The health impacts of energy performance investments in low-income areas: a mixed-methods approach

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Scientific summary

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Background

Research suggests that living in fuel poverty and cold homes contributes to poor physical and mental health, and that interventions targeted at those living in poor-quality housing may lead to health improvements. Most studies thus far have focused on a limited number of health outcomes and have excluded psychosocial outcomes that may be part of pathways to health. Furthermore, anonymous data linkage of routinely collected health-service utilisation data has not been used before to examine the impact of energy efficiency improvements. The overall aim of the study was to determine the health and psychosocial impact of energy performance investments in low-income areas through a mixed-methods programme of work. The research focused on a major investment programme that took place in Wales in two separate phases between 2010 and 2015.

Objectives

The project aimed to determine the impact of an energy performance investment programme on (1) hospital admissions for cardiorespiratory conditions, (2) the prevalence of respiratory symptoms and mental health status of residents, (3) internal hydrothermal conditions and household energy use and (4) psychosocial outcomes that may be part of pathways to health. It also aimed to (5) estimate the costs and consequences of the energy performance investments to the health system and (6) undertake a cost–utility analysis (CUA) of these investments.

Methods

The project used multiple methods to evaluate the health impact of energy performance investments in low-income neighbourhoods, including data linkage, a community-based field study, a household monitoring study and an economic evaluation. The project included a number of qualitative focus groups as part of the resident engagement.

Data linkage study

Data linkage was used to undertake a longitudinal analysis of residents living within homes who received energy efficiency improvements in 2010 and 2011. Routinely collected data were anonymously linked to intervention records provided by local authorities (LAs) and social housing providers who delivered the schemes. Counts of emergency hospital admissions from 2005 to 2014 were extracted from the Patient Episode Database for Wales. Primary health outcomes were obtained for baseline and follow-up periods for 25,908 people residing within the intervention homes ($n = 4968$) as well as for two comparator populations: 48,261 people living in 12,350 social homes and 524,596 people living in 118,982 homes in the top 10% of deprived areas according to the Welsh Index of Multiple Deprivation. Mixed multilevel linear regression models were constructed to assess associations of change in cardiorespiratory emergency admissions before and after the intervention, adjusting for potential confounders.

Community-based study

The community-based study had a quasi-experimental, controlled before-and-after design (intervention, $n = 364$; control, $n = 418$) to investigate the short-term health and psychosocial impacts of the intervention. The community-based study specifically focused on schemes that were delivered in 2014 and 2015. Matched control areas were identified with the assistance of LAs. Data were collected through self-completion questionnaires in the winters before and after installation of energy efficiency measures, and at the same time in the matched control areas. The primary health outcomes were changes in mental health status and self-reported respiratory and asthma symptoms. Secondary health outcomes were changes in self-reported health-related quality of life (and subjective well-being). Secondary psychosocial outcomes included changes in fuel poverty status, financial difficulties and stress, food security, social interaction, thermal satisfaction and reported housing conditions. Data were analysed using a multilevel modelling, repeated measures approach, with measurement occasions nested within the intervention or control individuals.

Household monitoring study

The household monitoring study used a quasi-experimental, controlled before-and-after design consisting of high-resolution long-term monitoring of indoor air temperatures and relative humidity (RH) levels in two consecutive heating seasons, before and after energy efficiency improvements, and controlled for external hydrothermal conditions. The final data set consisted of 99 households (intervention, $n = 50$; control, $n = 49$) at baseline and 88 households (intervention, $n = 48$; control, $n = 40$) at follow-up that were observed for a minimum of 4 weeks in the two periods. The main outcomes of the household monitoring study were average indoor air temperature and RH at different times of the day and in different rooms within the home, and the average daily duration and cumulative substandard internal hydrothermal conditions (i.e. the duration and time intensity integral of indoor temperatures of < 18 °C or < 16 °C and RH levels of > 60%). The final data consisting of 15,771 data points were analysed by constructing a series of controlled multilevel interrupted time series regression models.

Economic evaluation

The main health economic evaluation involved a cost–consequence analysis (CCA) and a CUA utilising the health outcomes from the data linkage study and utility values from the literature. The CCA considered resource use and cost impacts of the intervention associated with secondary care. The health consequences for the CCA were changes in emergency hospital admissions for cardiovascular and respiratory conditions. The CUA was undertaken using utility values for the relevant chronic obstructive pulmonary disease (COPD) health states for people who experienced an emergency hospital admission for an exacerbation. Each adverse health event resulting in an emergency hospital admission had a survival curve mapped from these utility values across the study period. This approach incorporated an initial impact of the event on utility and a time-variable component, using the area under the curve approach to generate an incremental cost-effectiveness ratio (ICER). Negative binomial regression models were constructed for both the CCA and CUA.

