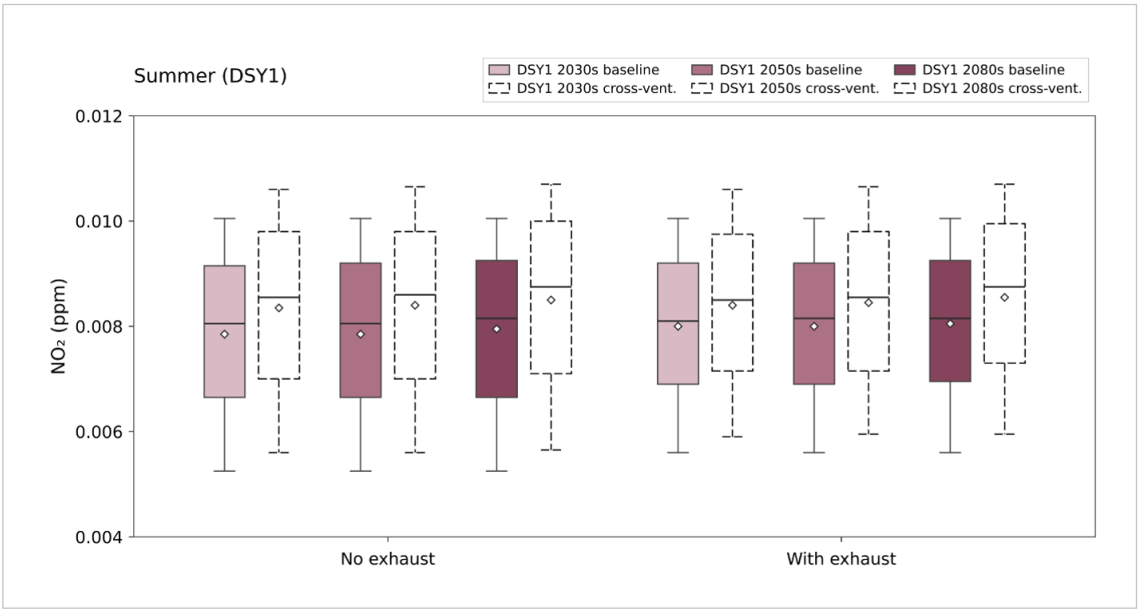


Figure 38: Summer NO_2 concentrations for baseline (coloured boxes) and cross-ventilated (dashed boxes) scenarios, with and without exhaust ventilation, for the 2030s, 2050s and 2080s, under the DSY1 weather files.

Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

Intervention screening findings

- The intervention screening identified different best performing interventions for each environmental variable. The findings below reflect average conditions during two different 14-day screening periods: a warm summer 14-day period, and a cool and humid heating season 14-day period.
- **Summer overheating:** Nighttime ventilation and continuous extraction were associated with lower summer temperatures in comparison to daytime-only window opening and scheduled extraction. Among shading options, external louvres and side fins and high-reflectance internal blinds performed best.

Overall, differences between different shading options were relatively small compared with those associated with ventilation and extraction.

- **Heating season relative humidity:** Window opening scheduled to open during moisture-generating activities produced the lowest average relative humidity. Scheduled extraction consistently produced lower relative humidity than continuous extraction. Keeping internal doors closed during moisture-generating activities further lowered indoor relative humidity levels.
- **$PM_{2.5}$:** Overall, interventions providing more sustained ventilation reduced indoor $PM_{2.5}$ concentrations. In winter, continuous extraction had the largest effect, with the lowest concentrations achieved when combined with scheduled window opening, trickle vents and internal doors kept open throughout. In the summer, day- and night- window opening was beneficial, while continuous extraction tended to lower $PM_{2.5}$ further.
- **NO_2:** Increased ventilation generally reduced indoor $PM_{2.5}$ but increased NO_2 towards the outdoor background modelled concentration of 11 ppb, as there were no modelled indoor sources of NO_2. Hence, limited window opening and extraction resulted in lower average NO_2 concentrations.

Impact of intervention packages on the environmental performance of PDR homes

The four intervention packages addressed different problems: packages A and B targeted summer overheating, C targeted heating-season moisture, and D targeted pollution. No single package performed best across all outcomes.

Figure 39 shows that packages A and B reduced average summer operative temperatures by approximately 2.4–3.0 °C across the three timescales. Both combined day- and night- time summer ventilation, open internal doors and continuous extraction. Package A used external louvres and side fins, while B used high-reflectance internal blinds. Their average temperature differed by less than 0.1 °C under the modelled conditions. However, this similarity concerns the complete intervention package, and it should not be assumed that the two shading systems would perform the same in isolation.

Figure 40 shows that package C produced the lowest average heating season relative humidity. It combined scheduled ventilation and extraction with internal door closure during moisture- and pollutant- generating activities. In the 2030s, average air relative humidity fell by approximately 2.5% and surface relative humidity by 3.7% compared with the baseline scenarios. Baseline relative humidity generally declined under future climates. However, these findings must be interpreted alongside the model's underestimation of heating season relative humidity levels.

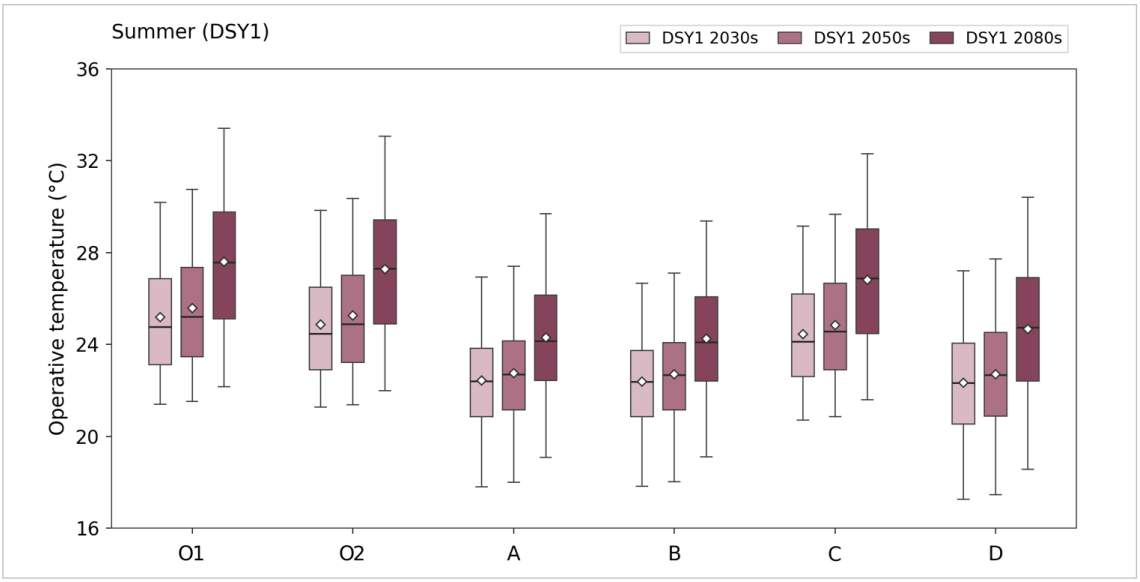


Figure 39: Summer operative temperatures under baseline scenarios without (O1) and with (O2) exhaust operation, and under selected intervention scenarios (A: overheating control with external shading, B: overheating control with internal shading, C: moisture control, D: pollutant control), for the 2030s, 2050s, and 2080s, under the DSY1 weather files. Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

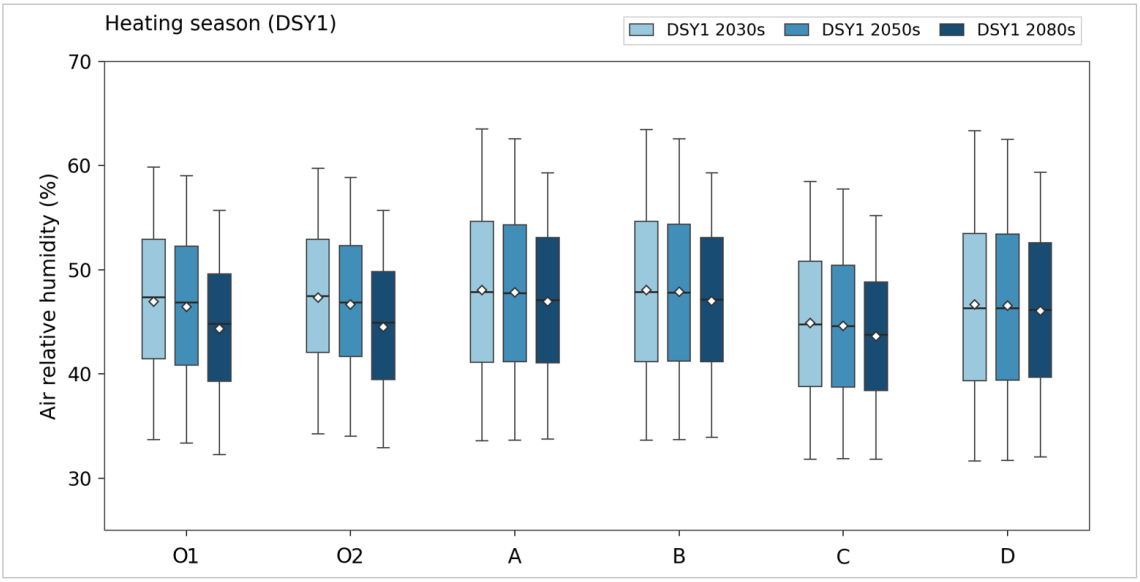


Figure 40: Winter air relative humidity under baseline scenarios without (O1) and with (O2) exhaust operation, and under selected intervention scenarios (A: overheating control with external shading, B: overheating control with internal shading, C: moisture control, D: pollutant control), for the 2030s, 2050s, and 2080s, under the DSY1 weather files. Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

As shown in Figure 41, Package D achieved the largest heating season reduction in $PM_{2.5}$, by approximately 48.5% with smoking and 47% without smoking. Reductions were approximately 35% for package A, 31% for package B, and 20% for package C. These patterns persisted across climate periods and weather files. Packages A, B and D also lowered winter indoor temperatures, highlighting the importance of assessing interventions' year-round performance to identify benefits and trade-offs across seasons.

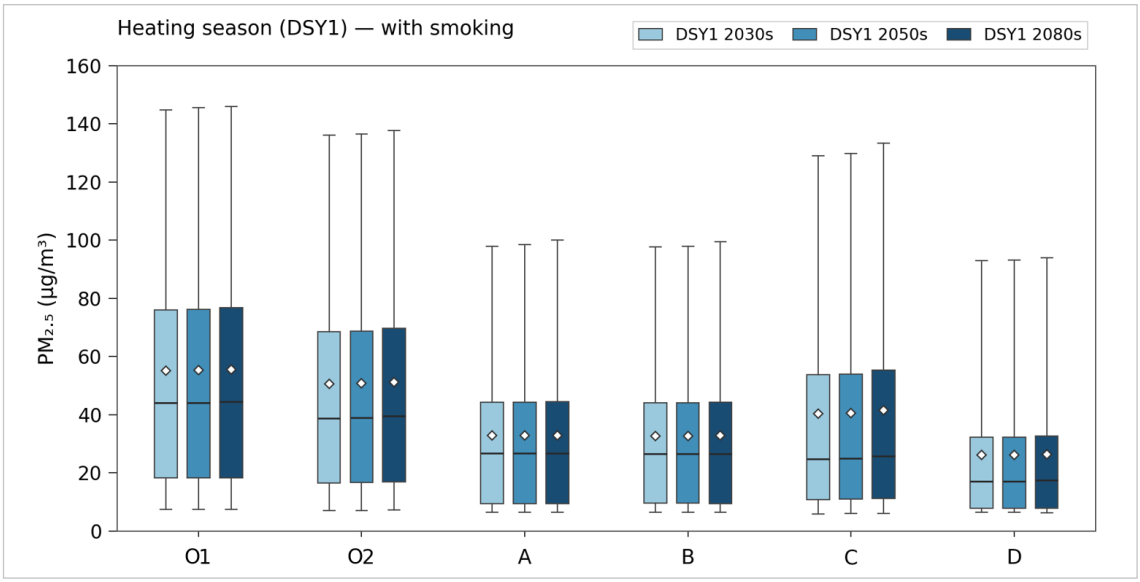


Figure 41: Heating season $PM_{2.5}$ under baseline scenarios incorporating smoking, without (O1) and with (O2) exhaust fan operation, and under selected intervention scenarios (A: overheating control with external shading, B: overheating control with internal shading, C: moisture control, D: pollutant control), for the 2030s, 2050s, and 2080s, under the DSY1 weather files. Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

Figure 42 shows that modelled NO_2 changed little between climate periods but increased slightly under package D. Average concentration during the heating season rose from approximately 7 ppb under the scheduled exhaust fan baseline scenario (O2) to approximately 9 ppb. Overall, concentrations were more stable under continuous extraction, clustering at around 9 ppb, whereas intermittent extraction and window opening produced greater variation, spanning between 5–9 ppb.

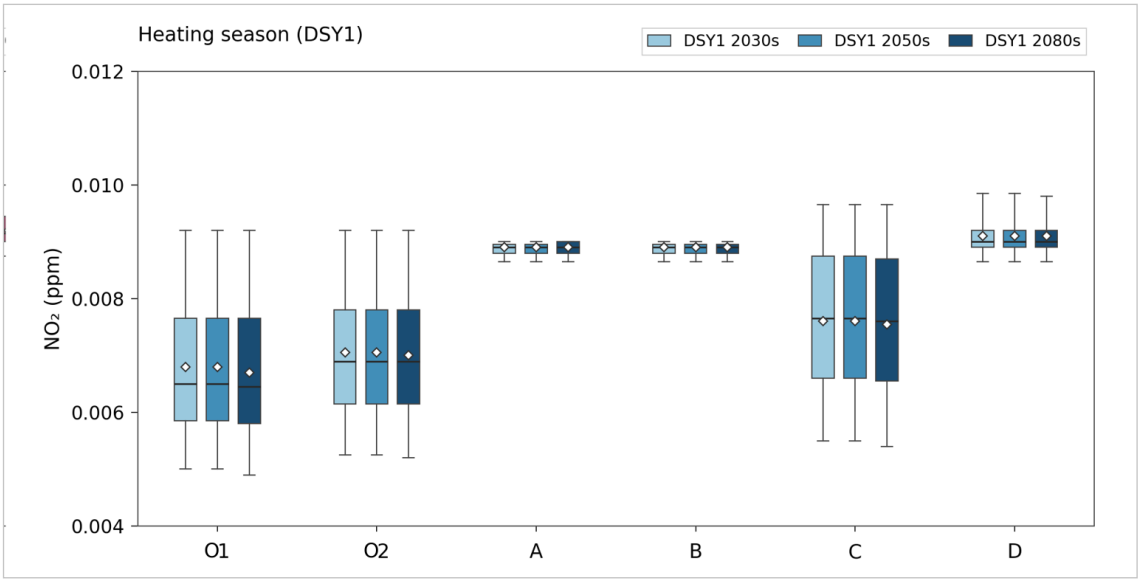


Figure 42: Heating season NO_2 concentrations under baseline scenarios without (O1) and with (O1) exhaust fan operation, and under selected intervention scenarios (A: overheating control with external shading, B: overheating control with internal shading, C: moisture control, D: pollutant control), for the 2030s, 2050s, and 2080s, under the DSY1 weather files. Box edges represent P25 and P75, whiskers represent P05 and P95, horizontal lines indicate medians, and diamonds indicate means. Each box represents median values of the corresponding run-level statistic across 24 model runs.

Limitations

The monitoring sample of 47 homes captured variation in PDR housing but was not statistically representative of the English PDR stock. Most homes were located in London and southern England, and the variations in monitoring duration and data availability limit comparisons between homes and seasons, and the possibility to extrapolate findings to the entire stock. Therefore, the reported summaries represent the monitored sample rather than the national PDR stock. The seasonal summaries and reference thresholds indicate potential concerns but do not establish compliance with guidelines requiring specific averaging periods. Comparisons between dwelling groups were exploratory because most groups contained a limited number of homes. Questionnaires and site observations provided useful context, but the relative contribution of building characteristics, occupant behaviour and external conditions to monitored conditions cannot be fully assessed solely based on the analysis of fieldwork data.

Modelling was, therefore, employed to quantify the influence of these factors on the indoor environmental performance of PDR housing. Archetype development drew on the available stock data, with variations in less well-documented characteristics, such as building fabric and glazing ratio. However, uncertainty remains where stock information was largely incomplete. Modelling used simplified assumptions about occupancy, space heating, ventilation and pollutant sources, including constant outdoor pollution concentrations. Simplified assumptions may not capture the full variability of real-world conditions but reduce computational demands, thus enabling consistent comparisons of the relative performance of different scenarios. London weather files and selected future climate change scenarios also capture only part of the geographical and future climate uncertainty.

The model evaluation assessed broad agreement with monitored conditions rather than reproducing individual homes. Heating-season relative humidity remained underestimated, warranting particular attention when interpreting moisture-related improvements. Last, the effectiveness of modelled interventions in practice depends on appropriate installation and maintenance, residents' ability to use them as intended, and constraints relating to noise, security and cost.

Conclusions

Key messages

Monitoring across 47 PDR homes, residents' perceptions through seasonal questionnaires, and modelling of the indoor environment highlight the need to address summer excess heat, cold during the heating season, high humidity levels and poor indoor air quality jointly in PDR homes.

Overheating

Around 30% of monitored homes experienced summer indoor temperatures above 26°C for a quarter or more of the monitoring period, and over 60% of the WP3 questionnaire respondents reported some degree of summer thermal discomfort. These findings are consistent with WP2 findings, where just under half of the survey respondents reported difficulty keeping comfortable during hot summer weather. Some residents even reported avoiding cooking or having to spend time outdoors due to the severity of overheating in their homes. This aligns with findings of recent national level studies including all types of housing: overheating, for example, has been documented across the wider English housing stock. Analysis of temperature monitoring undertaken as part of the Energy Follow-Up Survey (EFUS) during the summer of 2018 estimated that 19% of bedrooms and 15% of living rooms experienced overheating using an adaptive thermal comfort criterion accounting for household heat sensitivity.[146] More recently, the 2024 English Housing Survey (EHS)[147] reported that residents experienced uncomfortably warm conditions they were unable to alleviate in approximately 12% of homes across England – a figure increasing from 7% in 2019. These figures provide national context, although differences in overheating assessment methods, monitoring periods and sample characteristics limit direct comparison with the PDR findings.

Several features identified through the monitoring and resident surveys may help explain the summer overheating observed in PDR homes. Glazed areas (sometimes extensive) with limited shading can allow substantial solar heat gains. Cooking and higher occupancy levels contribute to higher internal heat gains, which can heat smaller spaces, typically found in PDR homes, faster.

146. Lomas, K.J., Watson, S., Allinson, D., Fateh, A., Beaumont, A., Allen, J., Foster, H. and Garrett, H., 2021. Dwelling and household characteristics' influence on reported and measured summertime overheating: A glimpse of a mild climate in the 2050's. *Building and Environment, 201, 107986. Available at:* **https://doi.org/10.1016/j.buildenv.2021.107986**

147. MHCLG, 2026. English Housing Survey 2024 to 2025: weather resilient homes – fact sheet, at: **https://www.gov.uk/government/statistics/english-housing-survey-2024-to-2025-weather-resilience-in-housing-fact-sheet/english-housing-survey-2024-to-2025-weather-resilient-homes-fact-sheet**

However, this also depends on the building fabric and ventilation characteristics. Single-aspect layouts do not allow cross ventilation, thus making it harder to remove accumulated heat, and non-openable or restricted windows, outdoor noise/pollution or security concerns can further limit window opening and heat removal. These constraints may be particularly relevant to PDR conversions, as Clifford et al.[148 149] and Pineo et al. [150] documented restricted ventilation arrangements, and Chng et al.[151] found that London PDR developments were disproportionately located in areas with higher outdoor pollution, as is also indicated by our locational analysis under WP1 in this research.

