Health impact, and economic value, of meeting housing quality standards: a retrospective longitudinal data linkage study

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Declared competing interests of authors: Wouter Poortinga, Nikki Jones and Simon Lannon received funding from Carmarthenshire County Council to conduct a health impact survey study from 2009 to 2016. Jonathan Morgan was responsible for delivering the Carmarthenshire Homes Standard improvement programme.

Published June 2018
DOI: 10.3310/phr06080

Scientific summary

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Public Health Research 2018; Vol. 6: No. 8
DOI: 10.3310/phr06080

NIHR Journals Library www.journalslibrary.nihr.ac.uk

Scientific summary

Background

Poor-quality housing has been linked to numerous health problems such as cardiorespiratory diseases, injuries and mental health conditions. Causal pathways include cold housing, which has a major influence on excess winter mortality, mainly driven by cardiovascular and respiratory conditions. One estimate is that there are 12.8 excess deaths per 100,000 persons due to living in housing with inadequate warmth. More deprived members of society are more likely to live in poorer-quality housing, which may exacerbate ill health and social inequalities. Cold housing constitutes an economic cost to society related to health-care utilisation and absenteeism from work and school, which may also have an adverse impact on educational attainment.

Several international studies have investigated the effects of housing improvements on health, but few have used a randomised controlled design or longitudinal data. Although current research suggests that both mental and physical health improvements are achievable, in particular when interventions are targeted at populations at risk, the evidence is inconclusive. Many studies suffer from varying sources of bias, contain small numbers of study participants, rely on self-reports and have only short follow-up periods post intervention. Furthermore, a comprehensive pool of evidence relates to thermal efficiency improvements, but there is a scarcity of research on other aspects of housing quality. No large-scale longitudinal studies with the ability to evaluate complex, whole-house interventions with large numbers and long follow-up periods have been published previously.

Objectives

We investigated the health impact of a programme bringing social housing up to a national quality standard. Changes in health events were examined for council house residents after their homes received at least one cointervention as part of a concentrated housing improvement scheme to meet the Welsh Housing Quality Standard. Health service utilisation, as a proxy for health outcomes, was investigated for associations with each separate cointervention.

The primary research question was:

- What is the change in emergency hospital admission rates for cardiovascular, respiratory and injury-related conditions (combined) for tenants aged ≥ 60 years?

Secondary research questions investigated emergency admission rate changes for tenants aged ≥ 60 years, and for tenants of all ages. This was done separately for each of the three categories of conditions: respiratory, cardiovascular and injuries.

We were also interested in capturing changes in health events managed in the community that may not have resulted in a hospital admission:

- What are the changes in emergency department attendances, general practitioner (GP) treatments for mental health and respiratory conditions, and attendances at the GP for respiratory conditions?

Finally, we estimated the impact on costs associated with hospital admissions.

Design and setting

This study was designed as a natural experiment of improvements to housing quality in Carmarthenshire, UK. Repeated monthly measures of health outcomes at an individual person level were counted for residents aged ≥ 60 years who were registered for at least 60 days between January 2005 and March 2015 to social homes that received housing improvements ('intervention homes'). We also analysed health events for residents of all ages and used health events for people in the wider region to adjust for temporal trends.

Interventions

The multiple internal and external housing improvements included electrical system upgrades, new windows and doors, wall insulation, garden path safety improvements, upgrades to heating systems including new boilers, loft insulation, new kitchens and new bathrooms. The electrical system upgrades included rewiring, power sockets, extractor fans in kitchens and bathrooms, external security lights, carbon monoxide monitors and smoke alarms.

Data sources

Carmarthenshire County Council home address and intervention records were anonymously linked within the Secure Anonymous Information Linkage databank to demographic information from the Welsh Demographic Service data set; hospital admission data from the Patient Episode Dataset for Wales; primary care contacts and prescribed medications from GP practice data; emergency department attendances from the Emergency Department Data Set; and deaths from the Office for National Statistics mortality register.

Data linkage

Study home addresses and the housing intervention data were provided to a trusted third party, who anonymised these data into an anonymised databank [Secure Anonymised Information Linkage (SAIL)]. Within the SAIL databank, property-level data were linked to individual-level records held within an anonymised databank. Retrospective linkage of individuals to their homes was achieved using addresses held in the Welsh Demographic Service data set. Person- and property-level encryption methods allowed linkage to demographic, health data and mortality records without the need for access to identifiable information on individuals or addresses. We assigned study exit or entry dates as a result of migration, birth and death to build the dynamic cohort. Property data were used to identify homes that received at least one of the eight separate cointerventions during our study window.

