

Housing Improvement and Health Gain: A summary and systematic review

Hilary Thomson, Mark Petticrew, David Morrison



MRC Social & Public Health Sciences Unit

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Housing Improvement and Health Gain: a summary and systematic review

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Lay summary

Poor housing is strongly linked to poor health. But can poor health be improved by improving housing. To answer this question we examined all housing research which had assessed the health of residents whose houses had been improved. We searched for studies from anywhere in the world which had been carried out in the past 100 years.

We found that

- housing improvements can improve residents' health, in particular their mental health;
- housing improvements can result in rent increases, which in turn can actually make people's health worse;
- the original residents may move to another area and not benefit from the housing improvements; and
- housing improvements can have negative as well as positive effects on health.

Lay summary approved by the Plain English Campaign

Executive Summary

Background: Epidemiological surveys have shown strong associations between housing and health but have been unable to show causal links. Intervention studies are, however, necessary to establish and explain causal links between housing and health. Evidence from such studies can be used to inform specific housing investment and predict health its health gains.

Aims: To provide policy makers and researchers with a summary of the evidence regarding the health impacts of housing interventions derived from experimental and non-experimental studies of housing interventions.

To make methodological recommendations for future research needs in the area.

Objective: To systematically review the evidence for the effectiveness of housing improvement as a health improvement measure.

Methods: A systematic review of experimental and non-experimental housing intervention studies which measured quantitative health outcomes. Studies dating from 1887, in any language or format, were identified from 17 clinical, social science and grey literature databases, personal collections, expert consultation and reference lists. Interventions to improve the indoor environment by means of furniture or indoor equipment were excluded unless they were part of other housing improvements.

Results

Nineteen completed studies dating from 1936 were identified. Interventions included Medical Priority Rehousing, energy efficiency improvements, rehousing, community regeneration and refurbishment. Eleven of the studies were prospective, of which six had control groups. Three of the retrospective studies used a control group. One study had used qualitative methods.

The range of interventions covered, together with the range of outcomes used and problems with study methodologies make it difficult to produce a clear statement of the effect of housing improvements.

A summary of the most methodologically sound studies, however, suggests that investment in housing does have the capacity to improve health; eight of nine studies which measured mental health showed improvements and one study demonstrated a 'dose-response' effect. Effects on specific physical outcomes (ie general health, respiratory symptoms) were less clear with similar studies sometimes showing similar sized effects but in opposite directions.

Adverse effects of housing improvements were also reported in a number of studies of rehousing and regeneration. In one study mortality rates increased. This was attributed to a doubling in rents which effected the households' ability to afford an adequate diet.

The identification of 14 ongoing housing intervention studies suggests increasing interest in generating evidence on how housing might improve health. Many of these studies are multi-disciplinary and indicate an increasing acceptance of collaborative, mixed method quasi-experimental evaluation of social interventions.

Recommendations for housing policy makers

- Housing improvements may improve residents' mental health.
- Small improvements in general health may also be observed.
- The associated increase in residents' housing costs may reduce the ability of the housing improvements to improve health and may have adverse health effects.
- Future housing investment should be accompanied by rigorous evaluations of residents' health before and after improvement.

Recommendations for housing research

- Large scale quasi-experimental studies which recognise the role of other social factors in the context of housing improvement and health are required.
- Studies comparing the effectiveness and cost-effectiveness of specific housing improvements are also required.
- In the absence of an extensive literature on housing interventions, large scale observational studies of housing and health should be systematically reviewed and used to contribute to the development of healthy housing policy.

1. Introduction

Poor housing has been used both as an indicator of poverty, and as a common target for interventions to improve public health and reduce health inequalities (Gauldie 1974). Although housing still has a prime place on the health inequalities agenda, it is also of wider importance, since small individual health impacts have the potential to exert large effects at the population level. The relationship between health and housing seems unarguable, and the basic human need for shelter would appear to make the relationship between poor housing and poor health self evident (Burrige and Ormandy 1993).