The locations of the 47 monitored PDR homes were mapped and compared against heat vulnerability indicators estimated for the 33,755 Lower Super Output Areas (LSOAs) in England.[152] When examining the heat vulnerability of the LSOAs in which the 47 homes were located, almost a third of them (15 out of 47) were in the top 10% of worst-performing LSOAs in terms of outdoor local environmental conditions, including factors that may affect heat exposure, such as tree cover, air quality and projected changes in exposure to very hot summer days. In addition, nearly one-fifth of LSOAs in the monitored sample (nine out of 47) ranked in the top 10% of LSOAs with the lowest estimated levels of population ability to respond or prepare for heatwaves. These indicators are highly aggregated and may not fully capture the local microclimate and dwelling- or household-level characteristics of the monitored homes. Taken together with the WP3 monitoring and questionnaire findings on overheating, however, they suggest that the location and area demographics of the monitored PDR homes may contribute to increased heat vulnerability, now and in the future.

148. Clifford, B., Ferm, J., Livingstone, N. and Canelas, P., 2018. *Assessing the impacts of extending permitted development rights to office-to-residential change of use in England. Royal Institution of Chartered Surveyors. Available at:* **https://www.rics.org/content/dam/ricsglobal/documents/to-be-sorted/assessing-the-impacts-of-extending-permitted-development-rights-to-office-to-residential-change-of-use-in-england-rics.pdf**

149. Clifford B, Canelas P, Ferm J, Livingstone N, Lord A, Dunning R., 2020.*Research into the quality standard of homes delivered through change of use permitted development rights. MHCLG. Available at:* **https://assets.publishing.service.gov.uk/media/5f159de5e90e075e90a720dc/Research_report_quality_PDR_homes.pdf**

150. Pineo H, Clifford B, Eyre M, Aldridge RW., 2024. Health and wellbeing impacts of housing converted from non-residential buildings: A mixed-methods exploratory study in London, UK. *Wellbeing, Space and Society. 6:100192. Available at:* **http://doi.org/10.1016/J.WSS.2024.100192**

151. Chng I, Reades J, Hubbard P., 2024. Planning deregulation as solution to the housing crisis: The affordability, amenity and adequacy of Permitted Development in London. *Environ Plan A. 56(3):961–78. Available at:* **https://doi.org/10.1177/0308518X231209982**

152. OCSI, 2026. *Extreme Heat Vulnerability Index. Oxford Consultants for Social Inclusion*

Moisture and underheating

Around 70% of homes with heating-season temperature data recorded temperatures below 18°C for 5% or more of the monitored time. Low indoor temperatures may reflect a combination of heat loss through the building fabric and inadequate heating provision. However, the exact reasons could not be determined through the data collected from this project. For context, low winter temperatures have also been documented in the wider English housing stock. The Energy Follow Up Survey (EFUS)[153] reported that during winter 2017/18, the coldest 10% of households recorded mean living-room temperatures below 15.7°C. However, the two samples are not directly comparable due to differences in the methods and metrics utilised.

Some homes experienced both low temperatures and high humidity. Three particularly cold homes recorded average relative humidity of 64–72%, over monitoring periods ranging from two to six months, highlighting the need to address underheating and moisture together when assessing damp and mould. For context, Approved Document F[154] also provides moisture-control criteria during the colder months, specifying that the moving average of indoor relative humidity should always be less than 65%, 75%, and 85% during the periods of one month, one week, and one day, respectively.

Indoor air quality

Indoor air quality was also a concern, with elevated CO_2 signalling insufficient ventilation in approximately one-third of the homes during the heating season. Fine particle pollution ($PM_{2.5}$) levels were elevated in many homes, with seasonal averages exceeding the WHO annual guideline value in nearly all homes with available data. WP1 provides relevant context for considering potential outdoor contributions to indoor $PM_{2.5}$. The locational analysis of WP1 found that nearly 40% of PDR addresses identified across London and England were located close to potentially incompatible land uses, including industrial manufacturing, vehicle repair, and waste, salvage and nightclub facilities. Commercial cooking may also be relevant to PDR homes in city centres and mixed-use locations. Camden Council identified cooking in restaurants, cafes, pubs and takeaways as the largest single category of locally emitted $PM_{2.5.}$[155] However, proximity alone does not establish pollutant exposure, and the relative contributions of indoor/outdoor pollution sources in the monitored sample remain uncertain.

153. BEIS, 2021. *Energy Follow Up Survey: thermal comfort, damp and ventilation. Final report. London: Department for Business, Energy & Industrial Strategy. Available at:* **https://assets.publishing.service.gov.uk/media/61449c52d3bf7f05b4562b66/efus-thermal.pdf**
154. HM Government, 2021. *Approved Document F: Ventilation. Volume 1: Dwellings. London: Department for Levelling Up, Housing and Communities. Available at:* **https://assets.publishing.service.gov.uk/media/61deba42d3bf7f054fcc243d/ADF1.pdf**
155. Camden Council, 2026. *Draft Camden Clean Air Action Plan 2027–2030. London: Camden Council. Available at:* **https://consultations.wearecamden.org/supporting-communities/camden-clean-air-action-plan-2027-2030/user_uploads/draft-camden-clean-air-action-plan-2027-2030---nf-1.pdf**

Small dwelling volumes and open-plan layouts may contribute to elevated exposure to indoor-generated pollutants. Effective extraction can remove emissions before they spread, whereas limited ventilation can allow them to accumulate. The WP3 monitoring found slightly lower $PM_{2.5}$ in homes with enclosed kitchens than in those with open-plan kitchens, while WP2 residents described cooking smells reaching others sharing the same room. The findings suggest that dwelling size and layout may influence indoor pollutant concentrations. This interpretation is supported by the modelling work on London housing,[156] highlighting that higher cooking emission concentrations were more strongly associated with smaller flats than larger detached homes, particularly those without a working kitchen extractor fan. However, in the PDR monitored sample, small comparison groups and potential confounding factors, including cooking practices, smoking, occupancy and ventilation, limit the ability to identify the independent effects of dwelling size and layout.

NO_2 was less frequently elevated in the case study sample, and CO was generally low. Formaldehyde sample averages were below the WHO reference value, but week-long sampling cannot rule out exceedances over its specified 30-minute period.

Benefits of dual-aspect layouts

Modelling focused on a small, single-aspect studio (bedsit), incorporating building, operational and household variations. Together, the bedsit and a single-aspect one-bedroom flat geometry represent approximately 30% of the identified PDR stock. The bedsit simulations projected an increase of approximately 2.4°C in average summer operative temperature by the 2080s. Enabling cross ventilation achieved an average summer temperature reduction of up to approximately 2°C in the 2080s, but this may not prevent future overheating on its own. Effective shading and opportunities for increased airflow when outdoor temperatures are lower than indoors are both important for reducing summer overheating.

Trade-offs

Modelling indicated higher heating season $PM_{2.5}$ than in summer, with smoking substantially increasing concentrations. Extended ventilation when outdoor temperatures are lower than indoor temperatures, and extended air extraction reduced summer overheating and $PM_{2.5}$ concentrations but also increased NO_2 towards the modelled outdoor background concentration. Hence, improving ventilation requires careful consideration of outdoor pollution levels while maintaining comfortable indoor temperatures during the heating season.

156. Ferguson, L., Taylor, J., Zhou, K., Shrubsole, C., Symonds, P., Davies, M. and Dimitroulopoulou, S., 2021. Systemic inequalities in indoor air pollution exposure in London, UK. *Buildings and Cities*, 2(1), pp.425–448. Available at: **https://doi.org/10.5334/bc.100**

WP2 highlights practical barriers to window opening, including outside noise and air pollution limiting higher ventilation rates in approximately 35% and 22% of survey respondents, respectively. Non-openable windows, restricted openings and single-aspect layouts further limit opportunities for airflow. Security concerns may also discourage window opening, particularly at night, when ventilation could help the most in releasing accumulated heat. Elevated CO_2 in some monitored homes provided further evidence that ventilation was insufficient. Particularly during colder weather, residents may keep windows closed to retain warmth, allowing moisture and pollutants from indoor activities to build up where air extraction or background ventilation is insufficient.

Screening individual intervention measures and their combinations indicated no single best overall intervention package. The selected interventions in each case need to match the problem.

- Shading combined with day and night ventilation and continuous extraction performed best for summer cooling.
- Scheduled ventilation and extraction, with internal door closure during moisture-generating activities, performed best for lowering heating season relative humidity. Maintaining suitable indoor temperatures is also important, as lower indoor temperatures alone can increase relative humidity.
- Enhanced ventilation and extraction, with internal doors open, performed best for reducing heating season $PM_{2.5}$, but increased NO_2 towards the modelled outdoor background concentration.

The issues identified above are not unique to PDR housing. Taylor et al. also showed that across Britain, building characteristics and ventilation influence both indoor overheating and pollution.[157] The PDR findings provide evidence of these concerns in converted homes, where small spaces, restricted window opening and limited opportunities for cross ventilation are likely to occur together. Where homes are also located near outdoor pollution sources and in higher heat-vulnerability areas, residents may be at greater risk of pollutant exposure and experience difficulties maintaining comfortable indoor temperatures.

157. Taylor, J., Davies, M., Mavrogianni, A., Shrubsole, C., Hamilton, I., Das, P., ... & Biddulph, P. (2016). Mapping indoor overheating and air pollution risk modification across Great Britain: A modelling study. *Building and Environment, 99, 1-12. Available at:* **https://doi.org/10.1016/j.buildenv.2016.01.010**

Implications for planning, design and building regulations

The WP3 findings highlight the need for planning, design standards and building regulations to jointly address indoor summer overheating, winter underheating, excess moisture and poor indoor air quality in PDR homes. Measures that improve one aspect can worsen another, e.g. increased ventilation can remove heat and pollutants generated indoors but may also allow the ingress of outdoor summer heat, pollutants and noise, or increase winter heat loss. PDR conversion proposals should, therefore, demonstrate how these benefits and risks can be balanced year-round both under current and future climate conditions.

For new residential buildings, Approved Document O of the Building Regulations in England (Part O) already addresses overheating. However, it still references the older version of the TM59 methodology for assessing overheating rather than the updated TM59 version.[158] The updated version requires assessment with and without restrictions due to noise, security or outdoor pollution, under the 2050s weather data. Applying this approach to PDR conversions should be promoted, given their unique characteristics that increase their sensitivity to overheating. For existing PDR homes, the Housing Health and Safety Rating System (HHSRS)[159] provides a framework for assessing health and safety hazards, and wider use of proactive inspections could help identify and address problems without relying on residents to raise concerns. There is also scope to explore how HHSRS could account for longer-term risks arising due to climate change.

PDR planning and design assessments should consider location, floor area, expected occupancy, internal layouts and the residents' practical ability to ventilate and cool their homes. Opportunities for cross ventilation should be prioritised, wherever possible. Where this is impractical, alternative strategies should be employed to ensure adequate ventilation and summer heat removal. Approved Document O explicitly mentions that the ventilation needed to remove excess heat may exceed that required under Approved Document F for indoor air quality.[160, 161]

The sustained high internal summer temperatures recorded in several homes, residents' reported thermal discomfort and the projected effects of climate change strengthen the case for extending Part O overheating requirements to the retrofit of existing buildings, including conversions of non-domestic

158. CIBSE, 2026. TM59: Overheating risk in dwellings: a design stage methodology. 2nd edition. London: Chartered Institution of Building Services Engineers. Available at: **https://www.cibse.org/knowledge-research/knowledge-portal/tm59-overheating-risk-in-dwellings-a-design-stage-methodology-2026/**
159. MHCLG, 2026. *Housing Health and Safety Rating System (HHSRS): Landlord and agent guide. London: Ministry of Housing, Communities and Local Government. Available at:* **https://www.gov.uk/government/publications/housing-health-and-safety-rating-system-hhsrs-landlord-and-agent-guide**
160. HM Government, 2021. Approved Document O: Overheating. London: Department for Levelling Up, Housing and Communities. Available at: **https://www.gov.uk/government/publications/overheating-approved-document-o**
161. HM Government, 2021. *Approved Document F: Ventilation. Volume 1: Dwellings. London: Department for Levelling Up, Housing and Communities. Available at:* **https://assets.publishing.service.gov.uk/media/61deba42d3bf7f054fcc243d/ADF1.pdf**

buildings, which is already included in the Climate Change Committee's recommendation R2023-27.[162] Part O also requires overheating strategies to account for practical constraints, including nighttime noise, outdoor pollution and security issues.[163] Applying these to PDR homes would help minimise reliance on window opening that residents cannot safely undertake.

The findings also underline the importance of appropriate implementation of Approved Document F,[164] ensuring that ventilation systems are correctly installed, tested and commissioned, and with clear instructions provided to residents on their use and maintenance. Ventilation strategies should consider local pollution and noise levels, dwelling layouts and the expected occupancy. Alongside the applicable commissioning requirements, checks should establish that windows, vents and controls are accessible and usable, and that residents understand how to operate the systems provided.

The findings also support evaluation after residents move in to establish whether PDR homes perform as intended. Alongside a broader call for checks on 'as-built' performance in both new and existing buildings,[165] the Climate Change Committee specifically recommends post-occupancy evaluation of new-build homes to check summer temperatures against Part O (R2023-28) and improved monitoring of overheating in existing dwellings (R2023-29).[166] Extending this approach to PDR conversions would allow indoor monitoring, ventilation checks and resident feedback across summer and winter to identify areas of concern and potential mitigation actions.

Overall, the findings indicate that location, design and expected indoor environmental performance under current and future climates should be carefully assessed when judging the suitability of new PDR conversions. Outdoor noise and pollution levels need to be considered alongside layouts, expected occupancy, shading and the residents' practical ability to ventilate their homes. The evidence strengthens the case for extending overheating requirements to residential conversions, tightening checks on ventilation adequacy and jointly assessing moisture and year-round thermal performance. Post-occupancy evaluation would be a useful tool in establishing whether the PDR design works as intended and identifying corrective actions, where needed. Ultimately, the quality of PDR conversions should be judged by the living conditions they provide.

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162. CCC, 2025. *Progress in adapting to climate change – 2025 report to Parliament. Climate Change Committee. Available at:* **https://www.theccc.org.uk/wp-content/uploads/2025/04/Progress-in-adapting-to-climate-change-2025-1.pdf**
163. HM Government, 2021. *Approved Document O: Overheating. London: Department for Levelling Up, Housing and Communities. Available at:* **https://www.gov.uk/government/publications/overheating-approved-document-o**
164. HM Government, 2021. *Approved Document F: Ventilation. Volume 1: Dwellings. London: Department for Levelling Up, Housing and Communities. Available at:* **https://assets.publishing.service.gov.uk/media/61deba42d3bf7f054fcc243d/ADF1.pdf**
165. CCC, 2019. *UK housing: Fit for the future? Committee on Climate Change. Available at:* **https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/**
166. CCC, 2025. *Progress in adapting to climate change – 2025 report to Parliament. Climate Change Committee. Available at:* **https://www.theccc.org.uk/wp-content/uploads/2025/04/Progress-in-adapting-to-climate-change-2025-1.pdf**



Work Package 4: Modelling the health impacts of indoor environmental quality in permitted development housing

Introduction and specific objectives

Work Package 4 of the project quantifies the health and economic burden of indoor environmental factors in permitted development housing, drawing on exposure modelling and monitoring from work package 3. Permitted development housing created through the change-of-use planning route that bypasses full planning permission has previously been linked to compromised space standards, natural light and ventilation. This analysis aimed to extend that evidence base by translating modelled indoor pollutant concentrations into estimates of all-cause mortality, asthma morbidity, years of life lost, and their monetized economic cost, for the population currently resident in this housing type across Great Britain.

Here, we present preliminary work that assesses the health and economic impact of air pollution exposure (fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2)) for an example single dwelling type using outputs from work package 3. We also present an assessment of incremental differences in mortality risk for occupants of permitted development homes based on the results of work package 3 monitoring.

The intention of the work package was to perform an integrated assessment of housing-related health risks of PDR homes, their health economic costs and the potential cost-benefit of altered regulation or required adaptations to inform decisions about health protection. Quantitative health risk and economic findings are presented in separate sections below to inform, respectively, the health evidence base and the cost-benefit assessment of possible regulatory interventions considered under WP4, and the policy guidance produced under WP5.

Specific objectives

The objectives of the work were as follows:

- To assess the incremental mortality risk of different types of permitted development homes using monitored indoor environmental data;
- To quantify the health risks associated with indoor exposures in the wider permitted development stock in the UK using modelled exposure data;
- To estimate the economic losses resulting from exposures in the permitted development stock in the UK.

These objectives were intended to address the following research questions:

- **RQ4.1** What are the quantified health impacts attributable to the dwelling characteristics of homes built under permitted development?
- **RQ 4.2** What is the associated health economic impacts?
- **RQ 4.3** What would be the likely cost-benefit of selected alterations to planning regulations to protect against the most negative effects on health?

Methods

The health analysis used modelled indoor air quality outputs for a single dwelling geometry from work package 3. This geometry, S, represents the conversion of an office to a small flat. Modelled indoor air pollutant concentrations were derived from building physics simulation of the S archetype dwelling. For further details of the exposure monitoring and modelling, please see the Work Package 3 section above.

An estimated 295,878 people (range: 250,733–341,021) currently live in permitted development housing in Great Britain, based on survey data collected under work package 2. Of this population, 25% are under 18 years of age and 62% are aged 25 or over. 32.2% of all PDR residents live specifically in S-type permitted development housing, the building typology modelled here – an estimated 95,273 residents.

Health outcomes were estimated by applying published concentration-response functions to the exposed population. Drawing on evidence from the epidemiological literature on association between air pollution exposure and health, in this preliminary work the following air pollution-related health outcomes were modelled:

- All-cause mortality;
- Mortality from five specific causes;
- Childhood asthma morbidity

Health outcomes were assigned to the age groups for which each outcome is most attributable: all-cause mortality was estimated for residents aged 25 and over, reflecting the age profile of pollution-attributable mortality risk, while asthma morbidity was estimated for residents aged 18 and under, reflecting the age group in which asthma incidence and exacerbation are most strongly associated with indoor air quality. Economic loss was calculated as the sum of three components: (i) the indirect cost of all-cause mortality (lost economic output and quality-adjusted life expectancy), (ii) the direct healthcare cost of five cause-specific mortalities, and (iii) the direct and indirect cost of asthma cases.

So far, four exposure case studies were modelled for $PM_{2.5}$, and two for NO_2, varying by the presence of an extractor/exhaust fan and, for $PM_{2.5}$, by whether a household member smokes indoors to help understand potential interventions for indoor environmental quality in already developed housing. The case studies are intended as illustrative examples that demonstrate factors that are likely to affect indoor exposures and that have the potential to be modified by policy interventions. To aid comparison across case studies and with published exposure-response literature, mortality and asthma morbidity counts are also expressed as rates per 10,000 residents of the relevant age group living in S-type PDR housing. Applying the age shares above to the estimated S-type population gives approximately 59,069 residents aged 25 and over (the mortality denominator) and 23,818 residents aged 18 and under (the morbidity denominator). Years of life lost (YLL) due to all-cause mortality under the baseline scenario are also reported by age band, to show how the mortality burden is distributed across the working-age and older populations.

Health risk assessment approach

In this study, we quantified (a) the long-term incremental mortality risk attributable to indoor $PM_{2.5}$ and NO_2 exposure in monitored permitted development homes and (b) the premature deaths and childhood asthma attributable to long-term $PM_{2.5}$ and NO_2 exposures for a single permitted development archetype (type S – see WP3 above).

To quantify the changes in health risk at a given concentration of $PM_{2.5}$ and NO_2, the exposure-response coefficient (ERC) can be derived by the following expression: ERC = ln(RR) / ΔC.[167] The RR is the relative risk based on epidemiological study or meta-analysis and ΔC is the change of pollutant concentration. For example, the RR for all-cause mortality reported by Orellano et al. (2024) was 1.095 (95% CI: 1.064–1.127) per 10 μg/m^3 (ΔC) increase in long-term $PM_{2.5}$.[168] Based on this study, the ERC for all cause-mortality is 0.00908 (95% CI: 0.00620–0.01196).

We employed a log-linear concentration-response function to estimate the RRs at the exposed concentrations.[169] The RR at a given exposed concentration (EC) was calculated using:

$$RR_{EC(d,a)} = exp[ERC_{d,a} \times (EC - TC)] \quad (1)$$

where d represents a specific disease (e.g., all-cause, cardiovascular, etc.) and a denotes a specific age group. A threshold concentration (TC) of 2.4 μg/m^3 was applied for $PM_{2.5}$ and 5 μg/m^3 for NO_2, reflecting the lowest exposure levels observed in the cohort studies underpinning the ERC. At TC the RREC = 1.