Resident engagement

A reconvened focus group study was conducted as part of the wider resident engagement of the project. Three focus groups were held with residents before ($n = 28$) and then again after ($n = 22$) they received energy efficiency improvements under the intervention programme. The focus groups were conducted to obtain a better understanding of the views and experiences of residents living in energy-inefficient houses, and to explore the ways in which the intervention may have improved those experiences. The recorded and transcribed discussions were analysed according to the themes of health and well-being, thermal comfort, staying warm and the use of living space, fuel poverty and experiences with the intervention programme.

Results

Data linkage study

The data linkage study assessed the impact of the intervention on health service use. No significant effect was found on our primary outcome of cardiorespiratory emergency hospital admissions [adjusted results: Δ 0.0011, 95% confidence interval (CI) –0.0103 to 0.0125]. No association was found with admissions for respiratory-related conditions (Δ 0.0042, 95% CI –0.0046 to 0.131), COPD (Δ 0.0002, 95% CI –0.0025 to 0.0022) or cardiovascular conditions (Δ 0.0014, 95% CI –0.0083 to 0.0055). We subsequently analysed the same outcomes for people aged ≥ 60 years. No evidence was found that the intervention had a significant effect on outcomes, with the exception of cardiovascular-related emergency hospital admissions. A significant increase was found in cardiovascular-related emergency hospital admissions after adjusting for potential confounders (Δ 0.0273, 95% CI 0.0068 to 0.0479).

Community-based study

The community-based study found no evidence that investments in energy efficiency improve respiratory or mental health in the short term. It was found that, after controlling for sex, age, housing benefits, household income and smoking status, investments were not associated with improvements in Mental Health Composite Scale scores [unstandardised regression coefficient (B) 0.00, 95% CI –1.60 to 1.60], self-reported respiratory symptoms (B –0.14, 95% CI –0.54 to 0.26) or self-reported asthma symptoms (B –0.14, 95% CI –0.54 to 0.25). Furthermore, no evidence was found that they provide physical health benefits in the short-term, as indicated by Short Form questionnaire-12 items Physical Health Composite Scale scores (B 0.38, 95% CI –0.34 to 2.29). The study found that, compared with participants in control households, participants who received the intervention reported improved subjective well-being (B 0.38, 95% CI 0.12 to 0.65; $p = 0.004$) as well as fewer financial difficulties (B –0.15, 95% CI –0.25 to –0.05; $p = 0.003$), higher thermal satisfaction [odds ratio (OR) 3.83, 95% CI 2.40 to 5.90] and higher satisfaction with the improvement of their homes (OR 3.87, 95% CI 2.51 to 5.96). Participants in the intervention group were also less reluctant to invite friends or family to their homes after they received the energy efficiency measures (OR 0.32, 95% CI 0.13 to 0.77; $p = 0.012$). The results were similar before and after controlling for socioeconomic covariates selected a priori.

Household monitoring study

The study found that the intervention raised indoor air temperature by an average of 0.84 °C (95% CI 0.64 to 1.04 °C), whereas daily gas usage dropped by an average of 37%. Similar increases were observed across different heating demand conditions. The largest changes were observed in the evening (1.17 °C, 95% CI 0.94 to 1.39 °C) and at night (1.01 °C, 95% CI 0.79 to 1.24 °C), and in the living room (1.01 °C, 95% CI 0.78 to 1.23 °C) and bedroom (1.28 °C, 95% CI 1.04 to 1.52 °C), suggesting that the biggest increases were for spaces that were in use. The intervention measures were not equally effective: external wall insulation (1.12 °C, 95% CI 0.69 to 1.55 °C) and connection to the gas mains network (0.69 °C, 95% CI 0.29 to 1.09 °C) significantly increased indoor air temperatures; windows and doors (–0.02 °C, 95% CI –0.39 to 0.35 °C) or a new heating system (–0.19 °C, 95% CI –0.69 to 1.09 °C) did not.