In spite of, or perhaps because of, this intuitive relationship there is a notable lack of good research evidence of the health gains that result from investment in housing (Thomson, Petticrew et al. 2001). Thousands of studies have investigated the health of populations and their housing conditions resulting in a body of evidence which displays consistent associations between poor health and poor housing (Thomson, Petticrew et al. 2001). Despite this, there remains some uncertainty about the strength of the evidence, as demonstrated in a speech by a former British Minister for Health, *“My officials tell me it’s hard to prove that better housing improves people’s health”*. (Frank Dobson, in a speech to the National Housing Federation in 1997)(Dobson 1997). Academics have also refuted claims that investment in housing can be justified on health grounds due to lack of evidence: suggesting rather that it should be on the basis of amenity and energy conservation (Strachan 1989; Maclennan and More 1999). While other academics have criticised housing research for failing to recognise that the potential for health gains from housing may lie outwith Medical Priority Housing (Smith 1989).

Going beyond associations

There is no shortage of evidence *per se*. There have been many, possibly hundreds, of cross-sectional studies which have reported statistically significant associations between poor housing conditions and poor health, though the results of these studies have also been conflicting (Martin, Platt et al. 1987; Williamson, Martin et al. 1997). Some of the main housing factors which have been consistently associated with health or illness in these studies are listed in Box 1 and are discussed in more detail in Chapter 2.

Observational studies demonstrating associations between poor housing and poor health show strong independent associations but their results remain open to debate and interpretation (Wilkinson 1999). In addition, observational studies are not

Box 1: Housing factors associated with health variation

Housing tenure
Outdoor temperature
Indoor air quality
Dampness & hygrothermal growth
Housing design- eg flats, terrace etc

Other housing related interventions associated with health variation

Rent subsidies
Relocation to different locality
Allergens & house dust mite
Home accidents prevention
Fire prevention

able to explain the nature or the strength of association observed or whether the damage done can be reversed.

Housing and environmental variables associated with poor health in cross-sectional surveys may show where housing interventions are warranted. However, such associations do not provide convincing evidence that such interventions will be effective. Well designed experimental or quasi-experimental studies (such as “natural experiments”) of the relationship between health and housing improvement provide stronger evidence of the potential for housing to generate health gains and also can help identify adverse effects. Quasi-experimental studies may not be appropriate for all aspects of housing; but to evaluate the effects of housing improvements and determine what it is about improved housing that may improve health, they are the design of choice where randomised controlled trials are not feasible.

Reviewing the evidence

It has been recommended that all future policies are prospectively assessed for their potential health impact and that recommendations should be evidence based (Acheson 1998). This call for evidence requires comprehensive reviews of empirical work but the volume of research literature accumulating in many areas, and the fact that the conclusions of studies are often conflicting can present problems. It has been suggested that this uncertainty may have prevented the development of healthy housing policy to improve the health and lives of those in poor housing (Maclennan and More 1999).

Comprehensive reviews of the housing literature already exist . (Raw and Hamilton 1995; Peat, Dickerson et al. 1998; Wilkinson 1999; Fuller-Thomson, Hulchanski et al. 2000; Holmes and Tuckett 2000). Two of these reviews reviews (Wilkinson 1999; Fuller-Thomson, Hulchanski et al. 2000) focussed on the more general literature reporting associations between poor housing and poor health as opposed to studies which attempt to look at health gains following improved housing. Both these reviews concluded that the body of existing research does demonstrate the existence of strong associations between poor housing and health. Other systematic reviews of housing related interventions, smoke alarms and house dust mite reduction measures, are summarised in chapter 2 (1996; 1996; DiGuseppi and Higgins 2000; Hammarquist, Burr et al. 2000).A comprehensive review of all epidemiological literature which links housing is due to be published in 2002(Hopton, Platt et al. 2001).

We conducted a systematic review of the evidence that housing improvements can be used to improve health. This is the first review which has attempted to systematically synthesise the body of evidence from intervention studies. Although this review does not report on the associations which have been reported in cross-sectional surveys, a brief summary of the main housing factors associated with health is also provided in the following chapter.

2. Housing and Health Variations

This chapter is intended to assist those carrying out Health Impact Assessments of new or improved housing. It provides an introduction to the literature and a guide to some of the main housing factors which have been related to health in previous studies [Box 1].