For the incremental mortality risk, based on WP3 monitoring, this was calculated as follows: (RREC – 1)*100. For example, for a population exposed at annual average $PM_{2.5}$ of 25 μg/m^3, the all-cause mortality risk would be increased by 23% (95% CI: 15–31) (based on Orellano et al., 2024).

To quantify the premature deaths attributable to long-term $PM_{2.5}$ and NO_2 exposures, we followed the well-established health impact assessment (HIA) method widely used in air pollution exposure mortality studies: [170, 171, 172]

$$\Delta Mor^{pol}_{d,a} = AF_{d,a} \times BM_{d,a} \times Pop_a \quad (2)$$

where AF is the attributable fraction at annual average pollutant concentration (pol), $BM_{d,a}$ represents the age-specific baseline mortality rate per person and Popa is the age-specific population in the PDR house type.

167. Chowdhury S, Pozzer A, Haines A, et al. 2022, Global health burden of ambient $PM_{2.5}$ and the contribution of anthropogenic black carbon and organic aerosols. *Environ Int. 159:107020. Available at:* **https://doi.org/10.1016/j.envint.2021.107020**
168. Orellano P, Kasdagli M-I, Pérez Velasco R, Samoli E. 2024, Long-Term Exposure to Particulate Matter and Mortality: An Update of the WHO Global Air Quality Guidelines Systematic Review and Meta-Analysis. *Int J Public Health. 69, 1607683.Available at:* **https://pmc.ncbi.nlm.nih.gov/articles/PMC11466858/**
169. Lelieveld J, Haines A, Burnett R, et al. 2023, Air pollution deaths attributable to fossil fuels: observational and modelling study. *BMJ, 383:e077784. Available at:* **https://doi.org/10.1136/bmj-2023-077784**
170. Pozzer A, Anenberg SC, Dey S, et al. 2023, Mortality Attributable to Ambient Air Pollution: A Review of Global Estimates. *Geohealth, 7. Available at:* **https://doi.org/10.1029/2022GH000711**
171. Anenberg SC, Achakulwisut P, Brauer M, et al. 2019, Particulate matter–attributable mortality and relationships with carbon dioxide in 250 urban areas worldwide. *Sci Rep., ;9:11552. Available at:* **https://www.nature.com/articles/s41598-019-48057-9**
172. Mallongi A, Syam A, Palutturi S, et al. 2025, Health Risk Assessment of NO□, PM□.□ and PM□□ Exposure in Children and Adolescents. *Journal of Human, Earth, and Future, 6:262–*75.Available at: **https://doi.org/10.3389/fpubh.2025.1721233**

AF can be estimated from equation 1, for each age group *a* and disease *d* as:

$$AF_{d,a} = (1 - RR_{EC(d,a)}) / RR_{EC(d,a)} \quad (3)$$

Along with all-cause mortality (ICD-10 codes A00-Z99), we estimated cause-specific mortality from five causes [ischaemic heart disease (IHD) (I20-I25), stroke (I60-I69), acute lower respiratory infections (LRI) (J12-J18, J20-J22), lung cancer (LC) (C33-C34: malignant neoplasm of the trachea, bronchus or lung only) and chronic obstructive pulmonary disease (COPD) (J40-J44, J47)] for individuals aged ≥25 years. We used RRs from the recent meta-analysis by Orellano et al.[173] for $PM_{2.5}$ and by Kasdagli et al.[174] for NO_2 exposure.

Additionally, we estimated number of asthma cases (morbidity) for ages ≤ 18 years for $PM_{2.5}$ and NO_2 exposure.[175]

Health economic valuation methods

Health economic valuation was conducted to quantify both the direct healthcare costs and indirect societal costs associated with $PM_{2.5}$ and NO_2 attributable mortality in GB. Direct costs included expenditures related to the diagnosis, treatment and management of $PM_{2.5}$ and NO_2-attributable diseases, based on National Health Service (NHS) treatment costs. Indirect costs were estimated to capture the broader economic burden associated with premature mortality resulting from $PM_{2.5}$-related health outcomes.

Indirect costs

The economic cost of premature mortality was assessed using the Value of a Life Year (VOLY) approach, where total life years lost (LYL) attributable to $PM_{2.5}$ and NO_2 exposure were monetised using standard economic valuation methods.[176] This approach reflects the societal value placed on reductions in mortality risk and is widely applied in environmental HIA. The age-specific number of attributable premature deaths was multiplied by the corresponding remaining life expectancy to estimate LYL. Local authority level life tables in England were used to obtain remaining life expectancy for each age group.[177]

173. Orellano P, Kasdagli M-I, Pérez Velasco R, Samoli E. 2024, Long-Term Exposure to Particulate Matter and Mortality: An Update of the WHO Global Air Quality Guidelines Systematic Review and Meta-Analysis. *Int J Public Health. 69. Available at:* **https://pmc.ncbi.nlm.nih.gov/articles/PMC11466858/**
174. Kasdagli M-I, Orellano P, Pérez Velasco R, Samoli E. 2024, Long-Term Exposure to Nitrogen Dioxide and Ozone and Mortality: Update of the WHO Air Quality Guidelines Systematic Review and Meta-Analysis. *Int J Public Health. 69. Available at:* **https://pmc.ncbi.nlm.nih.gov/articles/PMC11527649/**
175. Walton, H et al, 2019, Health Impact Assessment of Air Pollution on Asthma in London at: **https://www.london.gov.uk/sites/default/files/asthma_kings_report_april_2019_final.pdf**
176. Ricardo 2025, Air Quality Damage Cost Update 2025: Report for Defra at: **https://uk-air.defra.gov.uk/assets/documents/reports/cat05/2512151700_Damage_cost_update_2025_Defra_FINAL.pdf**
177. ONS, 2025. Dataset: Life expectancy for local areas of the UK at: **https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/datasets/lifeexpectancyforlocalareasoftheuk**

For example, accordingly, the total economic cost of $PM_{2.5}$–related premature mortality was calculated as the product of life years lost and VOLY (Economic Cost = LYL × VOLY).[178, 179, 180] The unit values used to monetise changes in life-years lost were originally estimated by Chilton et al.[181]

The study estimated a VOLY associated with a life-year spent in good health of £27,630 and in poor health of £14,280 (2002 prices).[182] The price base of the VOLY estimates (2025 prices: £59,200) was updated using the latest published set of per capita Gross Domestic Product (GDP) deflators.[183]

Direct costs

The direct healthcare cost was estimated using a cost-of-illness (COI) approach conducted from the perspective of the NHS in GB. Direct health care costs of mortality include treatment for chronic conditions before death, assuming a non-sudden process following disease onset involving hospitalisations, medication, and care for respiratory/cardiovascular diseases (Table 25). Disease-specific per-case direct costs were derived as survival-probability-weighted expected costs over each condition's typical post-diagnosis or post-event course, rather than a flat cost applied uniformly regardless of survival. For example, for IHD,[184] annual treatment costs were applied conditional on the 59% one-year post-myocardial infarction survival rate and 4.8-year median survival reported by Kochar et al.[185] For LRI, costs were weighted by a 50% one-year mortality rate and 5-year median survival (Table 25).[186, 187, 188]

Except asthma treatment cost among the young age population, the economic valuation does not capture other morbidity-related costs (e.g. non-fatal disease incidence), productivity losses, informal care costs, or wider societal impacts.

178. Dajnak D, Walton H, Evangelopoulos D, et al. 2026, Can the UK meet the World Health Organization $PM_{2.5}$ interim target of 10 µg m−3 by 2030? Part II: Associated health and economic benefits. *Environ Int., 209:110189. Available at:* **https://doi.org/10.1016/j.envint.2026.110189**
179. Im U, Brandt J, Geels C, et al. 2018, Assessment and economic valuation of air pollution impacts on human health over Europe and the United States as calculated by a multi-model ensemble in the framework of AQMEII3. *Atmos Chem Phys;18:5967–89. Available at:* **https://doi.org/10.5194/acp-18-5967-2018**
180. Leksell I, Rabl A. 2001, Air Pollution and Mortality: Quantification and Valuation of Years of Life Lost. *Risk Analysis.21:843–843. Available at:* **https://doi.org/10.1111/0272-4332.215156**
181. Chilton S, Covey J, Jones-Lee M, Loomes G, Metcalf H. 2004, *Valuation of Health Benefits Associated with Reductions in Air Pollution. DEFRA, London.*
182. Chilton S, Jones-Lee M … Spackman M. 2020, *A Scoping Study on the Valuation of Risks to Life and Health: The Monetary Value of a Life Year (VOLY). HSE, London. Available at:* **https://eprints.ncl.ac.uk/file_store/production/268506/90D29577-6AFC-4E8B-B523-52D824B14595.pdf**
183. Chilton S, Covey J, Jones-Lee M, Loomes G, Metcalf H. 2004, *Valuation of Health Benefits Associated with Reductions in Air Pollution. DEFRA, London.*
184. Shih K, Herz N, Sheikh A, et al. 2025, Economic burden of cardiovascular disease in the United Kingdom. *Eur Heart J Qual Care Clin Outcomes;11:678–90. Available at:* **https://doi.org/10.1093/ehjqcco/qcaf011**
185. Kochar A, Chen AY, Sharma PP, et al. 2018, Long‐Term Mortality of Older Patients With Acute Myocardial Infarction Treated in US Clinical Practice. *J Am Heart Assoc; 7. Available at:* **https://doi.org/10.1161/JAHA.117.007230**
186. Averin A, Sato R, Begier E, et al. 2025 Short-term and Long-term Mortality Following Hospitalized and Ambulatory Lower Respiratory Tract Illnesses Among US Adults. *Open Forum Infect Dis.; 12. Available at:* **https://doi.org/10.1093/ofid/ofaf186**
187. Manoukian S, Stewart S, Graves N, et al. 2021, Evaluating the post-discharge cost of healthcare-associated infection in NHS Scotland. *Journal of Hospital Infection;114:51–8. Available at:* **https://doi.org/10.1016/j.jhin.2020.12.026**
188. Manoukian S, Stewart S, Graves N, et al. 2021, Bed-days and costs associated with the inpatient burden of healthcare-associated infection in the UK. *Journal of Hospital Infection.;114:43–50.Available at:* **https://doi.org/10.1016/j.jhin.2020.12.027**

Incremental health risk (based on monitoring)

Table 26 and Figures 43 and 44 present the incremental mortality risk at each monitored home. These values represent the additional risk of death for a person living in that type of home (compared to the WHO guideline for $PM_{2.5}$ and to 5 µg/m³ for NO_2). Across the fifteen monitored S-type sites, incremental health risk for $PM_{2.5}$ closely tracked indoor exposure, with Site_1035 standing out as a clear outlier. At an estimated exposure of 132.9 µg/m³, this dwelling showed the greatest incremental risk.

The largest relative increase was for LRI, at 1027.65% (95% CI: 226.85–3834.75%), followed by stroke (492.05%, 95% CI: 251.01–889.48%), IHD (472.14%, 95% CI: 255.20–826.41%), COPDR (440.33%, 95% CI: 173.01–956.48%), and lung cancer (219.15%, 95% CI: 96.20–422.03%). For all-cause mortality specifically, Site_1035 carried an incremental risk of 226.85% (95% CI: 124.69–376.00%), well above every other site.

The next-highest all-cause mortality risk was seen at Site_631 (exposure 38.4 µg/m³; 38.64%, 95% CI: 25.02–53.79) and Site_234 (36.2 µg/m³; 35.90%, 95% CI: 23.33–49.80), followed by Site_383 (27.4 µg/m³; 25.47%, 95% CI: 16.78–34.84). Sites with the lowest measured exposure, Site_1308 (4.1 µg/m³) and Site_803 (5.3 µg/m³), correspondingly recorded the smallest incremental risks, at 1.55% and 2.67% respectively.

Table 26: Percentage increase [mean (95% CI)] in all-cause mortality risk due to indoor $PM_{2.5}$ and NO_2 exposure in S-type PDR housing.

PDR house location	$PM_{2.5}$ exposure incremental mortality risk (% increase)	NO_2 exposure incremental mortality risk (% increase)
Site_240	6 (8-5)	0
Site_234	36 (50-24)	0
Site_383	25 (35-17)	1 (2-1)
Site_506	6 (8-4)	5 (8-4)
Site_685	11 (15-8)	0
Site_631	39 (54-26)	1 (2-1)
Site_803	3 (4-2)	0
Site_960	7 (9-5)	3 (5-2)
Site_1035	227 (377-125)	2 (3-2)
Site_1194	6 (8-4)	0
Site_1259	16 (23-11)	2 (3-1)
Site_1245	19 (26-13)	0
Site_1209	20 (28-14)	4 (6-3)
Site_1248	10 (14-7)	0
Site_1308	2 (3-2)	0

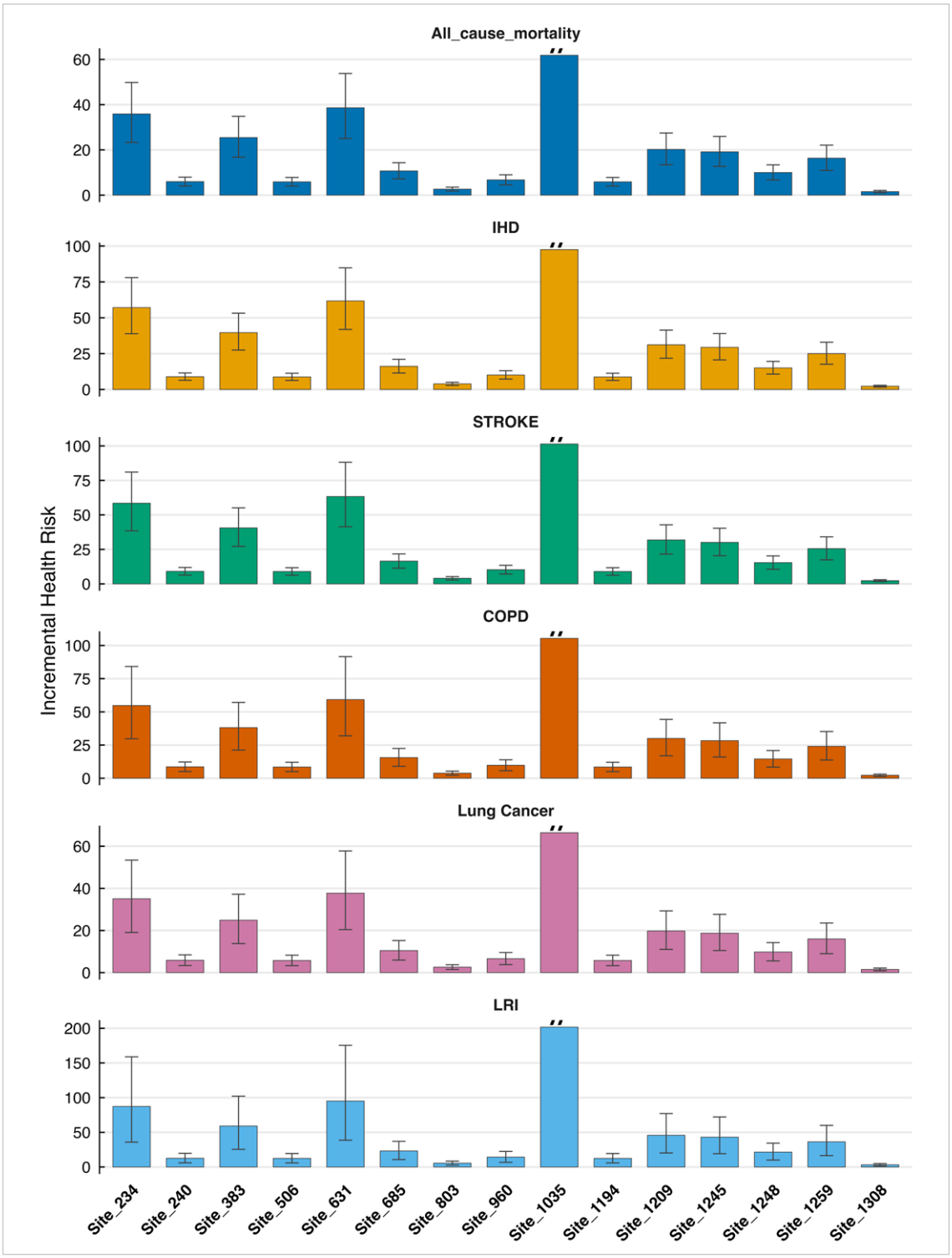


Figure 43: $PM_{2.5}$-exposure attributable all-cause and cause-specific incremental mortality risk in S-type PDR housing.

For NO_2, incremental health risk was calculated relative to a threshold concentration of 5 μg/m³. Seven sites (Site_240, Site_234, Site_685, Site_1194, Site_1245, Site_1248 and Site_1308) were at or below this cut-off, giving an RR of 1 and, correspondingly, zero incremental risk across every outcome. Among the remaining eight sites, Site_506 recorded the highest NO_2 exposure (15.06 μg/m³) and, consistently, the largest incremental risk for every health outcome examined, peaking at 8.05% for lower respiratory infection (LRI; 95% CI: 4.02–12.07%) and 7.04% for lung cancer (95% CI: 4.02–10.06%), with all-cause

mortality, IHD and Stroke each elevated by around 5.03% (95% CI: 3.02–7.04% to 3.02–8.05%). Site_1209 (12.23 µg/m3) and Site_960 (11.48 µg/m3) followed as the next highest-risk locations. Notably, this ranking differs from the $PM_{2.5}$ analysis, where Site_1035 was the clear outlier: for NO_2, Site_1035's actual exposure (9.22 µg/m^3) places it only fourth for all-cause mortality (2.08%, 95% CI: 1.26–2.90%), behind Site_506, Site_1209 and Site_960 indicating that NO_2 and $PM_{2.5}$ exposure, and hence risk, do not track the same sites uniformly across this housing stock.

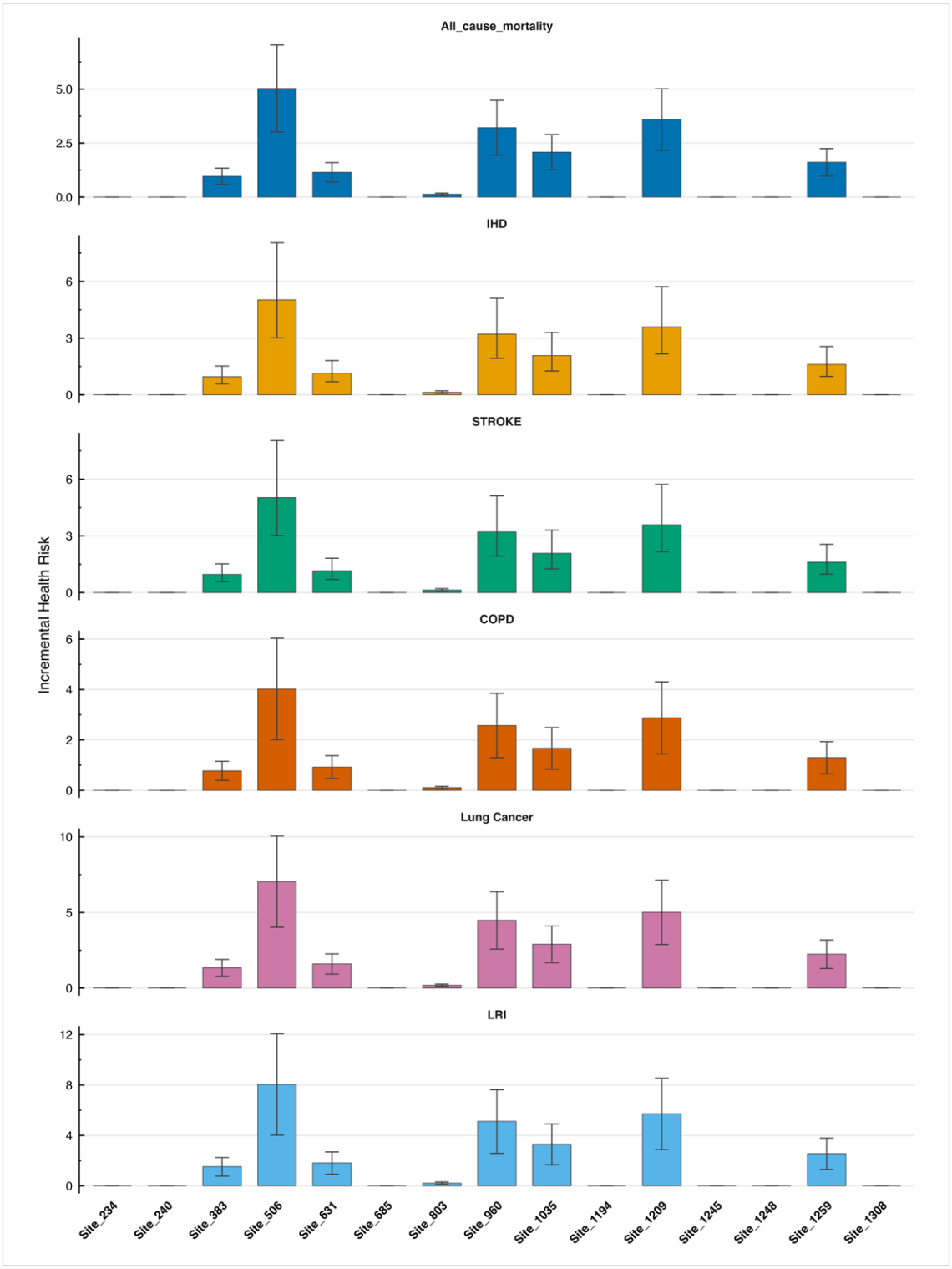


Figure 44: NO_2-exposure attributable all-cause and cause-specific incremental mortality risk in S-type PDR housing.