Outcome measures

The primary outcome was combined emergency hospital admissions for cardiorespiratory conditions and injuries. We used *International Classification of Diseases,* Tenth Edition codes to define each disease-specific admission outcome, using the primary diagnostic code.

The secondary outcomes were GP treatments and attendances for asthma, chronic obstructive pulmonary disease (COPD) and common mental health disorders (CMDs). We used Read codes to define diagnoses and prescriptions. GP attendances were derived from total GP activity. Emergency department attendances for injuries likely to have occurred at home were selected using standard emergency department codes, filtered to include home location and exclude non-home locations.

Statistical analysis

Changes in the standard of eight housing cointerventions were determined from intervention records and linked to individuals registered at intervention homes. Counts of health events were obtained retrospectively for each individual in a dynamic cohort and were captured for up to 123 consecutive months. The exposure group for each cointervention was compared with a reference group of people living in homes that did not receive that cointervention during their tenancy. Individuals contributed to different exposure and reference groups for each cointervention, depending on which interventions they received.

Counts of health events were analysed using negative binomial regression models to determine the effect of each cointervention for people who were living in homes while housing standards were improved during their period of tenancy. A multilevel approach was used to account for repeated observations for individuals living in intervention homes and the unbalanced data generated by a dynamic cohort. We adjusted for the potentially confounding factors of age, gender, income deprivation, settlement type (rurality), existing comorbidities and background trends in health service utilisation in the regional general population.

A health economic impact evaluation was conducted using a cost–consequences analysis.

Results

Between January 2007 and March 2015, 70,279 housing work cointerventions were carried out to meet the national housing quality standard. An average of 2.2% of properties did not receive cointerventions because tenants declined the work. During the entire study period there were 10,521 emergency admissions relating to the combined conditions, and 17.1% of all participants had at least one admission. We analysed outcomes for 32,009 council housing residents, of whom 7054 were aged ≥ 60 years. We used health events for 231,200 people in the wider region to adjust for regional trends.

Emergency admissions combined: older residents

Residents aged ≥ 60 years living in homes in which the electrical systems were upgraded were associated with 39% fewer emergency hospital admissions than those in the reference group [incidence rate ratio (IRR) 0.61, 95% confidence interval (CI) 0.53 to 0.72; $p < 0.01$]. Associations with reduced admissions were also found for windows and doors (IRR 0.71, 95% CI 0.63 to 0.81; $p < 0.01$), wall insulation (IRR 0.75, 95% CI 0.67 to 0.84; $p < 0.01$) and garden paths (IRR 0.73, 95% CI 0.64 to 0.83; $p < 0.01$). There were no associations of change in emergency admissions with upgrading heating (IRR 0.91, 95% CI 0.82 to 1.01; $p = 0.072$), loft insulation (IRR 0.98, 95% CI 0.86 to 1.11; $p = 0.695$), kitchens (IRR 0.98, 95% CI 0.83 to 1.17; $p = 0.843$) or bathrooms (IRR 0.93, 95% CI 0.81 to 1.06; $p = 0.287$).

Emergency admissions combined: all ages

The effects remained for all ages. People of all ages living in homes in which the electrical systems were upgraded had 34% fewer combined admissions than those the reference group (IRR 0.66, 95% CI 0.58 to 0.76; $p < 0.01$). Reduced admissions were also found for new windows and doors (IRR 0.78, 95% CI 0.70 to 0.87; $p < 0.01$), wall insulation (IRR 0.80, 95% CI 0.73 to 0.87; $p < 0.01$) and garden path improvements (IRR 0.81, 95% CI 0.73 to 0.90; $p < 0.01$). There were no associations of change in emergency admissions with heating upgrades (IRR 0.92, 95% CI 0.85 to 1.01; $p = 0.083$), loft insulation (IRR 1.02, 95% CI 0.93 to 1.13; $p = 0.618$), new kitchens (IRR 1.01, 95% CI 0.87 to 1.18; $p = 0.867$) or new bathrooms (IRR 0.99, 95% CI 0.87 to 1.13; $p = 0.900$).

Emergency admissions separated: older residents

The effects remained similar for the older population when the hospital admissions outcomes were separated into those for cardiovascular conditions and those for respiratory conditions. In contrast to combined admissions, wall insulation was not associated with emergency admissions for injuries.

There were no associations of change in any category of emergency admission with heating upgrades, loft insulation, new kitchens or new bathrooms.

Emergency admissions separated: all ages

The effects remained similar for people of all ages when hospital admissions outcomes were separated into those for cardiovascular conditions and those for respiratory conditions. In contrast to combined admissions, neither wall insulation nor garden path safety improvements were associated with emergency admissions for injuries. There were no associations of change in any category of emergency admission with heating upgrades, loft insulation, new kitchens or new bathrooms.