2.1 Housing factors associated with health

Housing tenure

There is a growing literature on the role of home ownership as an independent predictor of improved health. It is thought that home ownership may generate a degree of security and control, though again the direction of the relationship needs further investigation (Hiscock, Macintyre et al. 2000). Cultural variations in rates and meaning of home-ownership may give rise to international variations in the relationship between health and home ownership. However, home ownership is not always health promoting. Nettleton and Burrows' study of the health effects of mortgage arrears suggested that those living on the margins of home ownership suffer increased insecurity and poor mental health (Nettleton and Burrows 1998).

Outdoor temperature

There is considerable seasonal variation in mortality in the UK which is strongly related to reduction in outdoor temperatures (Curwen 1990/91). Recent analysis suggests that the seasonal variations are related to indoor rather than outdoor temperature and that this annual variation could be reduced by helping residents protect themselves from cold weather conditions (Wilkinson, Stevenson et al. 1998; Gemmell, McLoone et al. 2000).

Indoor Air Quality

The Building Research Establishment (Raw and Hamilton 1995) has produced a comprehensive review of the associated risks and health hazards of building fabric and indoor air quality. The hazards associated with the highest health risks were hygro-thermal conditions, radon, house dust mites, environmental tobacco smoke and carbon monoxide. This review has recently been updated (Raw 2001).

The MRC Institute for Environmental Health has an ongoing interest in the health effects of indoor and home air quality. In the most recent report of exposure to airborne particles in the home (Holmes and Tuckett 2000) the findings of observational epidemiological human studies and animal toxicological studies were reviewed. Most of the evidence relating to air quality and health arises from large-scale observational studies and much of the experimental evidence is based on animal studies which may not be generalisable to humans, in particular the more vulnerable groups. A major factor determining the level of indoor particles is the level of outdoor particles and their movement indoors. The most common sources of indoor airborne particles arise from environmental tobacco smoke, cooking, certain heating appliances and human activity. Short term elevations in ambient particles are strongly associated with increased mortality and morbidity, acute cardio-

pulmonary impairment being the predominant effect and vulnerable groups such as the elderly and asthmatics being most at risk (Holmes and Tuckett 2000).

Dampness and Hygrothermal growth

No recent systematic reviews of literature linking dampness, mould and health were identified. One paper has reviewed literature over 15 years which linked damp and mould in the home with respiratory health (Peat, Dickerson et al. 1998). The authors conclude that the increased risk of respiratory symptoms, if the home was damp or mouldy, was small (Odds Ratio range 1.5-3.5) and recommended that new build housing is designed to prevent the proliferation of indoor allergens.

Housing Design

Flat dwelling has been linked to social isolation, crime, reduced privacy and fewer opportunities for safe-play for children (Burrige and Ormandy 1993). There are many factors related to flat dwelling which may confound findings of surveys and there is no conclusive evidence that height of home from ground level is associated with reduced health or satisfaction with housing (Hannay 1981; Marmot 1983; Halpern 1995). A recent review of epidemiological surveys showed a consistent pattern of decreased levels of mental health being associated with housing height and multi-unit dwelling (Evans, Wells et al. 2000). It is not clear how these studies were selected for review and the authors point out that the poor quality of research prevents them making a causal link.

2.2 Housing related interventions

Housing Subsidies

Housing subsidies or vouchers have been used as a way of offering public housing tenants more control and choice over where they live and as a means of promoting integrated public housing tenancy. Housing vouchers which can be used in private rented accommodation can allow low income families to consume more housing and can free up funds to be spent on other work related expenses, such as travel to work, (Olsen and Barton 1983; Reeder 1985) as well as increasing employment opportunities and earnings. (Ong 1998) In one survey of child growth and nutrition, children whose family were on the waiting list for a housing subsidy were over eight times more likely to have low growth indicators than similar children whose families already received a housing subsidy (OR 8.2,95% CI 2.2-30.4). (Meyers, Frank et al. 1995) However, voucher programmes are effected by, and do themselves effect other important and inter-related factors such as the context of the housing market, income trends, housing supply and demand levels (Apgar 1990) and the quality of new-build subsidised housing. (Kennedy 1988).

Relocation initiatives in the US

The Gautreaux programme, introduced in Chicago in the mid 1970's, implemented a relocation and housing assistance package along with a housing subsidy. An experimental evaluation of the programme randomly allocated low income black families to improved housing in middle income white suburbs or improved housing in low income, mostly black, urban areas. The study followed 60% of the participants for 13 years and found that employment opportunities, education and social

integration were improved. The suburban movers attributed increased employment to increased job vacancies, increased neighbourhood security and less local gang activity (Rosenbaum 1991; Rosenbaum 1995).