Quantitative health impact assessment (based on modelling)

In the baseline simulation, the annual average concentrations of $PM_{2.5}$ and NO_2 in S1-type PDR housing were 26.0 ± 8 and 14.0 ± 0.7 μg/m³ (mean ± SD) respectively, both exceeding the WHO (2021) annual air quality guideline. At this baseline, indoor $PM_{2.5}$ exposure was associated with 104 (95% CI: 73–133) all-cause deaths, including 28 (95% CI: 21–34) attributable to ischaemic heart disease (IHD) and 14 (95% CI: 10–17) to stroke. NO_2 exposure was associated with a further 23 (95% CI: 14–32) all-cause deaths, including 4 (95% CI: 3–7) attributable to IHD and 3 (95% CI: 2–4) to lung cancer. $PM_{2.5}$ and NO_2 exposure were also associated with 140 (95% CI: 79–198) and 68 (95% CI: 29–117) asthma cases, respectively, among the younger population resident in PDR housing (Table 27). Indoor smoking and the absence of an exhaust fan in the S1-type PDR housing increased indoor pollutant concentrations and consequently increased both mortality and morbidity (Table 28).

Expressed as rates, the baseline (non-smoking, ventilated) scenario is associated with 17.6 excess all-cause deaths and 58.8 asthma cases per 10,000 relevant population for $PM_{2.5}$, compared with 3.9 deaths and 28.5 asthma cases per 10,000 for NO_2 demonstrating that $PM_{2.5}$ carries a substantially larger health burden than NO_2 in this archetype. Ventilation reduced the $PM_{2.5}$ mortality rate from 19.5 to 17.6 per 10,000 among non-smoking households (a 10% reduction), while smoking increased it further, to between 26.7 and 28.8 per 10,000 depending on ventilation status 50–64% higher than the non-smoking, ventilated baseline. The same pattern holds for asthma morbidity, which peaked at 100.8 cases per 10,000 in the smoking, unventilated scenario, roughly 72% above the cleanest modelled scenario.

Table 27: Modelled all-cause mortality and asthma morbidity outcomes as case counts and as rates per 10,000 relevant population for the baseline scenario, in which an exhaust fan is present and no household member smokes.

Simulation type	Exposed conc (μg/m³)	Mortality (all-cause)	Mortality per 10,000	Morbidity (asthma)	Morbidity per 10,000
S1 PDR house, $PM_{2.5}$, no smoking + exhaust fan	26.0±8	104 (73–133)	17.6 (12.4–22.5)	140 (79–198)	58.8 (33.2–83.1)
S1 PDR house, NO_2, exhaust fan	14.0±0.7	23 (14–32)	3.9 (2.4–5.4)	68 (29–117)	28.5 (12.2–49.1)

Table 28: Modelled Extended analysis across the full set of smoking and ventilation combinations for $PM_{2.5}$, alongside the equivalent NO_2 scenario without an exhaust fan.

Simulation type	Exposed conc (µg/m³)	Mortality (all-cause)	Mortality per 10,000	Morbidity (asthma)	Morbidity per 10,000
S1 PDR house, $PM_{2.5}$, smoking + exhaust fan	40±17	158 (114–198)	26.7 (19.3–33.5)	222 (126–312)	93.2 (52.9–131.0)
S1 PDR house, $PM_{2.5}$, no smoking, no exhaust fan	29±10	115 (82–146)	19.5 (13.9–24.7)	156 (88–221)	65.5 (36.9–93.4)
S1 PDR house, $PM_{2.5}$, smoking, no exhaust fan	44±19	170 (123–211)	28.8 (20.8–35.7)	240 (137–336)	100.8 (57.5–141.1)
S1 PDR house, NO_2, no exhaust fan	13.7±0.7	22 (14–31)	3.7 (2.4–5.2)	65 (28–113)	27.3 (11.8–47.4)

The years-of-life-lost profile is heavily concentrated in the 30–64 age band, which accounts for 3,911 of the 5,644 combined years lost (69%), compared with 1,652 (29%) in the 25–30 age band and just 81 (1%) in the 65+ band. This pattern reflects the combination of population size and remaining life expectancy: the 30–64 band contains the largest share of the exposed adult population, and a death at this age forfeits substantially more expected years of life than a death at 65 or older, even though death counts themselves do not vary as sharply by age (Table 29). $PM_{2.5}$ accounts for the majority of YLL in every age band, roughly 83% overall (4,693 of 5,644 years), consistent with its larger contribution to mortality risk relative to NO_2 shown in Tables 25 and 28.

Table 29: Estimated years of life lost (YLL) due to all-cause mortality under the baseline scenario (Table 20) by age band.

Age band	$PM_{2.5}$ YLL	NO_2 YLL	Combined YLL
25–30 years	1,374	278	1,652
30–64 years	3,252	659	3,911
65+ years	67	14	81
Total	**4,693**	**951**	**5,644**

Economic loss assessment

Investigating the preliminary modelled interventions using the health economic valuation methods mentioned found that smoking status had a substantially larger effect on economic loss than ventilation. With an exhaust fan present, smoking raised economic loss by around 52% (£254m to £386m) relative to the non-smoking, ventilated scenario (Table 30, Table 31). Without an exhaust fan, smoking raised economic losses from £281m to £413m (a 47% increase). The single largest modelled economic burden was the combination of smoking and no exhaust fan (£413m), roughly 63% higher than the cleanest scenario modelled (no smoking, with exhaust fan, £254m). NO_2-attributable economic losses were consistently smaller than $PM_{2.5}$-attributable losses, ranging from £55m to £57m across ventilation scenarios and showing little sensitivity to exhaust fan status, mirroring the pattern seen in the underlying health risk and YLL estimates.

Table 30: Estimated years of life Estimated economic losses associated with the baseline scenario in Table 24.

Simulation type	Economic loss (£m)
S1 PDR house, $PM_{2.5}$, no smoking + exhaust fan	254 (179–323)
S1 PDR house, NO_2, exhaust fan	57 (35–78)

Table 31: Estimated economic losses across the full set of scenarios in Table 21.

Simulation type	Economic loss (£m)
S1 PDR house, $PM_{2.5}$, smoking + exhaust fan	386 (278–483)
S1 PDR house, $PM_{2.5}$, no smoking, no exhaust fan	281 (199–357)
S1 PDR house, $PM_{2.5}$, smoking, no exhaust fan	413 (299–515)
S1 PDR house, NO_2, no exhaust fan	55 (33–75)

Summary of initial findings

These preliminary results indicate that indoor exposure to $PM_{2.5}$ and NO_2 in PDR homes are likely to represent a substantial health risk and that there are considerable variations in risk between dwellings of different type. Based on this initial modelling work and the intervention scenarios we modelled, in S-type PDR housing, occupant smoking behaviour is a larger driver of $PM_{2.5}$-attributable health and economic burden than the presence or absence of mechanical ventilation, although ventilation still confers a consistent, if smaller, benefit across all scenarios and outcome measures.

This has two practical implications for the WP4 cost-benefit assessment and the WP5 policy guidance. First, interventions targeting ventilation provision such as minimum extract-fan requirements in prior-approval conditions are likely to deliver a real but constrained reduction in health and economic burden and should not be presented as a substitute for smoke-free-home measures.

Second, because the modelled economic losses and YLL scale with the size of the exposed population, and 32.2% of PDR residents live in this single archetype, even a modest per-dwelling improvement in ventilation standards could translate into an economically significant aggregate benefit given the scale of PDR housing nationally (an estimated 100,000+ homes since 2013).

The concentration of years of life lost in the 30–64 age band also points to a specifically working-age burden, with implications for productivity loss that go beyond the direct healthcare costs captured in this economic assessment. NO_2 exposure, by contrast, contributed comparatively little to the modelled burden across all outcome measures in this archetype and was largely insensitive to ventilation status, suggesting that NO_2-focused interventions are a lower priority for this specific housing type than for others where outdoor NO_2 infiltration is more significant (e.g. dwellings on high-traffic roads).

Conclusion

Based on our analysis of the S-type PDR housing, the scale of the potential annual air pollution-related health burden in PDR housing, up to 28.8 excess deaths and 100.8 asthma cases per 10,000 residents, and 5,644 years of life lost under the modelled scenarios and the associated economic loss of up to £413m annually under the worst-case scenario, underscore the potential value of targeted regulatory or advisory intervention in this housing type.

In the longer-term, we will extend this analysis by including a wider range of dwelling archetypes (from WP3 modelling), considering health impacts from a wider range of indoor environmental factors (such as temperature), and producing estimates of relative health and economic impacts under a range of potential alterations to planning regulations to protect health. These quantitative health risk and economic findings will feed directly into cost-benefit modelling to be published in a future peer-reviewed output.



Work Package 5: Legislative and policy levers for managing permitted development housing

This section provides an overview of the work from Work Package 5, focusing on the legislative and policy context that led to the extension of Permitted Development Rights (PDR) to allow conversion of non-residential buildings into housing outside of the full planning process, and the implications for local government in seeking to promote better health outcomes through shaping the quality and location of homes produced in this way. It sets out:

1. The research approach
2. The national policy context underpinning PDR changes
3. Legislative and policy findings:
    - A legacy of poor-quality PDR housing will exacerbate health inequalities
    - Deregulation harms local placemaking and resources
    - Regulatory gaps and weak enforcement put residents at risk

Research approach

The Work Package 5 (WP5) team[189] aimed to address the following research questions:

- What policy levers can policy makers at different scales use to ensure that new developments support residents health, and how has the introduction of PDRs for residential conversion impacted the effectiveness of these levers?
- How are policy makers adjusting the way they regulate the quality of homes following the expansion of PDR?
- Given the expansion PDR, what are the most effective policy levers policy makers can use to ensure that new developments support residents health?

WP5 undertook various research and output activities to address each question, as summarised in Table 32. This included a review of grey literature in 2023, regarding the national policy and legislation relating to PDR housing and health.[190] The review considered how the PDR rules prevented or enabled local authorities to address twelve evidence-based Healthy Homes Principles – principles that were co-produced by over 60 organisations in the housing sector.[191] The review identified a gap in literature about the various levers available to local authorities to shape the quality of PDR housing at different stages. So the review was followed by a national survey of local authorities in England, as well as six focus groups – with responses from officers across all nine regions, from different departments, including planning, environmental health, building control, development management, and public health officers. We also conducted a further ten semi-structured interviews with local government officers and representatives of national professional bodies in 2024 and 2025. These consultative activities aimed to address the research questions, to consider the levers that were currently being used, as well as to better understand public sector and industry views of the PDR rules, and their experiences of working with PDR conversions locally.

189. WP5 was formerly led by Julia Thrift and latterly by Dr Hugh Ellis, supported by Dr Rosalie Callway and Sally Roscoe at the Town and Country Planning Association (TCPA) with contributions from Prof. Ben Clifford, Dr Helen Pineo, Dr Mina Sufineyestani, and the wider team at UCL.
190. TCPA, 2024, Permitted development, housing and health: a review of national policy and regulations at: **www.tcpa.org.uk/resources/permitted-development-housing-and-health-a-review-of-national-policy-and-regulations**
191. TCPA 2023, Healthy Homes – what's the evidence? at **https://www.tcpa.org.uk/wp-content/uploads/2023/02/HH-principles-and-evidence-V2.pdf**

Table 32: Activities to address the WP5 research questions

Question	Activities
RQ5.1. What are the policy levers and their effectiveness in supporting health outcomes?	• **National review of PDR rules** (TCPA, 2024) • Dialogue with government agencies • **Parliamentary question and briefing** (2024)192,193 • **Guardian article** (2024) • **New Statesman article** (2025)194
RQ5.2. How are policy makers adjusting the way they regulate the quality of PDR homes?	Consultation with local government and professional bodies: • National local government survey – 47 respondents across the nine regions of England • Six regional round tables – 32 participants • Detailed interviews – 10 participants Presentations at the Healthy Cities Design Congress sessions (2023, 2025) and review **article (2024)**195
RQ5.3. What are the most effective policy levers policy makers can use to ensure that new developments support residents health?	Informed by the above review and consultation we have produced the following outputs: • Hot Housing: **Overheating** article (2026)196 • Full project report, government briefing and launch event (2026) • Progress in Planning article (under preparation) • Local Government PDR housing toolkit (2026) • Town and Country Planning journal, Special Issue (2026)

The following section outlines the political context that has led to PDR rules being extended before examining main findings from our research at national and local levels.

National context underpinning PDR changes

As discussed in the introduction to this report, the original intention of 'permitted development rights' (PDR) as set out in 1947 was very limited – to allow small-scale changes such as household extensions to proceed without requiring review through a full planning application process. The decision to expand PDR rules to allow buildings to be converted to residential use without full planning application process – dates back to 24 January 2013, during the coalition government's 'Red Tape Challenge' promoting removal of planning and other regulatory rules to free up economic growth. The then Secretary of State for Communities and Local Government, Eric Pickles stated:

192. **Housing: Permitted Development Rights - Hansard - UK Parliament** (Lord Crisp, 18 December 2024)
193. Crisp, N 2024, Housing: Permitted Development Rights at **https://hansard.parliament.uk/Lords/2024-12-18/debates/8A51B8CF-BB26-4DE1-96D6-F6400D83A222/HousingPermittedDevelopmentRights**; See also **https://www.tcpa.org.uk/resources/permitted-development-rights-health-and-housing-parliamentary-briefing/**
194. Callway, R. and Ellis, H. 2025, The category error of planning deregulation, at: **https://www.newstatesman.com/spotlight/economic-growth/2025/09/the-category-error-of-planning-deregulation**
195. Grove-White, A., & Callway, R. 2024. The SALUS healthy cities design congress, session review: healthy homes panel debate: facing up to the health impact of planning deregulation in England. *Cities & Health*, *8*(5), 846–849. Available at: **https://doi.org/10.1080/23748834.2024.2349392**
196. TCPA 2026, Hot Housing: Why is the government still permitting overheated office conversions? at: **https://www.tcpa.org.uk/hot-housing-why-is-the-government-still-permitting-overheated-office-conversions**

> '*The new permitted development rights allow change of use from B1 (a) offices to C3 residential. They will provide badly needed homes for local people and will make a valuable contribution to easing our national housing shortage. By bringing underused offices back into effective use they will also help create jobs in the construction and services industries, and help regenerate our town centres and former commercial areas*.'

The General Permitted Development Order 2013 allowed Offices (use class B1(a)) to be converted to residential uses (use class C3), and was only subject to appraisal of potential flooding, highways, transport and contamination impact.

Prior to the rule change, there was a consultation in April 2011, where local authorities could ask to be exempted from the new right but only on the basis of 'either national or local economic impacts'.[197] In 2015, the Coalition Government went on to further expand the application of PDR through the Town and Country Planning (General Permitted Development) Order (England) 2015 (as amended).[198, 199] Since that date, several further amendments have been introduced, as outlined in Table 1 of this report. Conversion to residential use peaked in 2016/2017 at 10% net new homes, and has since steadied to around 7–9,000 units per annum – less than half the total number of buildings being converted to residential use through the full planning system.

Several groups have raised concerns about the quality and location of homes produced through permitted development rights (PDRs) in England, since the rules were changed in 2013. In a review of the planning system in 2018,[200] the TCPA, critiqued PDR changes as undermining local government's capacity to protect local amenity and public interests – and stated that the government had failed to 'provide any systematic analysis of the impacts of major policy initiatives, such as the expansion of permitted development rights'. A BBC Panorama programme in 2020 highlighted some of the worst conditions residents were experiencing.[201]

197. DCLG 2013, Explanatory memorandum to the Town and country Planning (General Permitted Development) Amendment) (England) Order 2013 at: **https://www.legislation.gov.uk/uksi/2013/1101/pdfs/uksiem_20131101_en.pdf**
198. Pickles, E. 2015, Planning Update: Statement made on 25 March 2015, at: **https://questions-statements.parliament.uk/written-statements/detail/2015-03-25/hcws488**
199. UK Government 2015, The Town and Country Planning (General Permitted Development) (England) Order 2015 at: **https://www.legislation.gov.uk/uksi/2015/596/contents**
200. TCPA 2018, *Planning 2020: Raynsford Review of Planning in England*. Available at: **https://tcpa.org.uk/wp-content/uploads/2022/03/Planning-2020-Raynsford-Review-of-Planning-in-England-Final-Report.pdf**
201. BBC News, 2020, What's it like living in a converted office block? at: **https://www.bbc.co.uk/news/av/uk-51363012**

As already discussed, research led by the UCL Bartlett School of Planning found in 2020 that homes created through PDRs resulted in "worse quality residential environments" than those that required planning permission from the LPA, and asked whether we are creating the right type of housing, in the right places".[202] The Housing, Communities and Local Government Committee expressed concerns that some homes delivered through PDRs were "of poor quality and situated in unsuitable places". The Local Government Association also raised concerns that local Planning authorities (LPAs) could not require developers to deliver affordable housing or contribute to community infrastructure for PDR schemes.[203] In 2020 and 2021, the UK Government made minor changes regarding PDR housing conditions to ensure access to natural light and minimum space standards but they did little to address the wider concerns about the poor conditions and location of PDR housing.

Various reporters met PDR residents and described the poor housing conditions they had found.[204] Visting former office blocks on isolated industrial estates in Harlow, Vicky Spratt (I–News) met residents stuck in temporary accommodation in dire conditions, including a single mum living for five years in a one bedroom flat with her four children. And a single dad of three, housed for six years in a small ground floor flat – exposed to damp and noise from neighbours, and miles from the nearest school or shops.[205] When she raised these issues in an interview with the then Housing Minister, Michael Gove, he said acknowledged the situation was 'deeply concerning.[206]

The TCPA produced a photobook 'These are homes' in 2023 to highlight the dire consequences of this deregulatory drive.[207] They pressed for reform in parliament, championed by crossbench peer Lord Nigel Crisp (former chief executive of the NHS England). Lord Crisp introduced a Healthy Homes Bill (2022–23) – a private members bill which aimed to establish a comprehensive basis for housing standards – including for PDR housing – in order to protect residents from the worst effects of the rule changes.[208]

202. Clifford, B., Canelas, P., Ferm, J. Livingstone, N., Lord, A. and Dunning, R. 2020. *Quality standard of homes delivered through change of use permitted development rights*. MHCLG. Available at: **https://www.gov.uk/government/publications/quality-standard-of-homes-delivered-through-change-of-use-permitted-development-rights**
203. Rankl, F. 2024, Planning in England: Permitted development and change of use at: **https://commonslibrary.parliament.uk/research-briefings/sn00485/**
204. Apps, P, 2024, The office-to-residential conversions which have become slum housing at: **https://www.insidehousing.co.uk/home/the-office-to-residential-conversions-which-have-become-slum-housing-84138**
205. I–News 2023, I was housed temporarily in an office block five years ago – I'm still here at: **https://inews.co.uk/news/housed-temporarily-office-block-five-years-still-here-2806779**
206. The I–paper 2023, Inside the UK's 'human warehouses' at: **https://www.youtube.com/watch?v=yHfQaxvmX1M**
207. TCPA 2023, These are Homes photobook at: **https://www.tcpa.org.uk/these-are-homes-photobook/**
208. House of Lords 2023, Healthy Homes Bill [HL] at: **https://bills.parliament.uk/bills/3171**

A narrative of deregulation unsupported by evidence

While in opposition, the Labour party broadly supported the Healthy Homes Bill, as the then shadow housing minister stated:

> *'We fully support the principles of [the Healthy Homes] campaign. We disagree with the government that the issue is already addressed...'*
> Shadow Housing Minister, Matthew Pennycook MP, 17 Oct 23 (Hansard)

However, once in government the language depicting planning as a 'blocker' to housing supply was co-opted by Labour's Minister of Housing, Steve Reid MP, when in 2025 he described the need 'to rip up planning laws' in order to 'Build Baby Build'.[209] Underpinning this rhetoric was a strong emphasis on deregulation to boost housing supply as an low cost means to stimulate GDP growth.[210] It fails to recognise that planning policy and regulations are safeguards which aim to protect and promote the safety, quality and location of those homes, i.e. that housing standards are a key determinant of people's health.[211, 212]

What is clear is that the PDR rule changes were never about promoting housing standards or ensuring health outcomes for those living in such converted buildings. Indeed, there was no appraisal of the potential health impact (beyond loss of 'amenity') of the GPDO 2013 and GPDO 2015 legislation when they were introduced.[213, 214, 215] However, as evidence from this project illustrates, all too often PDR housing is used for people with a range of complex needs, sometimes together in one building, sometimes in isolated unsuitable locations with limited access to vital support systems. Such environments will not produce safe, secure or healthy homes for vulnerable people, including those with protected characteristics.