Primary care outcomes

Prescribed medications for individuals with a history of asthma or COPD were reduced for those of all ages living in properties that had windows and doors upgraded (IRR 0.92, 95% CI 0.88 to 0.97; $p < 0.01$), compared with those for people in the reference group. Attendance at a general practice for people with respiratory conditions was also reduced for those living in homes that underwent electrical system upgrades (IRR 0.91, 95% CI 0.87 to 0.95; $p < 0.01$). There were no associations with any cointervention and prescribed common mental health medications among those with a CMD.

Emergency attendances

Residents of all ages living in homes in which the garden path was made safe had 20% more emergency attendances (IRR 1.20, 95% CI 1.07 to 1.35; $p < 0.01$) than those in the reference group.

Health resource impact

The cost of the housing improvements included in our study was £138M. The estimated costs relating to the reduction in emergency admissions associated with electrical system upgrades was £198,455 per 1000 persons (aged ≥ 60 years) per year, based on the assumption that benefits will be accrued for 10 years into the future, which reflects the minimum lifespan of the different cointerventions.

Conclusions

This complex interdisciplinary study required substantial consideration of the study design to most effectively capture the rolling programme of multiple housing cointerventions that extended for > 8 years, together with objectively recorded health events for the dynamic study population for our study decade.

Housing improvements, including electrical systems upgrades, wall insulation, new windows and doors, and garden path safety improvements, were associated with a reduction in emergency hospital admissions for people aged ≥ 60 years, and for all ages. Other housing improvements, including heating upgrades, loft insulation, new kitchens and new bathrooms, were not found to be associated with changes in emergency admissions. Upgrading electrical systems, which included rewiring, security lighting and installing extractor fans in kitchens and bathrooms, found a 39% and 34% reduction in emergency hospital admissions for older tenants and for all ages, respectively.

Social housing tenants contributed to different exposure groups for each cointervention based on their residency in a home that received each housing cointervention. Residents of homes that underwent improvements to meet national quality standards had their health events counted monthly, and these counts were compared with those for residents of homes that were not upgraded for the same cointervention. Our design overcame the lack of a standard comparator group to use reference groups comprising different tenants for each of our eight cointerventions.

The strengths of our study include the use of home- and individual-level data, which minimises the possibility of concealing health improvements within areas; minimal selection, participation and recall biases; complete data for hospital admissions; a large number of 183,553 person-years for follow-up;

adjustment for multiple potential confounders to enable generalisation to all homes of people of a similar socioeconomic status; censoring for people who died; and the evaluation of multiple cointerventions. Our study limitations included a lack of randomisation, a lack of precise costs spent on each individual home, a reliance on the accuracy of the routinely collected demographic data to link people into the relevant home and periods of occupancy, and the inability to estimate the effect of the entire regeneration programme in this complex intervention. Ideally, the intervention would be carried out in randomised stepped-wedge design, with a health and economic evaluation component built into any large-scale improvement from project conception.

Our study is a valuable addition to the literature, which recommended that long follow-up times are needed for the changes to be shown to have an impact on health outcomes. We have near-complete follow-up using data linkage to reduce follow-up bias. Our study is an order of magnitude larger than any other published work, with several thousand study subjects, 45% of whom were followed up for > 10 years. We have also added a whole-home intervention evaluation to the literature, isolating effects for individual cointerventions. No large-scale longitudinal studies with the ability to evaluate complex, whole-house interventions with large numbers and long follow-up time have been published previously.

Funding

Funding for this study was provided by the Public Health Research programme of the National Institute for Health Research.

Public Health Research

ISSN 2050-4381 (Print)

ISSN 2050-439X (Online)

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This report

The research reported in this issue of the journal was funded by the PHR programme as project number 09/3006/02. The contractual start date was in April 2011. The final report began editorial review in November 2016 and was accepted for publication in June 2017. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The PHR editors and production house have tried to ensure the accuracy of the authors' report and would like to thank the reviewers for their constructive comments on the final report document. However, they do not accept liability for damages or losses arising from material published in this report.

This report presents independent research funded by the National Institute for Health Research (NIHR). The views and opinions expressed by authors in this publication are those of the authors and do not necessarily reflect those of the NHS, the NIHR, NETSCC, the PHR programme or the Department of Health and Social Care. If there are verbatim quotations included in this publication the views and opinions expressed by the interviewees are those of the interviewees and do not necessarily reflect those of the authors, those of the NHS, the NIHR, NETSCC, the PHR programme or the Department of Health and Social Care.

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