Overall, the intervention did not increase indoor RH levels (0.04% RH, 95% CI –0.74% to 0.83% RH), although some individual measures did. Both a gas network connection (3.86% RH, 95% CI 2.31% to 5.41% RH) and the installation of new windows and doors (5.15% RH, 95% CI 3.73% to 6.57% RH) increased indoor RH levels. External wall insulation (–0.60% RH, 95% CI –2.26% to 1.06% RH) and installation of boilers or heating systems (–1.59% RH, 95% CI –3.52% to 0.34% RH) did not change indoor RH levels.

The intervention reduced the cumulative amount of indoor air temperature of < 18°C (3.62 °C·hour, 95% CI –6.95 to –0.30 °C·hour) and < 16 °C (4.20 °C·hour, 95% CI –6.64 to –1.76 °C·hour) and the average daily duration (1.14 hours, 95% CI –2.00 to –0.28 hours) and cumulative amount (19.32% RH·hour, 95% CI –29.68% to –8.96% RH·hour) of indoor RH levels of > 60%.

Economic evaluation

In the CCA, the disaggregated outcomes derived from the intervention were balanced against the costs. The intervention resulted in no meaningful change in emergency admissions from the pre-intervention period. When undertaking the CUA, exploring the impact on quality-adjusted life-years (QALYs) of the change in rate of emergency admissions for people with COPD, the small non-significant change in emergency admissions for COPD is overpowered by the cost of the intervention, and the ICER of > £10M per QALY gained is not cost-effective using commonly accepted norms, even with discounted costs and benefits to present-day values in line with best practice.

Resident engagement

The reconvened focus group study found that living in a cold home was generally viewed as depressing, stressful and detrimental to both mental and physical health. According to residents, the energy efficiency work made great improvements to their comfort and indoor temperatures, opened up spaces within the home and substantially reduced their heating bills. This not only helped to relieve financial stress and fuel poverty but made them less reluctant to invite others to their homes. Residents felt that physical health improvements following the work were secondary to improvements in thermal comfort and their ability to invite friends and family into their homes. Although the improvements were, for the most part, positively received by residents, and clearly fulfilled the goal of the programme to make homes warmer and cheaper to heat, the focus group study identified the need to consider community engagement and communication to involve residents more closely in the decision-making and delivery of affordable warmth programmes.

Discussion

The research found no evidence of demonstrable effects of the intervention on health or health service utilisation in the short and medium term. As a result, the health economic analysis concluded that the intervention may not be considered cost-effective in a traditional sense. These findings are in line with a recent systematic review that concluded that area-based programmes are less likely to produce measurable health improvements than those that specifically target at-risk populations. It is nevertheless surprising that no apparent effects were found, given that the intervention programme targeted low-income neighbourhoods with poor-quality housing where residents were consequently at a higher risk of living in fuel poverty.

That does not, however, mean that the intervention is without substantial merit. The main purpose of the intervention was to deliver affordable warmth, alleviate fuel poverty and reduce CO_2 (carbon dioxide) emissions. The research found clear evidence that this was achieved. The research showed that the intervention provided a wide range of benefits to residents. Public health decision-makers and budget holders may feel that these improvements alone are worth the investments. The lack of association with emergency hospital admissions may indicate that benefits do not show up in hospital statistics; future evaluations should perhaps focus on less-severe conditions that may be treated in primary care settings.

Strengths of our study include the use of multiple methods to explore the health impacts of a government-led energy efficiency programme. Together, the methods provide a more comprehensive evaluation of the intervention than could have been delivered by a single method alone. For example, although the community-based field study was subject to a number of biases, it was able to cover a wider range of subjective psychosocial outcomes and, although routine data may lack detail regarding subjective health experiences, it minimises selection and attrition biases with near-complete follow-up. Household monitoring showed objective changes in internal hydrothermal conditions, and focus groups provided an in-depth exploration of how residents experienced the intervention. Limitations included a lack of randomisation and, as with all observational studies, the potential for unmeasured confounding remains. Data quality was also an issue. The effort required to validate and clean intervention records received from data providers was considerable, and there was missing data for many intervention homes.

Future housing improvement programmes should build in health and economic evaluation components from conception with longer follow-ups; strategies may then be developed to increase response and retention rates. A stepped wedge randomisation in the delivery of a programme, together with improved reporting standards regarding the timing, delivery and costs, would provide more-robust evidence regarding health and psychosocial benefits. This research has shown that the use of multiple methods is preferable over single-method evaluations, and that there is a need to directly compare area-based with more-targeted affordable warmth programmes. Finally, process evaluation should become an essential part of testing complex housing-based interventions.

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