The emphasis of the PDR changes was about increasing the supply of housing numbers and seemingly blaming planning rules as getting in the way – despite evidence to the contrary. From the outset, the TCPA and others have contested this deregulatory position as unsubstantiated by the evidence,216 noting that there has been;

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209. LBC 2025, Labour 'to rip up planning laws' to prevent locals from blocking housing using lengthy judicial reviews at: **https://www.lbc.co.uk/article/labour-rip-up-planning-judicial-review-housing-5HjdFKG_2/**
210. MHCLG 2025, Pro-growth package unshackling Britain to get building, at: **https://www.gov.uk/government/news/pro-growth-package-unshackling-britain-to-get-building**
211. Marmot M. 2010 *Fair society: health lives. Strategic review of health inequalities in England post-2010. London: The Marmot Review.* Available at: **https://www.parliament.uk/globalassets/documents/fair-society-healthy-lives-full-report.pdf**
212. WHO (2018). *WHO housing and health guidelines*. Geneva: World Health Organization; Available at: **https://www.who.int/publications/i/item/9789241550376**
213. MHCLG 2025, Reducing planning regulations to support housing, high streets and Growth: Impact Assessment at: **https://www.legislation.gov.uk/ukia/2015/211/pdfs/ukia_20150211_en.pdf**
214. TCPA 2018 Planning 2020: Raynsford Review of Planning in England at: **https://tcpa.org.uk/wp-content/uploads/2022/03/Planning-2020-Raynsford-Review-of-Planning-in-England-Final-Report.pdf**
215. Marsh, R, Chang, M and Wood, J, 2022, The Relationship between Housing Created through Permitted Development Rights and Health: A Systematic Review. *Cities & Health*, 6(4), 833–52. Available at: **https://doi.org/10.1080/23748834.2020.1833281**.
216. Callway, R. and Ellis, H. 2025, The category error of planning deregulation, at: **https://www.newstatesman.com/spotlight/economic-growth/2025/09/the-category-error-of-planning-deregulation**

> *'no comprehensive econometric study of the full benefits and costs of the English planning system has ever been undertaken. This is a remarkable fact, given the crude way planning is dismissed as a burden on growth. It ignores the health and wider societal costs of failing to provide decent housing – conservatively costed at more than £18.5bn every year, according to the Building Research Establishment.'* (TCPA, 2025)

Examining the rates of planning consent and build out rates over the last decade would suggest wider market factors are an important part of the explanation for the undersupply of housing. The MHCLG Live Tables on housing supply over the last 13 years indicates that planning approval for new homes frequently exceeded 300,000 homes a year but that the delivery of those approved homes rarely surpassed 200,000. Indeed in 2025, nearly 600,000 homes received full or outline planning consent – yet again, only 200,000 new homes were actually built.

The planning sector has undoubtedly faced challenges, in terms of the resourcing and capacity to turn around consents and ensure developers meet planning conditions.[217] There will also be a time lag between a scheme receiving planning approval and the developer building those homes but there are more significant market factors at play in the under provision of housing. This includes issues like the market absorption rate – where housing developers will not supply new homes at a rate that will reduce the price they can achieve, to ensure assumed returns on investment.[218]

Furthermore, despite these arguments about deregulation helping to boost housing supply, since the extension of PDR rules in 2015, PDR housing has contributed approximately 6% of the total number of new homes. Local authority participants in our research questioned whether these relatively small numbers of homes made the PDR changes justifiable:

> *'PDR does not count for a big percentage of housing coming forward – A sense check is needed about whether it is worth it for such a small percentage.'* Planning officer

> *'We have found no evidence in [City name] that PDR has boosted housing numbers'* Planning officer

217. RTPI 2024, Report reveals £70 billion in additional value could be lost without investments into planning at **https://www.rtpi.org.uk/new-from-the-rtpi/report-reveals-70-billion-in-additional-value-could-be-lost-without-investments-into-planning/**
218. CMA 2024. *Housebuilding market study. Final report*. CMA. Available at: (**https://assets.publishing.service.gov.uk/media/65d8baed6efa83001ddcc5cd/Housebuilding_market_study_final_report.pdf**

It is also notable that in 2025, the Scottish government conducted their own a public consultation to consider whether they would extend PDR to convert non-residential buildings, particularly in rural towns. In March 2026, on reviewing the evidence they received, the Scottish government decided not to proceed with extending PDR rules,[219] referring to 'limited support for, and significant opposition to, the introduction of PDR for new-build homes in rural areas'.

Legislative and policy findings

The review of PDR housing levers in England, consultation with local and national actors, and the wider project findings, point to the following findings:

- **A legacy of poor-quality PDR housing will exacerbate health inequalities:** Deregulation via PDR rule changes since 2013 has produced too many unhealthy and unsafe homes, increasing the risk of exacerbating health inequalities, especially for vulnerable people housed in temporary PDR accommodation.
- **Deregulation undermines local placemaking and resources:** PDR rules have increased planning complexity, reduced resources and significantly reduced the levers available to local government to shape their areas and communities.
- **Regulatory gaps and weak enforcement put residents at risk:** gaps in Building Regulations around the change of use to residential use include structural safety, fire risk from external cladding, inaccessibility, and overheating.

The following section looks at these three areas in turn.

A legacy of poor-quality PDR housing will exacerbate health inequalities

MHCLG data records that over 120,000 homes have been produced via PDR since 2013[220]. Too often the result has been unhealthy, isolated and sometimes even uninhabitable conditions. According to this data, the majority of PDR housing produced between 2013 and 2025 was by the conversion of former offices into flats (see Figure 45).

219. Scottish Government 2026, Permitted development rights to support provision of new homes at: **https://consult.gov.scot/planning-architecture/potential-development-rights-new-homes-provision/**
220. MHCLG 2026. Live tables on housing supply: net additional dwellings at **https://www.gov.uk/government/statistical-data-sets/live-tables-on-net-supply-of-housing**

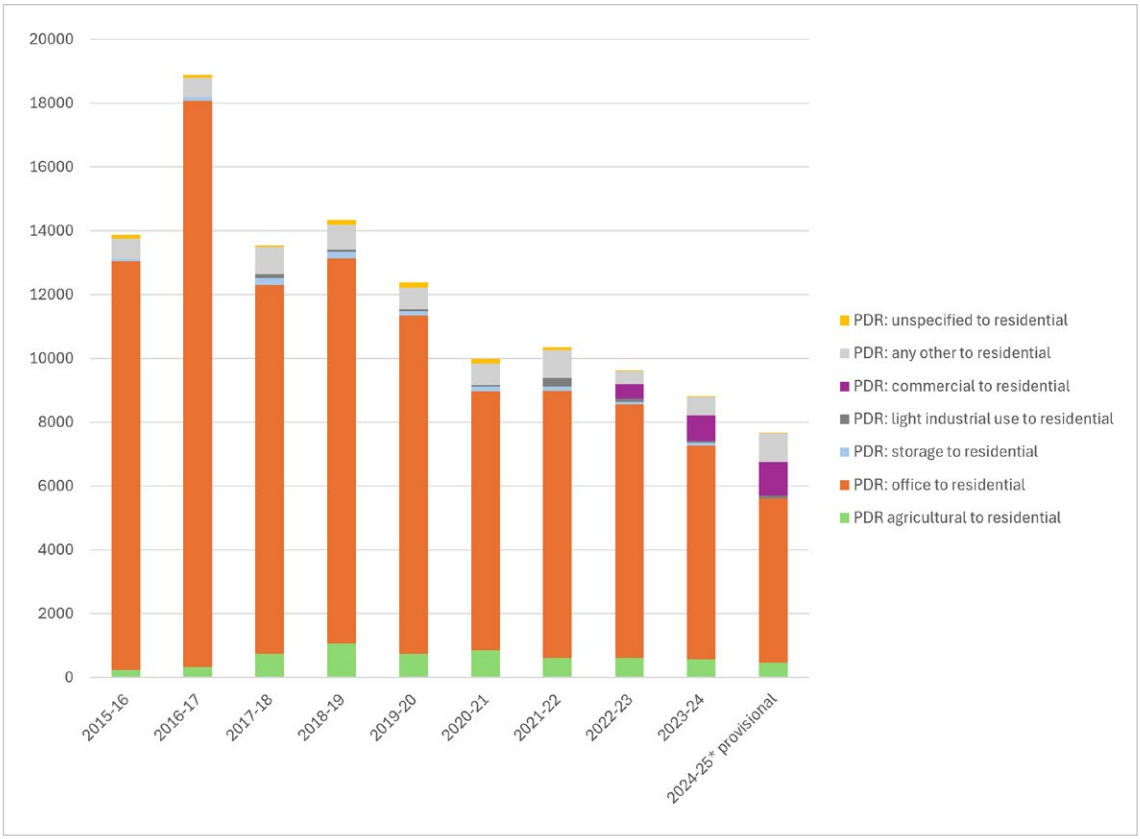


Figure 45: Total additional PDR dwellings in England by type of conversion, 2015–2025 (Data source: MHCLG, 2026)

As discussed under Work Package 1, a high proportion of PDR housing is concentrated in London and the South east, but have also been identified in other cities, such as Bristol, Leicester, Manchester, and Reading. Frequently, these conversions have been in buildings at the end of their commercial use. As one public health officer commented, it is 'entirely inappropriate' to see PDR conversion of ageing buildings that were near the end of life for commercial purposes used to house people. An environmental health officer agreed, suggesting that many PDR buildings 'would not last another 20 or 30 years without external repairs'. Others raised concerns that some developers involved in converting such buildings had little (financial) incentive to ensure buildings were converted to a good standard:

> *'PDR was about quick wins, a fast buck for dodgy developers. They are not going to be interested in investing in keeping properties up to date.'* Planning officer

The findings from this research, and elsewhere, suggest that those being housed in PDR conversions include some of the most vulnerable groups of people from disadvantaged backgrounds.[221] Too many homes produced through PDR are of such poor quality that they are only used to house those with the least choice and agency over where they can live and the conditions they in. Those living in PDR temporary accommodation include victims of domestic abuse and their children, people with substance abuse issues, people (adults and children) with mental health conditions and neurodiversity conditions.

The earlier UCL study for MHCLG, examined PDR housing in eleven LPAs in England. It found that the larger building conversions, typically former offices, tended to be poorer quality for residents. They noted, 'lower quality housing is more likely to be produced in areas where there are higher levels of deprivation and where office markets are suffering from a lack of demand and obsolescence' (UCL 2020, pp10 & 70–71).

Unlike with full planning applications, there are very limited (to no) requirements in the GPDO 2015 to consider health impacts when taking decisions on PDR prior approval applications, regarding impacts to individual health and wider community. The national review of the PDR rules by the TCPA,[222] applied twelve evidence-based Healthy Homes principles[223] to examine the degree to which homes produced through PDR would be expected to address each principle. The review found that none of the principles were fully addressed through PDR rules except, to a limited extent, on indoor space standards – which were made an additional condition for PDR housing in 2021. Even on space standards however, residents in PDR housing still report facing overcrowded and inadequate space provisions, including lack of outdoor amenity space. And Local Authorities reported instances of developers installing more flats that had been agreed at prior approval.

Earlier research, alongside the resident surveys, interviews, and monitoring from this project, show PDR housing presents multiple problems - across all tenures - likely to harm physical, mental and social health outcomes for residents, and not only for those residents living in temporary accommodation.[224, 225] PDR resident participants reported very poor quality and insecure conditions, especially those in temporary accommodation.

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221. Del Canto, N. 2026, Planning Deregulation and Commodification: How Is Housing Precarity Structurally Encouraged through Permitted Development Rights?' *Environment and Planning A: Economy and Space* 58(5), 680–97. Available at: **https://doi.org/10.1177/0308518X261438248**.
222. TCPA 2024, *Permitted development, housing and health: a review of national policy and regulations*. TCPA. Available at: **https://www.tcpa.org.uk/resources/permitted-development-housing-and-health-a-review-of-national-policy-and-regulations/**
223. TCPA 2025, Healthy Homes – what's the evidence? at: **https://www.tcpa.org.uk/wp-content/uploads/2023/02/HH-principles-and-evidence-V2.pdf**
224. Marsh, R, Chang, M and Wood, J, 2022, The Relationship between Housing Created through Permitted Development Rights and Health: A Systematic Review. *Cities & Health*, 6(4), 833–52. Available at: **https://doi.org/10.1080/23748834.2020.1833281**.
225. Clifford, B., Pineo, H., Aldridge, R. and Eyre, M. 2023. *An exploratory study investigating the health and wellbeing impacts of housing created through permitted development in London*. UCL. Available at **https://www.ucl.ac.uk/bartlett/sites/bartlett/files/ucl_pd_housing_and_health_study_-_may_202350.pdf**

Common problems include no provision of outdoor space, overheating in summer, feeling unsafe, exposure to excess cold and damp in winter, exposure to noise – linked to the poor insulation of PDR flats particularly the former office blocks – as well as overcrowded and poor space provisions.

> *'Doing development by the backdoor has allowed developers to build as quickly as possible, as low quality and as cheaply as possible and with no green spaces.'* Public health officer

Such poor conditions are unsuitable for families or vulnerable individuals. And building managers and landlords often seemed ill-equipped to manage the needs of PD residents, especially those in temporary accommodation. Figure 46 is an illustrative example of a ground floor bedroom used for three children in a PDR flat in a former office block in Harlow. There was no space for a cupboard. Neighbours could be heard through walls and from the flats above. There was damp and the windows and the blinds were kept shut all day long to avoid people looking in as they passed by outside.

By limiting the opportunity to shape housing quality, PDR rules are in direct contradiction with legislation and government guidance which recognise that 'The design and use of the built and natural environments, including green infrastructure are major determinants of health and wellbeing'.[226] Section 14Z42(4)) of the Health and Care Act 2022[227] states that the provision of housing accommodation is a health-related service, as a determinant of health, and thereby requires local authorities to secure the quality of housing conditions and address health inequalities as a part of an integrated health care service. More recently, Clause 45 of the English Devolution and Community Empowerment Act 2025 establishes a new health duty on strategic authorities which also explicitly recognises housing standards as a key determinant of health.

226. MHCLG 2022, Healthy and safe communities at: **https://www.gov.uk/guidance/health-and-wellbeing**
227. UK Parliament 2022, Health and Care Act 2022, at: **https://www.legislation.gov.uk/ukpga/2022/31/data.pdf**



Figure 46: A ground floor bedroom used for three children in a PDR flat in a former office block in Harlow.

The findings generally indicate that poor-quality PDR housing contributes to widening health inequalities by concentrating adverse housing and environmental conditions among residents and communities with fewer housing choices and greater existing vulnerabilities. The failure to consider the health impact of PDR rule changes at the outset, and during PDR approvals, has led to the production of converted housing that is exposing residents to multiple housing problems regarding the location and quality of those homes – especially for residents from more vulnerable backgrounds. It is vital that the UK Government reconsiders the impacts to residents' health and health inequalities before continuing to apply PDR rules in this way.

Deregulation harms local placemaking and resources

The conversion of empty buildings that are in the right location and to a habitable standard is arguably worthwhile – to meet urgent housing needs and use the existing embodied carbon of those buildings.[228] But as change of use conversion is already possible through the democratic and discretionary planning process, surely more fundamental questions should be asked: What kind of homes and places are we trying to create, and for who? Planning policy and regulations are there for clear reasons – as safeguards to protect people from harm and to promote healthy and vibrant homes and communities.

228. Ermgassen, S. O. S. E. zu, Drewniok, M.P., Bull, J.W. et al 2022. A Home for All within Planetary Boundaries: Pathways for Meeting England's Housing Needs without Transgressing National Climate and Biodiversity Goals. *Ecological Economics*, 107562. Available at: **https://doi.org/10.1016/j.ecolecon.2022.107562**.

The original intention of PDR when introduced in 1943 was to speed up planning approval for very minor extensions or changes to buildings. These rules were never intended to be used to undercut the place-based intentions of national and local planning policy. By avoiding planning policies PDR directly undermines these local place-based objectives.

Previous reviewsand many of the local authorities we spoke to described how PDR directly limits their ability to deliver local plan policies that aim to promote healthy placemaking in local communities. [229, 230]

> *'Not sure there is a half-way house. Either PDR policy or full planning – which [place-based] issues would you pick up and which would you drop? Different local authorities will have different priorities – open space, affordable housing needs vary. [It is] very hard to set these at the national level.'* Planning officer

Based on this evidence, we find that PDR rules changes harm healthy placemaking in five ways:

i. Limited powers on where PDR conversion can take place
ii. Limited scope of prior approval conditions
iii. Limited powers to address unhabitable conditions and nuisance
iv. Reduced resources from Section 106 agreements
v. Increased planning burden

First, PDR rules have directly undermined a council's ability to define the best locations and type of housing to meet local needs. This has meant PDR housing in locations that expose residents to environmental pollutants or 'statutory nuisances' – such as noise, dust, fumes, soil and water pollution – also risking liabilities to surrounding industries and businesses. Article 4 Directions (A4Ds, which provide English authorities with powers to define specific areas where PDR cannot apply) are very limited in scope. Local authorities reported challenges in making A4Ds, in part due to the National Planning Policy Framework (NPPF) requirements and geographic restrictions.

> *'The bar for the justification and rationalisation of Article 4 directions have changed and it is harder to prove their case. Street by street evidence is needed and businesses in the community have lobbied against it. There is little interest in the evidence of poor quality, and we had to play to loss of economic growth as a consequence.'* Planning officer

229. TCPA 2018 Planning 2020: Raynsford Review of Planning in England at: **https://tcpa.org.uk/wp-content/uploads/2022/03/Planning-2020-Raynsford-Review-of-Planning-in-England-Final-Report.pdf**
230. Slade, D., Dangerfield, J., and Ellis, H. 2020 *No Place for Placemaking.* **TCPA. Available at: https://www.tcpa.org.uk/resources/no-place-for-placemaking/**

These limitations mean that PDR housing can still be permitted in active, noisy and polluting industrial estates, alongside major roads, and busy high streets. Such sites expose residents to additional noise and air pollution (as evidenced by the location analysis under Work Package 1) and can limit access to outdoor private space and recreation. This issue is illustrated by Crawley Borough Council,[231] who described how PDR residents in industrial locations experienced operations running night and day, with residents subjected to noise, fumes, vibrations, and vehicle movements, including heavy goods vehicles. Local authorities surveyed also referred to high street challenges, where ground floor retail premises are converted into residential use expose residents to street traffic, commercial noise and impact their privacy. Even for agricultural-to-residential conversions, local authorities said that while they might be better quality conversions (and typically smaller and higher value), their location was a concern regarding their distance from public transport, amenities and health care, i.e. built-in car dependency.

The latest National Planning Policy Framework (NPPF) published in 2026,[232] may increase the scope of application of A4Ds somewhat. NPPF policy DM10 says PDR can be removed by A4D but only in 'situations where it is necessary to protect local amenity or the wellbeing of the area' when application of PDR 'could affect the quality of life such as small Houses in Multiple Occupation, or supporting the vitality and viability of parts of town centres'. The application of A4D remains very constrained however – it must still be supported by unspecified 'robust' evidence and can only be applied to 'smallest area required to mitigate the evidenced harm'.

Second, the prior approval conditions outlined in the GPDO 2015 are very limited in scope (compared to Local Development Plans), and there is variation about which conditions local authorities can ask for across the different use classes of buildings being converted (see Table 33). For example, when converting a commercial use-class (MA/E) building to residential use LPAs cannot require design conditions, such as regarding provision of an adaptable / accessible internal layout, higher insulation standards to improve energy performance and reduce noise ingress from neighbours, or require dual aspect windows to support ventilation.

> *'The difficulty is, there are so many different classes within the GPDO, it is a minefield for planning officers to know what conditions they can apply and then make a decision on whether it is appropriate and won't go to appeal...We need consistency for prior approval. It would all be solved if we didn't have PDR and everything went through the planning system.'*
> Policy officer

231. Crawley Borough Council, 2021, Written evidence submitted by Crawley Borough Council, at: **http://committees.parliament.uk/writtenevidence/26750/pdf/**
232. MHCLG. 2026, National Planning Policy Framework at **https://www.gov.uk/guidance/national-planning-policy-framework**

Table 33: Prior approval conditions permitted for different building use classes – as defined by GPDO 2015

Use class **Prior Approval conditions**	**M**	**MA**	**N**	**Q**	**O**
Transport and highways impacts	Y	Y	Y	Y	Y
Contamination risks	Y	Y	Y	Y	Y
Flooding risks	Y	Y	Y	Y	Y
Noise impacts of the development	N	N	N	Y	Y
The impact of the change of use on the adequate provision of laundrette services	Y	Y	N	N	N
Whether the location or siting makes the change of use impractical or undesirable, for example if the building is in a remote location.	N	N	N	Y	Y
The design or external appearance of the building.	Y	N	N	Y	N
Compliance with Nationally Described Space Standards	Y	Y	Y	Y	Y
Development must be completed within 3 years, starting with the prior approval date.	Y	Y	Y	Y	Y
Where the proposal is for a change of use and an extension of the building, the impact of the proposed extension on the amenity of any adjoining premises.	N	N	N	Y	N

Third, due to the limited range of Prior Approval conditions that authorities can apply before a conversion takes place – public health and environmental health officers described their frustrations in trying to respond to the unhabitable conditions and statutory nuisances arising from PDR housing 'after the horse has already bolted'. For example, focusing specifically on noise, the Crawley Local Plan 2015 (Policy ENV11) sets out local noise standards for new housing – recognising noise impact becomes harmful to human health when it is greater than 60 decibels (dB), the Unacceptable Adverse Effect level. This policy cannot be applied to PDR applications however.

> *'the Local Plan approach to managing noise has been found sound and NPPF compliant, yet PDR continues to undermine a sound policy that is in place to ensure a good quality of life for residents. The omission of transport noise consideration therefore represents a significant flaw in the permitted development rights, as it stands enabling residential accommodation to be created in areas where transport noise is significantly above the unacceptable level, and which would not allowed were planning permission to be required.'*

The GPDO 2015 considers the impacts of noise from any commercial premises on intended occupiers but not the impact of noise from transport sources likely to occur on active industrial estates. This means residents can be exposed to unacceptable noise impacts that can result in sleep disturbance and resultant long-term health impacts. The omission of transport noise from PDR rules resulted in cases where:

'occupiers are exposed to daytime noise from surface transport of 77dB, and 73dB (façade level) at night, well beyond the limits that could be applied were planning permission to be required...'

Fourth, PDR housing reduces financial contributions from developers towards affordable housing and amenities locally, vital for meeting local housing needs, as well as contribute to the provision of key services such as school spaces and health care services. In England, the Local Government Association (LGA) has estimated that, since 2013, PDR housing conversion has cut developer contributions by the equivalent of at least 28,000 affordable homes through lost Section 106 agreements since 2015.[233] This could be addressed through amendment of Regulation 122 of the Community Infrastructure Levy Regulations 2010. The regulations set out the circumstances under which planning obligations can be entered into under Section 106 Agreements and currently refers specifically and solely to 'planning permission' – that definition could be updated to include consents under PDR.

Fifth, PDR rule changes have increased the planning burden for authorities. Instead of helping to simplify development requirements for building conversions, PDR rules have produced a 'shadow' planning system which undermines local discretion and democratic processes.[234] Planning officers said that PDR rules have increased their administrative burden, reducing the time allowed to scrutinise applications and cut the fees paid to authorities to undertake that work. This is happening at a time when public authorities are already extremely overstretched and under resourced.

Regulatory gaps and weak enforcement put residents at risk

The review and consultation with local government outlined additional challenges regarding building control that relaxed PDR rules have created for local authorities. In a national survey, authorities were asked; 'What are the key challenges that can limit the effective management of the quality &/or location of Permitted Development conversion to residential use?'. 43% of survey respondents referred to under-resourcing of enforcement of regulations. Significant concerns were also raised about the limited scope of PDR rules and building regulations regarding buildings undergoing a Material Change of Use (Figure 47).

233. LGA, 2025, **New LGA analysis shows nearly 28,000 affordable homes lost due to permitted development rights** at: **https://www.local.gov.uk/about/news/new-lga-analysis-shows-nearly-28000-affordable-homes-lost-due-permitted-development**
234. TCPA, 2026. **From slums to homes – the story of the Campaign for Healthy Homes** at: **https://www.tcpa.org.uk/from-slums-to-homes-the-story-of-the-campaign-for-healthy-homes/**

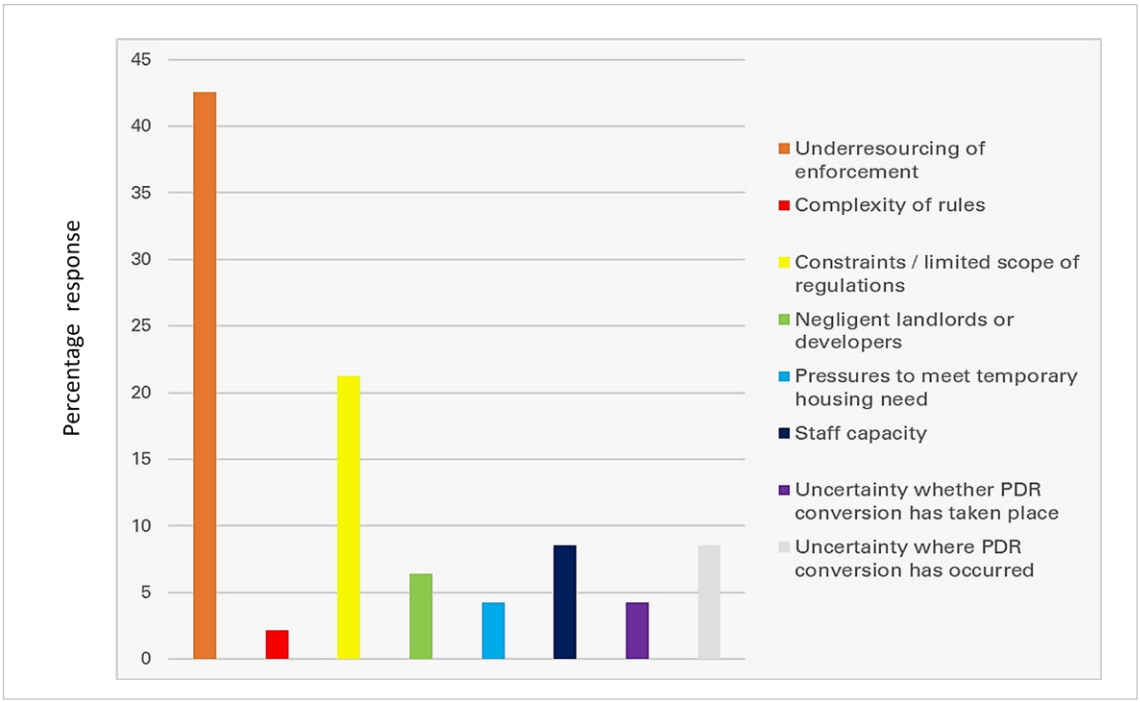


Figure 47: Key challenges reported by local authorities limiting their capacity to shape the quality of PDR housing (% responses)

In relation to enforcement, within local authorities, planning, development management, building control and environmental health teams are all under-resourced. There is a severe lack of capacity in housing enforcement in many locations. This can be particularly problematic in the case of PDR housing where lower quality housing has sometimes been developed from the start due to planning deregulation but then is also not being effectively regulated through building control, environmental health and housing regulations either. Further, there are a number of PDR buildings where fire safety concerns have come to the fore after they have been occupied by residents.[235]

In relation to building control specifically, there are around 300 Registered Building Control Authorities (RBCAs) in England. Sector-wide concerns have been raised about their capacity to check and enforce compliance and there are reported challenges with recruitment. As the Building Control Independent Panel, chaired by Dame Judith Hackitt, found:

> *'The public sector system of building control has been progressively neglected, with [RBCAs] unable to sustain the level of advice, oversight and enforcement expected of them for all building work on a consistent basis.'*[236]

235. For example, in Croydon enforcement action was taken in 2018 against the landlord of 5 Sydenham Road (**https://www.yourlocalguardian.co.uk/news/17186054.croydon-landlords-fined-32-000-fire-breaches-unlicensed-flats/**) and there was a fire in 2022 at Sycamore House (**https://www.croydon.gov.uk/sites/default/files/2024-12/2023-2024-internal-audit-sycamore-house-implementation-of-lessons-learned.pdf**) whilst in Harlow, Joesph Rank House was evacuated in 2024 (**https://www.insidehousing.co.uk/news/large-housing-association-to-demolish-essex-office-block-conversion-due-to-fire-risks-80055**) and Redstone House in 2025 (**https://www.bbc.co.uk/news/articles/cdj2j8g7l40o**)
236. Building Control Independent Panel 2026. Building Control Independent Panel Report at **https://www.gov.uk/government/publications/building-control-independent-panel-report/building-control-independent-panel-report**

The panel's findings raise significant concerns regarding housing standards more broadly, but especially for people living in PDR housing, where the quality of work appears to be at greater risk of weaker scrutiny and checks. Interviews with built environment professionals pointed to examples where certain developers were not applying Building Control checks to PDR housing projects. It was felt this was due to the misconception that Building Control was unnecessary for an existing building that has previously undergone such checks, or perceptions that buildings which had received approval from Planning departments demonstrate compliance with the Building Regulations or the Fire Safety Order 2005 (as amended).[237] To be clear, this means there is an unknown number of buildings undergoing a 'Material Change of Use' (MCU) to residential use that may NOT have applied the necessary Building Control checks to ensure they are meet safety minimum requirements.

The TCPA review identified multiple loopholes that exist in Building Regulations regarding the conversion (or MCU) of non-residential buildings to residential use, whether through full planning or under PDR. The following building regulations do not apply for MCU converted dwellings or flats, as defined in **Part 2, section 5 of Building regulations 2010**:

- A1 to 3: Structure
- Reg 6(3): Fire standard for external wall materials (in buildings under 11 meters)
- C2: Resistance to moisture
- K: Falling, collision or impact
- M1 to 3: Visitable and accessible dwellings
- O: Overheating

These gaps raise significant concerns regarding the safety of residents in buildings converted to residential use – especially those buildings which may have structural issues, or fire safety concerns if they applied external wall systems that do not meet Reg 6(3) and fall below 11 meters in height. Even minimum requirements on accessibility and overheating are not required for MCU residential conversions,[238] producing flats that are unsuitable and potentially unsafe, especially for families with young children, older people, or for people with disabilities.

> '*...when it is hot or humid we can't physically breathe on our floor, we all have to have all the fire escapes open, which is illegal for a start.*'
> PDR resident

237. NFCC 2025. Planning Policy Position Statement. Part 3. Permitted Development Rights at: **https://nfcc.org.uk/our-services/public-policy/position-statements/planning/**
238. TCPA 2024. Quick office-to-housing conversions will risk residents' health, according to new TCPA research at: **https://www.tcpa.org.uk/quick-office-to-housing-conversions-will-risk-residents-health-according-to-new-tcpa-research/**

'You can't open the windows because of security issues; therefore, there's no air in here. It's a Catch 22.' PDR resident

'These doors are not child-friendly or disabled-friendly … I see my neighbour with a wheelchair and they need all the time help to get in or out." PDR resident

These gaps are particularly a concern in relation to the potential risks of overheating in large former office blocks – as identified by this research – especially since minimum Part O regulations still does not apply to MCU residential conversions and currently only applies to new builds. There is an opportunity to address this gap on overheating in MCU residential buildings when Part O of Building Regulations are reviewed.

Specific building control recommendations: Based on these concerning findings we propose the following specific recommendations to the Government regarding the application of building regulations on buildings undergoing a material change of use to residential purposes:

- Adopt the recommendations of the **Building Control Independent Panel report**, including moving building control back under, properly resourced, independent public control[239].
- Extend the application of approved documents A1 to A3, M1 to 3, C2, K, and O for buildings undergoing MCU for all residential use classes – i.e. regulations: 5(a), 5(b), 5(g), 5(h), and 5(i), as defined in Part 2 of the Building Regulations 2010.
- Amend the Building Regulations 2026 to include requirements for MCU to residential uses – i.e. regulations: 5(a), 5(b), 5(g), 5(h), and 5(i), as defined in Part 2 of the Building Regulations 2010.
- Apply the Reg 6(3) standard for external wall materials to all MCU to residential use, to ensure external walls (or specified attachments) only contain materials in line with European Classification A2-s1, d0 or A1 (and not just for regulation 5(k)).

239. Building Control Independent Panel 2026. Building Control Independent Panel Report at **https://www.gov.uk/government/publications/building-control-independent-panel-report/building-control-independent-panel-report**

Conclusions: PDR rules undermine public health duties on housing

The recognition by the Government of housing standards as 'determinants of health' in the Heath Care Act 2022 and the English Devolution and Community Empowerment Act 2026 make it clear that decisions taken regarding the location and quality of homes contribute directly towards achieving public health improvements and reducing health inequalities. Public authorities must be supported in ensuring that those buildings used to house people are of good quality and well connected to communities, amenities and work, in order to meet that health duty, as part of an integrated health care service.

The evidence produced by this and other research indicates that Permitted Development Rights as written in the GPDO 2015 (and later amendments) are undermining public authorities' ability to deliver their duties regarding meeting housing improving public health, reducing health inequalities and meeting housing standards. We have found that the PDR rules are damaging as they:

- prohibit consideration of the impact of such conversions to health improvement and reducing hearth inequalities;
- harm local placemaking and public resources used to shape that health creation; and
- expose residents to unnecessary risk of harm, especially vulnerable residents.

As such, urgent action is required to prevent and remediate the human cost of PDR housing – for existing residents most immediately and for future residents.

Consultation with local government and other professional bodies has indicated there is a need to support authorities in preventing and minimising the negative outcomes from PDR housing conversions for residents and wider local communities. Until PDR housing rules are changed, UCL and TCPA have committed to co-produce with local and national partners local guidance and case studies, to support their use the limited levers that are currently available to them. However, what is required is regime change to return powers to local government to enable them to better shape the quality of housing, including those produced through the conversion of buildings.

The overall conclusions section of this report (below) outlines our legislative and policy recommendations – in the short and longer term – to address the consequences of this harmful and short-sighted policy.



Overall conclusions

Key research findings

Allowing the conversion of office buildings to residential use without full planning permission, under 'permitted development rights' was a significant deregulation of the planning system by the Coalition Government in 2013. This has been followed by various expansions since so that the majority of commercial buildings (offices, retail and associated units, light industrial units) can now theoretically be converted to residential use under PDR, as can agricultural buildings. Although some additional regulatory safeguards have been introduced over time, most notably a requirement for adequate natural light to all habitable rooms in 2020 and compliance with Nationally Described Space Standards (NDSS) in 2021, there are still significant differences between permitted development prior approval and full planning permission and a large quantity of now occupied housing created through conversions from 2013–2019.

Previous studies have demonstrated that PDR has created on average poorer quality housing than comparable conversions through full planning permission, with a number of issues around space standards, poor window arrangements, the mix of units within conversions and access to outdoor space being particularly highlighted. At the same time, drawing on existing studies, a number of potential pathways by which these housing conditions might negatively impact health and wellbeing have been highlighted.

No existing research has, however, investigated comprehensively who the residents of PDR housing are, environmental conditions within the dwellings, everyday experiences of living in such housing and health and wellbeing implications of this.

It is increasingly recognised that the built environment is a fundamental determinant of population health, with a vital relationship between planning and public health. Within this, housing is an important determinant of health with multiple, complex pathways linking the quality of housing to a range of physical and mental health outcomes. There is an unequal experience of the health burdens related to housing, with extensive evidence that more socio-economically deprived groups are often worse affected whilst some population groups, such as children and older people, are often more vulnerable to a range of environmental risk factors. Complementing the evidence on the health risks associated with poor quality and poor location of housing, there is now also evidence from evaluation studies showing that interventions to improve housing conditions may have beneficial effects on health. It is therefore timely to have investigated the health and wellbeing implications (including health equity considerations) of housing created under permitted development rights.

Our findings highlight a number of areas of concern, as we will now discuss in turn. It is important to note, however, that this is not to say that adaptive reuse – the conversion of a building from one use type to another, in this case into residential use – is per se a bad thing. The built environment generates about 37% of global carbon dioxide emissions, and embodied carbon within buildings is a growing concern.[240] Adaptive reuse of existing buildings is an important part of responding to this, with enhanced sustainability vital to planetary health and wellbeing. There are many examples of good quality conversions both in England and also internationally, and growing guidance as to how to do change of use schemes well.[241] In the following sections, we summarise key findings from our different work packages, before drawing our overall conclusions.

240. UNEP 2024. Why making buildings greener is crucial to countering climate change at **https://www.unep.org/news-and-stories/story/why-making-buildings-greener-crucial-countering-climate-change**
241. See for example, Armstrong, G. et al 2023, A framework for sustainable adaptive reuse: understanding vacancy and underuse in existing urban buildings at **https://www.frontiersin.org/journals/sustainable-cities/articles/10.3389/frsc.2023.985656/full** and Remøy, H. et al. 2025, Adaptive reuse for housing at **https://bookrxiv.com/index.php/b/catalog/book/59**

Type and location of PDR housing

We created a new data set, identifying the addresses of 77,421 PDR housing units across England, within 13,122 schemes. This allows for the most comprehensive study of PDR housing to date. Within our data set, Office-to-residential conversions accounted for the largest share (85.0%, n=65,771), followed by agricultural-to-residential (8.5%, n=6,608) and retail/sui generis-to-residential conversions (5.3%, n=4,089). Most units were approved between 2013 and 2019 (85.3%, n=66,016), with 11.9% (n=9,213) approved in 2020–2021 and 2.8% (n=2,192) approved in 2022–2023. Overall, the mean average scheme size was 64 units however this is influenced by some very large office-to-residential conversions (the largest found being 439 units) and the median scheme size of 31 units perhaps gives more sense of a typical PDR conversion. The majority of agricultural-to-residential conversions produced houses, whereas the majority of commercial-to-residential conversions produced flats.

Hotspots for PDR housing are located in London and the south east of England with Slough, Crawley and Reading being the local authorities with highest ratio of PDR units per 1,000 population. There are large concentrations of PDR housing in most London boroughs, major urban areas across much of England but particularly in the south of England (for example, Bristol) and new town locations, particularly those in the south east of England (for example Crawley and Harlow). Agricultural-to-residential conversions were less likely to be in socio-economically deprived areas than any of the commercial-to-residential PDR schemes.

Whilst previous research identified that a minority of 11% of PDR schemes were in primarily industrial or business park locations (albeit noting the extreme unsuitability of such locations for a not insignificant proportion of housing), we have extended this research to look at the location of PDR housing in relation to what may be termed 'bad neighbour' uses such as waste/salvage sites, vehicle repair and industrial manufacturing facilities which are likely to create environmental externalities such as noise and atmospheric pollution. We found that within Greater London 39.2% of PDR housing and for the rest of England 38% of PDR housing was in close proximity to at least one such bad neighbour use.

We further examined distances for GP surgeries, primary schools, and bus stops by conversion type and area. In London, service access is consistently good across all three measures and all conversion types, with median distances to GP surgeries of 335m to 419m and fewer than 1% of addresses located more than 2km from a GP. Across the rest of England, office-to-residential and retail conversions have similar accessibility with median GP distances below 500m. Access is poorer for storage and light industrial conversions, where approximately 35% of addresses lie more than 2km from a GP surgery. Agricultural conversions record the most severe deficits, with a median GP distance of 2,951m and 72.5% of addresses more than 2km from the nearest surgery. A similar gradient is seen for school and bus stop access, with agricultural conversions the poorest served across all three measures.

The location of the conversions in industrial and commercial areas also suggest potential exposure to external environmental pollution. Regardless of the type of conversion, in London more than half of PDR addresses are within 100 metres of a commercial cooking outlet. Retail conversions were the closest, with a median distance of 38 m and 58.9% within 50m which is in line with their previous use. Outside London, similar proportions were seen only for office and retail conversions. Location close to major roads could also be a concern. Nearly half of London PD addresses were within 50m of a motorway or A road compared with 28.8% in the rest of England. London median distances were shorter for every conversion type, outside London they ranged from 102m (office conversions) to over 1 km for agricultural ones.

For London, daily $PM_{2.5}$ data (for external air pollution) were available for 79.8% of PD addresses (n=18,385). In 2023, PDR addresses experienced a median of 31 days on which daily $PM_{2.5}$ exceeded the WHO 24-hour guideline of 15μg m^{-3}. The median annual mean $PM_{2.5}$ concentration was 7.9μg m^{-3}(IQR 7.7-8.2), around 1.6 times the WHO annual guideline. Daily concentrations ranged from 0.5 to 62.4μg m^{-3}, seemingly driven by locational proximity to sources of air pollution.

Across England, 25.3% of PDR addresses were located in the 10% most heat-vulnerable LSOAs. The breakdown by domain shows that this is driven by the built and outdoor environment rather than the characteristics of the population. Almost half of PDR addresses (47.7%) were in areas with the highest housing related vulnerability. In London, around half or more of each conversion type was in the most vulnerable decile for housing, with office and retail conversions showing the highest proportions (66.7% and 57% respectively. In the rest of the country, 15.3% of PD addresses were located in highly vulnerable areas. By PD type, this was mainly due to office conversions (18%). Agricultural conversions were almost never in vulnerable areas (0.4%).

Unit size

Although there are reasons to treat Energy Performance Certificate data on internal floorspaces with caution, we have linked this EPC data to our PDR address list for 12,076 housing units. This does allow comparison between types and locations. For schemes consented from 2013–19, before NDSS applied, our analysis found much better compliance and larger average unit sizes for agricultural-to-residential conversions (86.5% complying with NDSS according to our assumptions and median average unit size 147m^2) than any of the commercial-to-residential categories (for example, 35.5% compliance and median average 34m^2 for former offices and 35.7% compliance and median average 50m^2 for former retail and related sui generis spaces).

The more units in a particular scheme, the smaller less likely compliance with NDSS and the smaller, on average, the units (for example, 58.5% compliance and 67m^2 median average for housing units where the PDR scheme comprises 1–4 units, compared to 20% compliance and 35m^2 median average where the scheme comprises 100 or more units). Interestingly from a health equity perspective, NDSS compliance and median size was lowest in the most socio-economically deprived neighbourhoods (29% compliance, 43m^2 median average floorspace) compared to the least (51.7% compliance, 58m^2 median average).

Unfortunately, the sample size on our survey for those living in housing consented after 2021 is too small to be able to tell with high confidence the direct experience and perspective of residents themselves on the impact of the introduction of the minimum space standards for PDR housing. However, the EPC data does allow comparison between sufficient number of housing units to notice a significant difference when comparing housing receiving prior approval in 2022–23 compared to 2013–19. For the housing units with only one habitable room (studio flats), there was a mean increase of 49.8% in floorspace and the odds of being NDSS compliant increased 7.6 times.

Healthcare utilisation and mortality

Looking nationally, through linking our addresses with ONS data, we found that a total of 2,148 deaths occurred among residents of PDR housing between 2013 and 2024. Annual deaths roughly tripled over the period, from around 100 a year in 2013 and 2014 to a peak of 303 in 2022, with 284 in 2023 and 258 in 2024. This rise should not be read as a mortality trend: the PDR housing stock grew substantially over the period, the 2020 to 2022 counts include the COVID-19 pandemic years, and the early years describe the increase in the number of PDR residents rather than resident mortality. Overall, 1,139 deaths (53.0%) occurred under age 75. The cause pattern differed markedly by sex.

Among deaths under 75, males accounted for 181 of the 223 circulatory deaths and 123 of the 164 alcohol-related and drug-related deaths, and for 35 of the 47 deaths from intentional self-harm; neoplasm deaths were near-equal by sex (99 male, 96 female). Alcohol-related and drug-related deaths made up 16.6% of male deaths under 75 (123 of 740) and 10.3% of female deaths under 75 (41 of 399). This analysis does not establish whether mortality risk among PDR residents is elevated relative to the general population, with a further analysis to understand this due to be published after this report.

We had hoped to examine healthcare utilisation on a national basis by linking our PDR address list to NHS data. Unfortunately we were told this was technically feasible but there was insufficient staff capacity within NHS England to undertake work, and attempts to do this work on a more local basis through a number of Integrated Care Broads was also not possible. We were, however, able to do an analysis within one case study local authority area, Bradford, through the 'Connected Bradford' whole-system data linkage research database. A sample of 590 residents of PDR housing was identified for analysis. Among the Bradford PDR resident's asthma was the most commonly recorded condition, present in 18% of the population, followed by hypertension and diabetes. The data offers a clear signal of change following a person moving into a PDR conversion: residents showed a statistically significant increase in primary care contact after moving into PDR housing after adjusting for yearly changes and COVID-19 effects. In the adjusted mixed-effects model, moving into PDR housing was associated with a 49.9% increase in the rate of primary care appointments.

Who are the residents of PDR housing?

We conducted a postal survey of residents across all types and tenures of PDR housing located throughout England and received 1,029 valid responses. We estimate 295,878 people (range: 250,733–341,021) currently live in PDR housing across England. According to our survey data, residents of PD housing are a young population, with a mean age of 36.0 years, 56.3% were under 35. The survey sample is also ethnically diverse relative to the national population (53.9% white, 21.6% Asian and 11.8% Black). Educational level and employment were high, 78.5% had a bachelor's degree or higher and 68.8% were employed. PDR households were most frequently single-person (37.3%) or 2-person households (43.6%), and 77.1% of households had no children.

Most residents rented their home (72.8%) of whom 22.0% were on housing benefit. A total of 88 survey respondents reported living in temporary or emergency accommodation across 45 unique PD schemes. Applying our survey response to our broader set of identified PDR housing, we estimate that approximately 5,528 housing units (95% CI: 4,347–6,709) within PD schemes across England are used for TA/EA. Considering the mean household size of 2.395 occupants in such accommodation (in our sample), we estimate that 13,241 people (95% CI: 10412–16069) are living in PD housing under TA/EA in England. This housing is not always particularly temporary, though: 59.1% of our survey respondents had lived in their temporary accommodation for over a year, and a third of the survey respondents living in TA/EA (33.0%) had been there for over three years. From our focus groups, it was often mothers with children in this accommodation for extended time periods.

Mental health and wellbeing of residents

In our resident survey, we measured mental wellbeing using the Warwick-Edinburg Mental Wellbeing Scale (WEMWBS), a validated questionnaire where scores range from 14 (lowest) to 70 (highest possible wellbeing). The mean wellbeing score in PD residents in our survey was 46.8 (95% CI 46.4–47.2). For comparison, the mean score of the England general population is 50.5 (95% CI 50.1–50.9) as recorded in the 2024 Health Survey for England. The difference of 3.7 points (95% CI 3.1–4.5) was statistically significant in all age groups under 65 years old. WEMWBS scores can also serve as a proxy for probable depression. Using a validated threshold of 41 or below, 22% of PDR residents fell within the range of probable depression.

We examined whether specific housing problems (noise, space insufficiency and thermal discomfort) were associated with poor mental health outcomes. PD residents that reported these issues had significantly higher odds of probable depression and lower wellbeing scores compared to those who did not, after adjusting for age, education level, ethnicity, employment, living with children, tenure and income.

Residents in office conversions reported lower wellbeing scores compared to those in agricultural conversions. Residents living in larger schemes had lower wellbeing scores than those living in smaller schemes. Living in a studio was associated with both lower wellbeing scores and increased odds of probable depression, compared to residents in non-studio flats. Specific characteristics such as dwelling type, noise, thermal comfort and sufficient space seem to play a role in residents' wellbeing and highlight the need for minimum space and amenity standards that adequately protect the mental health of residents.

Resident experience of housing quality

Residents reported several housing issues which were grouped into four domains. Safety and security (five items, including difficulty locking doors or windows and concerns about fire safety), damp and structural (six items including damp, mould and leaky roofs), noise and pollution (five items including noise from neighbours and pest infestations) and space and light (three items including shortage of space and inadequate lighting). A total of 76.5% respondents reported at least one housing issue and more than half (56.3%) reported issues across more than one domain. Analysing the number of individual issues, we found that 23.1% of PDR respondents reported five issues or more, suggesting cumulative burdens from several interacting housing quality issues for a significant population of PDR housing residents.

We interviewed 75 residents of PDR housing who had responded to our survey and volunteered through that. We also worked with grassroot organisations to recruit 36 residents from four areas with experience of living in PDR housing being used as temporary and emergency accommodation for focus group discussion, as these residents appeared to be more difficult to recruit for interview through the survey.

From these different sources (survey, interview and focus groups), the following issues were quite widely reported as housing quality issues:

1. **Location of PDR conversions.** Some were in isolated non-residential areas with consequent poor access to social and green infrastructure as well as potential externalities from neighbouring uses. Others were near busy roads or in town centre locations with issues relating to crime and pollution.

2. **Noise.** Linked to location, more than a third of survey respondents (36.1%) agreed or strongly agreed that outdoor noise (from any source) caused trouble sleeping. Road traffic noise was very or extremely disturbing for 19.9% of respondents.

3. **Shortage of space and overcrowding.** The findings point to several material differences in regard to a shortage of space and overcrowding between PDR converted dwellings and general housing stock, which are instrumental in harming health and wellbeing. These are: high dwelling density, limited internal space (particularly for conversions that took place before 2021), and a lack of outdoor space. Overall, 15.5% of survey respondents were in households classified as overcrowded (using a calculation of people compared to rooms rather than perceptions of space sufficiency, which were far worse), with the problem most acute amongst TA/EA residents. The persistence of this problem amongst conversions consented in 2022–23 demonstrates that the regulatory amendments may

have increased the absolute space in dwellings but cannot manage the number of people living in each unit, but the preponderance of studio and one bed flats and inability to requite more family sized units in PDR conversions (unlike ordinary planning permission schemes) may exacerbate issues. Smaller dwellings are often perceived to be well suited to some groups, particularly younger, single residents who may value location or being able to live alone over space but our research findings point to a more complex reality where insufficient space and overcrowding was experienced as a hardship rather than a choice, and space constraints appeared as a material burden rather than an aspirational trade-off.

4. **Daylight, windows and ventilation.** There were particular problems in studio and one-bed flats. Among survey respondents living in studio units, 10.5% reported having no windows at all in their accommodation, 10.7% had no or only a partial outside view, and 16.4% could not open their window, or could only open it partially, often owing to locked fittings or landlord-installed restrictors. A further 8.2% could not cover their window, and 40.4% reported having no trickle vent, with an additional 14.4% unsure whether one was present. Equally other residents reported in interview having extremely large windows (from former commercial uses of the buildings) they could not cover properly. These issues can be linked to multiple health and wellbeing outcomes, including poor ventilation causing respiratory issues and strong association with thermal comfort, damp and mould.

5. **Safety and security.** The locations of some conversion schemes mean this can be a concern across tenures, whilst the large size of some PDR conversions in use as TA/EA can lead to particular issues here as reported in our focus groups. Perceptions of safety were consistently poorer amongst residents of rental and TA/EA accommodation than those in owner-occupied housing. Crime was reportedly enabled in TA/EA settings both through a concentration of large numbers of people with complex needs and vulnerabilities who were poorly supported, as well as through the location of the PDR conversions in locales far away from the norms and passive surveillance typical of more residential areas.

6. **Thermal comfort.** Overheating was described by some interviewees and focus group attendees as so unbearable that they avoided going home or cooking, with particular impacts for those raising children. The findings linked overheating and poor ventilation to the fact that the PDR conversions were not originally designed to be dwellings, and that high levels of density to maximise developer profits meant that many units were single aspect and often lacked operable windows. These problems were present across all tenures of PDR housing: keeping comfortable in hot summer weather was problematic for 45.4% of respondents, while 25.3% reported they could not

keep comfortably warm during cold winter weather. Inadequate window arrangements appeared to be a particular driver of thermal discomfort among studio dwellers: External environmental factors also shaped ventilation practices: over a third of respondents (36.1%) agreed or strongly agreed that outside noise prevented them from opening windows for cooling or ventilation, while 22.2% reported the same difficulty owing to outdoor air pollution. Security concerns also prevented some residents from feeling comfortable having the windows open (if they could open them).

Issues in relation to space standards and problematic window arrangements had been reported in previous research on PDR housing, whilst issues relating to noise, safety and security and thermal comfort were not previously considered. Issues relating to location problems in terms of industrial/business estate locations were mentioned in previous research but not locational elements such as those relating to neighbouring uses causing disturbance, loss of amenity and pollution, which appear to be quite widespread. For all these housing quality issues, even those previously reported, additional evidence directly from residents demonstrates the realities of everyday life whilst experiencing these. Significant associations were found between experience of the various housing quality issues and low wellbeing.

Temporary and emergency accommodation

It is challenging to capture here in summary the extent and detail of at times harrowing testimony we heard from TA/EA residents about their housing experience. We have also worked with the charity Groundswell to produce an account of the actual experience of some residents we met through the focus group research and an accompanying art work. In general, although this type of accommodation represents a minority of PDR housing, as noted above it still comprises thousands of housing units (we estimate about 5,500 units), often characterised by extreme housing quality issues which may be having more severe impacts on the health and wellbeing of residents. Many TA residents are living in these conversions for longer than may be imagined by the 'temporary' label, with a third (33.0%) of our survey respondents living in PDR schemes being used for TA telling us they had been there for over three years.

Issues with the quality and suitability of temporary accommodation are much broader than just the part of the TA housing stock that has come through PDR, however we feel there are several characteristics of the PDR TA housing stock that are particularly noteworthy and may be particularly problematic, in particular:

- The sheer number of units in large conversions all being used for TA, with examples of building with hundreds of flats housing people with multiple and differing vulnerabilities, which can lead to cumulative problems and issues with anti-social behaviour and strong concerns about safety and security as well as placing additional unplanned burdens on local services including healthcare
- Location, with a number of these conversions being in industrial / business park locations remote from social and green infrastructure and with associated environmental problems
- Poor thermal comfort which can be challenging for residents with little control over their units and strained financial resources to manage. Evidence on the everyday realities of life in overheated flats was particularly strong in our focus groups
- Small space standards, which can magnify other issues, whilst being particularly problematic for families with evidence of everyday impacts on the wellbeing and development of children presented in our focus groups

Indoor environmental quality

We conducted monitoring of 47 PDR homes using environmental monitors of temperature, humidity and air quality, supplemented by site surveys of the housing units undertaken by our researchers, and seasonal questionnaires recording residents' perceptions. We developed PDR housing 'archetypes' based on shared building design characteristics of the monitored homes and wider housing stock data, including EPC information, and assessed their representativeness against the English stock of PDR homes, using wider stock datasets. We then conducted modelling of the indoor environments under current and future climate scenarios.

Overheating

Around 30% of monitored homes experienced summer indoor temperatures above 26°C for a quarter or more of the monitoring period, and over 60% of the WP3 questionnaire respondents reported some degree of summer thermal discomfort. These findings are consistent with WP2 findings. Some residents even reported avoiding cooking or having to spend time outdoors due to the severity of overheating in their homes. Although any comparisons with the broader national housing stock must account for differences in overheating assessment methods, monitoring periods and sample characteristics, analysis of temperature monitoring undertaken as part of the Energy Follow-Up Survey (EFUS) during the summer of 2018 estimated that 19% of bedrooms and 15% of living rooms experienced overheating using an adaptive thermal comfort criterion accounting for household heat sensitivity whilst the 2024 English Housing Survey (EHS) reported that residents experienced uncomfortably hot conditions they were unable to alleviate in approximately 12% of homes across England.

These findings highlight overheating as an important concern in the monitored PDR homes. Several features may help explain the summer overheating observed in PDR homes. Glazed areas (sometimes extensive, with little adaptation from former commercial use) with limited shading can allow substantial solar heat gains. Cooking and higher occupancy levels contribute to higher internal heat gains, which can heat smaller spaces, typically found in PDR homes, faster. However, this also depends on the building fabric and ventilation characteristics. Single-aspect layouts do not allow cross ventilation, thus making it harder to remove accumulated heat, and non-openable or restricted windows, outdoor noise/pollution or security concerns can further limit window opening and heat removal. Although highly aggregated locational data may not fully capture the local microclimate and dwelling- or household-level characteristics of the monitored homes, our analysis under WP1 taken together with WP3 monitoring and questionnaire findings on overheating suggest that the location and area demographics of the monitored PDR homes may contribute to increased heat vulnerability, now and in the future.

Moisture and underheating

Around 70% of homes with heating-season temperature data recorded temperatures below 18°C for 5% or more of the monitored time. Low indoor temperatures may reflect a combination of heat loss through the building fabric and inadequate heating provision. However, the exact reasons could not be determined through the data collected from this project. For context, low winter temperatures have also been documented in the wider English housing stock. The Energy Follow Up Survey (EFUS) reported that during winter 2017/18, the coldest 10% of households recorded mean living-room temperatures below 15.7°C. Although the two samples are not directly comparable due to differences in the methods and metrics utilised, this does suggest there are problems with underheating as well as overheating which are quite widespread in the monitored PDR homes.

Some homes experienced both low temperatures and high humidity. Three particularly cold homes recorded average relative humidity of 64–72%, over monitoring periods ranging from two to six months, highlighting the need to address underheating and moisture together when assessing damp and mould.

Indoor air quality

Indoor air quality was also a concern, with elevated CO_2 signalling insufficient ventilation in approximately one-third of the homes during the heating season. Fine particle pollution ($PM_{2.5}$) levels were elevated in many homes, with seasonal averages exceeding the WHO annual guideline value in nearly all homes with available data: for $PM_{2.5}$, seasonal averages exceeded the WHO annual guideline value of 5µg/m^3 in 40 of 42 homes in summer and all 36 homes with heating-season data.

Mean concentrations exceeded the DEFRA statutory annual limit for outdoor air in England of 20µg/m^3 in 12 of 42 homes in summer, and in 10 of 36 homes in winter. NO_2 was less frequently elevated in the case study sample, and CO was generally low.

The locational analysis under WP1 already discussed provides relevant context for considering potential outdoor contributions to indoor $PM_{2.5}$. However, proximity alone does not establish pollutant exposure, and the relative contributions of indoor/outdoor pollution sources in the monitored sample remain uncertain. Small dwelling volumes and open-plan layouts may contribute to elevated exposure to indoor-generated pollutants. Effective extraction can remove emissions before they spread, whereas limited ventilation can allow them to accumulate. The WP3 monitoring found slightly lower $PM_{2.5}$ in homes with enclosed kitchens than in those with open-plan kitchens, while WP2 residents described cooking smells reaching others sharing the same room. The findings suggest that dwelling size and layout may influence indoor pollutant concentrations. This interpretation is supported by modelling work on London housing, highlighting that higher cooking emission concentrations were more strongly associated with smaller flats than larger detached homes, particularly those without a working kitchen extractor fan. However, small comparison groups and potential confounding factors in our monitoring sample limit the ability to definitively identify the independent effects of dwelling size and layout.

Dual aspect layouts and other planning and design considerations

Our findings highlight indoor environmental concerns in PDR homes, where small spaces, restricted window opening and limited opportunities for cross ventilation are likely to occur together. Where homes are also located near outdoor pollution sources and in higher heat-vulnerability areas, residents may be at greater risk of pollutant exposure and experience difficulties maintaining comfortable indoor temperatures.

Modelling focused on a small, single-aspect studio (bedsit), incorporating building, operational and household variations. Together, the bedsit and a single-aspect one-bedroom flat geometry represent approximately 30% of the identified PDR stock. The bedsit simulations projected an increase of approximately 2.4°C in average summer operative temperature by the 2080s. Enabling cross ventilation achieved an average summer temperature reduction of up to approximately 2°C in the 2080s, demonstrating the potential benefits of dual aspect layouts that allow increased airflow. This may not, however, prevent future overheating on its own. Effective shading and opportunities for increased airflow when outdoor temperatures are lower than indoors are both important for reducing summer overheating.

Modelling indicated higher heating season $PM_{2.5}$ than in summer, with smoking substantially increasing concentrations. Extended ventilation when outdoor temperatures are lower than indoor temperatures, and extended air extraction reduced summer overheating and $PM_{2.5}$ concentrations but also increased NO_2 towards the modelled outdoor background concentration. Improving ventilation requires careful consideration of outdoor pollution levels while maintaining comfortable indoor temperatures during the heating season.

WP2 highlights practical barriers to window opening, including outside noise and air pollution limiting higher ventilation rates in approximately 35% and 22% of survey respondents, respectively. Non-openable windows, restricted openings and single-aspect layouts further limit opportunities for airflow. Security concerns may also discourage window opening, particularly at night, when ventilation could help the most in releasing accumulated heat. This indicates the important interaction between locational considerations, resident behaviour and dwelling design features. Elevated CO_2 in some monitored homes provided further evidence that ventilation was insufficient. Particularly during colder weather, residents may keep windows closed to retain warmth, allowing moisture and pollutants from indoor activities to build up where air extraction or background ventilation is insufficient. Screening individual intervention measures and their combinations indicated no single best overall intervention package. The selected interventions in each case need to match the problem.

Our indoor environmental quality work has found evidence of summer excess heat, cold during the heating season, high humidity levels and poor indoor air quality occurring in many of the PDR homes monitored. Problematic indoor environmental conditions were found across all types of office-to-flat conversion monitored and the retail-to-flat conversion. Indoor environments were generally better in the agricultural-to-residential and storage-to-residential conversions monitored. The findings highlight the need for planning, design standards and building regulations to jointly address indoor summer overheating, winter underheating, excess moisture and poor indoor air quality in PDR homes. PDR conversion proposals should demonstrate how benefits and risks can be balanced year-round both under current and future climate conditions. This should involve consideration of location (including outdoor noise and pollution levels), floor area, internal layouts, expected occupancy, shading, and the residents' practical ability to ventilate and cool their homes. Opportunities for cross ventilation should be prioritised, wherever possible. Further post-occupancy evaluation would be a useful tool in establishing whether the PDR design works as intended and identifying corrective actions, where needed. Ultimately, the quality of PDR conversions should be judged by the living conditions they provide.

Modelling the health impacts of indoor environmental quality

We undertook preliminary work to assesses the health and economic impact of air pollution exposure (fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2)) for an example single dwelling type using outputs from work package 3, archetype S PDR housing (office to small studio or one bedroom flat). 32.2% of all PDR residents live specifically in this S-type housing, an estimated 95,273 residents. We also conducted an assessment of incremental differences in mortality risk for occupants of permitted development homes based on the results of WPwork package monitoring. Health outcomes were estimated by applying published concentration-response functions to the exposed population. Drawing on evidence from the epidemiological literature on association between air pollution exposure and health, in this preliminary work, all-cause mortality, mortality from five specific causes and childhood asthma morbidity were modelled.

In the site monitored with the worst indoor air quality in relation to $PM_{2.5}$, a studio flat in an office-to-residential conversion under our 'S-type' of PDR housing, the incremental mortality risk from lower respiratory infections increased 1027.65%, followed by increased risk of stroke (492.05%), ischaemic heart disease (472.14%) chronic obstructive pulmonary disease (440.33%), and lung cancer (219.15%). For all-cause mortality specifically, this site carried an incremental risk of 226.85%, well above every other site. The site with the lowest measured exposure, by comparison, recorded an incremental risk of just 1.55%. $PM_{2.5}$ exposures were usually more problematic than NO_2 so that NO_2 exposure contributed comparatively little to the modelled burden across all outcome measures in this archetype. This suggests that NO_2-focused interventions are a lower priority for this specific housing type than for others where outdoor NO_2 infiltration is more significant (e.g. dwellings on high-traffic roads).

Overall, our preliminary results indicate that indoor exposure to $PM_{2.5}$ and NO_2 in PDR homes are likely to represent a substantial health risk but that there are considerable variations in risk between dwellings of different type. Based on monitoring data and subsequent modelling from our S-type housing, the scale of the estimated potential annual air pollution-related health burden in PDR housing was found to be up to 28.8 excess deaths and 100.8 asthma cases per 10,000 residents. We found 5,644 years of life lost under the modelled scenarios and the associated annual economic loss of up to £413m under the worst-case scenario, underscoring the potential value of targeted regulatory or advisory intervention in this housing type. Because the modelled economic losses and years of life lost scale with the size of the exposed population, and 32.2% of PDR residents live in this single archetype, even a modest per-dwelling improvement in indoor environmental quality could translate into an economically significant aggregate benefit given the scale of PDR housing nationally.

The concentration of years of life lost in the 30–64 age band also points to a specifically working-age burden, with implications for productivity loss that go beyond the direct healthcare costs captured in this economic assessment.

We conducted an initial analysis of two possible interventions to improve air quality within S-type dwellings, focusing on resident behaviour (smoking indoors) and design (improved ventilation). In the longer-term, we will extend this analysis by including a wider range of dwelling archetypes (from WP3 modelling), considering health impacts from a wider range of indoor environmental factors (such as temperature), and producing estimates of relative health and economic impacts under a range of potential alterations to planning regulations to protect health.

Regulatory controls and levers

A review of grey literature regarding the national policy and legislation relating to PDR housing and health considered how the PDR rules prevented or enabled local authorities to address twelve evidence-based Healthy Homes Principles. The review found that none of the principles were fully addressed through PDR rules except, to a limited extent, on indoor space standards – which were made an additional condition for PDR housing in 2021. Even on space standards however, residents in PDR housing still report facing overcrowded and inadequate space provisions, including lack of outdoor amenity space. Compared to full planning permission, prior approval for the commercial-to-residential change of use schemes does not allow consideration of key areas such as:

- The suitability of the location in terms of impact to reducing health inequalities, externalities from neighbouring uses such as noise and air pollution
- Accessibility including by public transport but also to key social infrastructure, schools, GPs and shops
- The mix of homes in terms of the number of bedrooms (i.e. requiring a certain number of family sized flats) and tenure (such as a concentration of people in TA)
- The provision of outdoor space as well as neighbourhood green space
- Window arrangements beyond the requirement for overall adequate natural light
- Sustainability considerations, including the provision of exterior design aspects, such as roof, wall and window insulation, PV solar, or green roofs
- Any other health or economic related placemaking policies
- Contributions towards affordable housing and necessary supportive infrastructure

The review also identified that a number of key parts of the Building Regulations do not apply to 'material change of use' schemes in the same way as they would to a new build development, including in relation to structure, fire standard for external wall materials, resistance to moisture, falling, collision or impact, accessible dwellings and overheating.

The review was followed by a national survey of local authorities in England, as well as six focus groups with local government officers including planning, environmental health, building control, and public health and a further ten semi-structured interviews with local government officers and representatives of national professional bodies. The recognition by the Government of housing standards as 'determinants of health' in the Heath Care Act 2022 and the English Devolution and Community Empowerment Act 2026 make it clear that decisions taken regarding the location and quality of homes contribute directly towards achieving public health improvements and reducing health inequalities.

Our research found, however, that Permitted Development Rights as written in the GPDO 2015 (as amended) are undermining public authorities' ability to deliver their duties regarding meeting housing improving public health, reducing health inequalities and meeting housing standards. We have found that the PDR rules are damaging as they:

- prohibit consideration of the impact of such conversions to health improvement and reducing hearth inequalities;
- harm local placemaking and public resources used to shape that health creation; and
- expose residents to unnecessary risk of harm, especially vulnerable residents.

There was widespread concern as to the degree of scrutiny of PDR housing able to be applied through the prior approval process compared to full planning permission, the challenges in making Article 4 directions, the ability to apply local plan policies including those specifically developed with health and wellbeing in mind, and the resources available for enforcement post-construction including environmental health / housing enforcement in the private rental sector in particular.

Implications from our findings

It was clear from interviews and focus groups with residents, how much many people are in housing need, and the value placed by many on having their own private space in housing, somewhere safe and secure in which to build a home. The adaptive reuse of existing buildings to residential use can make an important contribution to housing supply whilst promoting sustainability and carbon reduction. The key issue is whether planning deregulation through the form of permitted development rights (PDR) for adaptive reuse of agricultural and residential buildings into residential use is the best means by which to achieve this additional housing supply.

Following extensive new data collection, analysis and modelling work involving multiple methods and datasets, our research findings demonstrate that the expansion of PDR has had implications for health, wellbeing and health equity. Whilst some higher quality housing has been provided through PDR, providing acceptable living environments, in many cases this could have been achieved through full planning permission, whilst much of the poorer quality housing would not have been allowed as new development by law and design.

A substantial proportion of PDR housing exposes residents to conditions known within existing public health literature to be associated with poorer physical and mental health and wellbeing. The research has identified multiple pathways through which PDR housing may affect health including:

- Inadequate space and overcrowding
- Poor thermal comfort, including both overheating and underheating
- Poor ventilation, increasing risk of damp and mould
- Elevated indoor air pollution, particularly $PM_{2.5}$
- Noise disturbance, both from internal and external sources
- Safety concerns and limited opportunities to control the living environment
- Location in areas characterised by environmental burdens including proximity to industrial uses, major roads and other sources of pollution and in some cases isolated from key services and social and green infrastructure

Although there were examples of poor as well as good quality housing across all types of PDR, by all indicators except access to services and infrastructure (and related broader issues like resultant built-in car dependency), agricultural-to-residential conversions were characterised by better living environments than any of the various categories of commercial-to-residential PDR. Some housing quality problems also tended to be more associated with larger conversion schemes, and we note the broader issue of a lack of potential affordable housing contribution primarily applies in conversions of 10 units or more.

In addition to evidence of poorer living conditions, poorer outdoor and indoor environments which are known to have health implications, we also found direct evidence of health impacts through raised levels of low wellbeing and potential clinical depression which appeared to be associated with housing defects and increased primary care utilisation. Although looking on average across all survey respondents showed increase rates of low wellbeing and looking on average across all eligible PDR residents in our Bradford case study found increased primary care utilisation, both of which we found to be significant, in both cases these averages are likely to hide some variation which may be important given the variation in quality across the PDR stock observed in this and previous research. Our findings align with wider evidence linking poor housing conditions to mental ill-health, respiratory disease, cardiovascular risk, reduced wellbeing and diminished quality of life, reinforcing longstanding scholarship demonstrating that housing quality, indoor environmental conditions and neighbourhood context are fundamental determinants of health. These environmental and housing-related exposures may have measurable consequences for health service demand and an economic as well as social burden.[242]

From a health equity perspective, the burden of these risks does not appear to be distributed evenly with poorer housing conditions and associated health risks disproportionately experienced by more deprived and vulnerable populations. For example, smaller units and lower compliance with space standards were disproportionately concentrated in more deprived areas. This accords with previous research,[243] but the quality variation in PDR housing made for an especially stark illustration of this. Residents with the least agency over their housing, including some in the Private Rental Sector (PRS) but particularly those in temporary and emergency accommodation, frequently experienced the most severe housing conditions. Such housing is unlikely to positively improve health and wellbeing, instead placing additional burdens on some of the most vulnerable in society. Considering housing as an important social determinant of health,[244] this suggests than planning deregulation through PDR may contribute to the concentration of environmental and housing disadvantage among already vulnerable populations, reinforcing rather than reducing existing health inequalities.

242. See for example **https://bregroup.com/insights/the-cost-of-poor-housing** and **https://bregroup.com/insights/the-cost-of-ignoring-poor-housing**
243. See for example Philippa Howden-Chapman, Julie Bennett, Richard Edwards, David Jacobs, Kim Nathan, David Ormandy. 2023. Review of the Impact of Housing Quality on Inequalities in Health and Well-Being. *Annual Review of Public Health 44:233-254. Available at:* **https://doi.org/10.1146/annurev-publhealth-071521-111836**
244. See for example Wilson, W and Barton, C 2022. Research briefing: The role of homes and buildings in levelling up health and wellbeing at **https://commonslibrary.parliament.uk/research-briefings/cdp-2022-0170/**

Whilst there may be emerging evidence that the 2020 and 2021 PDR regulatory changes introducing requirements for natural light and space standards compliance are having positive impacts, a number of identified problematic pathways remain unaddressed. Some issues such as thermal comfort and air quality are at the boundary of planning and building regulations, with potential design and so housing quality improvements possible through both regimes. Others, such as location (including accessibility, infrastructure provision, neighbourhood context and amenity / externalities of neighbouring uses), are more firmly planning considerations. A consistent finding across all work packages is that many of the adverse outcomes associated with PDR housing are not simply the result of individual building design decisions but stem from the removal of the wider place-based considerations that ordinarily form part of the planning process.

There has been some recent discussion about potential advantages of more 'by right' planning systems as opposed to the discretionary system in the UK, but such systems often have more sophisticated rule sets than has been the case under PDR and in many places are linked to zoning systems that seek to separate potentially incompatible land uses. Under PDR, the ability of a discretionary judgement to consider location (and other relevant sustainability, design and health related contextual issues) is lost but not replaced with an appropriate placed-based rule set.

Taken together, this research offers further evidence on the important of considering not just the number of homes delivered but also the health outcomes and distributional consequences resulting. Given the general apparent difficulty in responding to some very poor quality housing delivered by some existing PDR housing schemes (despite evidence of the health and health economic benefits that can be achieved from improving the quality of existing housing),[245] it seems all the more important to try and get schemes delivering new housing right from the start. This involves greater emphasis on producing healthy and climate-resilient homes supported through regulatory frameworks placing health, wellbeing and equity at the centre of decision-making about the design and location of housing. Housing development has long-term consequences for population health and wellbeing, with the potential to take a preventative approach to ill health and reduce health economic burdens. Given this, the ability to apply holistic health related assessment of all development, including adaptive reuse schemes, through planning seems vital.

245. See for example Rodgers SE, Bailey R, Johnson R, Poortinga W, Smith R, Berridge D, *et al. 2018, Health impact, and economic value, of meeting housing quality standards: a retrospective longitudinal data linkage study. Public Health Res 6(8). Available at:* https://doi.org/10.3310/phr06080

Recommendations for policy, practice and landlords

Policy / legislative recommendations

The expansion of permitted development rights to allow the creation of new housing was introduced by central government by amending secondary legislation. The largest benefit would likely be achieved by central government action. It is possible to make changes to the relevant regulations to reduce the likelihood of creating poor quality housing with negative health and wellbeing implications whilst still supporting the provision of additional housing through adaptive reuse of existing buildings.

On balance, our key overall recommendation would be to remove the GPDO 2015 (PDR) conversion to residential use entirely, replacing it with a supportive policy on adaptive reuse / material change of use to residential in the National Planning Policy Framework. Although not all PDR housing is poor quality in terms of location, design and indoor environmental conditions, a significant proportion is and current regulations are insufficient to prevent further related issues in future. This causes additional costs and burdens for local authorities and the NHS in dealing with poor quality housing and its consequences. Good quality adaptive reuse schemes would still be possible through full planning permission (MHCLG live tables show that in 2024–25, 10,030 net additional dwellings were provided across England through change of use under full planning permission compared to 7,680 under PDR). This would involve giving power over decisions regarding PDR housing location and quality (and associated conditions) back to local government, as defined in their Local Development Plans.

We believe this option would achieve the greatest overall health and wellbeing benefit, and actually simplify the regulatory landscape. We would be cautious about adding too many additional requirements into the GPDO given the additional complexity this could cause and burden on local authorities, under the time limited and less well-resourced prior approval process. However, if central government were unwilling to adopt our main recommendation, two alternative options would be:

- **Modify GPDO 2015 to set impact to promoting good health, preventing ill-health and/or reducing health inequalities as a prior approval consideration for conversion to residential use in all use classes** – following the NPPF and the Health and Care Act 2022. Alongside this, amend Regulation 122 of the Community Infrastructure Levy Regulations 2010 to include consents under PDR, regarding the circumstances where planning obligations can be entered into under Section 106 Agreements

- **Modify GPDO 2015 to exclude schemes creating 10 or more units from Class MA** (Class E to Class C3 commercial, business and services to residential), requiring them to go through full planning permission. Although we did find evidence of problems such as problematic indoor environmental conditions in some smaller conversions, there did appear to be some association between scheme size and likely housing quality and commercial-to-residential conversions were generally more likely to produce poor quality housing than agricultural-to-residential. This option could therefore reduce the likelihood of harm to health and wellbeing, minimise the potential population impacted by potential problems and resolve the current loophole around planning gain, albeit there could still be additional burdens associated with the consequences of poorer quality issues in smaller PDR conversions so this does not represent a precautionary approach.

Alongside any changes to planning regulations, we recommend that the government should address the gaps in Building Regulations regarding the Material Change of Use to residential uses, including expanding Part M on visitable and accessible buildings, and Part O on overheating to include MCU housing (see further detailed recommendations under Work Packages 3 and 5).

Whilst planning and building regulation changes can improve housing quality and so health and health equality for new conversion schemes coming forward, this does not address the existing stock of PDR housing, which includes thousands of poor quality homes. **We therefore recommend that central government should fund a full review and, where required, retrofitting programme for existing PDR housing to ensure they are habitable and safe to live in.** Existing research has demonstrated the health and economic benefits from retrofitting poor quality existing housing.

In the longer term, we need a systemic shift to how the built environment is regulated to better target positive health outcomes and reduce health inequalities, including consideration of the interaction between planning and building control to secure health benefit. We would recommend that government **elevates health improvement and reduction of health inequalities as primary legal duties in planning law and building control.**

Recommendations for practice

Local government

We believe that the best option to address the concerns identified by our evidence is policy and legislative change by central government, as recommended above. At the same time, if there is no action by central government we are producing a toolkit for local government officers in planning, housing and environmental health teams with recommendations as to how best to use existing policy levels available to them to try to minimise the risk of poor quality housing under PDR. This will be published in November 2026, but again we do not believe that placing additional unfunded burdens on local government to address these issues is an optional solution, however.

Architects and designers

We would recommend for architects and designers of adaptive reuse schemes, to consider the following:

- **Integrated building design** – Optimise the dwelling layout, and where possible, window size and placement. Attention should be given to shading and ventilation provision to address potential constraints of the existing building, such as its location, layout limitations or large glazing areas. In particular, enable cross-ventilation, where possible, and provide effective kitchen and bathroom extraction with simple controls, while accounting for outdoor pollution, noise, security and accessibility.
- **Integrated building performance assessment** – Consider the impact of conversion design decisions on year-round indoor thermal performance (including the risk of summer overheating and winter underheating), moisture and air quality together, under current and future climates.

For larger conversion schemes, developers and those advising them should ensure that an Independent Building Control, fire safety and HHSRS review is undertaken during the detailed design phase. Engaging a Registered Building Control Authority (RBCA), local fire authorities and the local authority Environmental Health team before prior approval and during conversion, to ensure all building safety and housing regulations are met.

Recommendations for landlords

Once conversion schemes are occupied, for those in the Private Rental Sector (the majority of adaptive reuse developments), landlords and managing agents should consider the following:

- **Proactive assessment:** Identify problems early through post-occupancy evaluations, combining resident feedback, regular inspections, and targeted indoor environmental monitoring.
- **Effective maintenance:** Ensure space heating and ventilation systems are working effectively and address the causes of damp and mould promptly, including leaks, cold surfaces and inadequate air extraction.
- **Clear guidance:** Provide practical, home-specific instructions on the use of space heating, shading and ventilation, including seasonal adjustments.
- **Accessible reporting:** Provide a straightforward way for residents to report indoor environmental problems or equipment failures.

Next steps

Further analysis flowing from our now completed core data collection is ongoing, in particular there is further analysis of mortality data and modelling-based health economic evaluation to complete. A number of academic journal articles flowing from this research have already been submitted for peer review and others will follow completion of all analysis.

Alongside academic outputs, an artwork and a dramatized oral account capturing the perspective of residents on their everyday living conditions in PDR housing being used for temporary accommodation have been produced. A toolkit for local government officers considering the range of powers available under current policy and regulations to help manage PDR housing has been produced and will be published soon after this report.



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Appendix 2: The Project Steering Committee and Public & Advisory Group

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