Critics of the Gautreaux programme point out that the effects are confounded by the selective nature of the participants and by respondent attrition, and that the programme removes potential leaders and socially mobile families leaving the community even more deprived of resources and role models. The cost of providing tailored housing assistance is high and programmes need to be tailored to the local context. This, together with the effects of and on the local housing market make it difficult to be unequivocal about the cost-effectiveness of such programmes (Rosenbaum 1995). A large scale, quasi-experimental evaluation of a similar programme, Move To Opportunity (MTO), is currently being carried out in 5 cities across the United States (Goering, Kraft et al. 1999, Princeton University). Households are randomly assigned to the intervention which incorporates relocation from high to low poverty neighbourhoods, assistance to secure a suitable lease and training in domestic budgeting. Some preliminary findings confirm that of the original Gautreaux study (Ludwig, Duncan et al. 1999; Sard and Lubell 2000). One of the most recent publications reports that households in the treatment groups experienced improved health among household heads, and children in the experimental group were less likely than the control group children to experience an asthma attack (Katz, Kling et al. 2000). From the available reports of this work there are some data on changes in housing quality but no information on associated health changes. The final results of these evaluations are still being prepared. A systematic review of the effects of relocating low income families to middle income areas has been undertaken in the USA. This review only includes literature from USA based research and includes results of the evaluations of the Move To Opportunity programme (MTO), the results of the review have not yet been published (Anderson 2001).

Moving house

Moving house is considered to be a stressful, health damaging life-event (Hooper and Ineichen 1979). In the field of social housing, Allen attributes much of this stress to lack of opportunity to negotiate with the housing authority regarding the move (Allen 2000) and fits this into Easterlow's model of housing and health inequality; lack of desired control being a significant source of stress. Housing relocation has also been associated with loss of community, uprooting of social networks (Fried 1966) and unsatisfied social aspiration (Yuchtman-Ya'ar and Spiro 1979) which may counter satisfaction with improved housing.

Authors of a comprehensive review of relocation in the elderly were unable to come to any conclusions as to whether relocation was health damaging or not. (Danermark and Ekstrom 1990). In a follow-up qualitative study of the temporary relocation of elderly residents, the complex nature of meaning and context and the variation between individuals is highlighted (Ekstrom 1994; Ekstrom 1994).

Residents' satisfaction with their neighbourhood and housing has also been used as an indicator of quality of life and as an ad hoc measure of the success of housing investment. However, prioritising improvements in factors associated with high dissatisfaction may not maximise the well being of residents; residents who are dissatisfied with the local neighbourhood may prioritise housing improvements before neighbourhood improvements. (Galster 1985) Consultation with residents effected by the proposed housing improvements is important.

2.3 Systematic Reviews of housing interventions

Four systematic reviews of related intervention studies were identified while undertaking the searches for this review. The results are summarised below.

Interventions to reduce house dust mite

One review (Hammarquist, Burr et al. 2000) covered the effectiveness of house dust mite control measures in the management of asthma. This included physical measures such as vacuuming and acaricidal chemical measures. Twenty-three randomised controlled studies were included in the meta-analysis. Five of the studies did not assess reduction in house dust mite, and six other studies did not achieve a reduction in house dust mite. The authors concluded that current chemical and physical measures to reduce exposure to house dust mite allergens seem to be ineffective in the management of asthma. This is partly because asthma sufferers are often sensitive to other allergens as well as house dust mite.

Home Accidents, fire and falls

A systematic review of prevention of unintentional injuries in children and adolescents included a section on the home environment. (Towner, Dowswell et al. 2001) Interventions aimed at prevention of burns and scalds, poisoning as well as general home injuries were included. The authors conclude that the use of safety devices in the home, particularly smoke alarms and child resistant packaging on poisonous products, can reduce the risk of unintentional injury. Targeted programmes of free distribution of devices along with education and home visits are recommended to achieve highest level impact.

A review of 26 trials of smoke alarm promotion (13 were randomised) (DiGuseppi and Higgins 2000) concludes that counselling incorporated into health service provision as opposed to media and community education appeared to increase smoke alarm ownership (OR=1.26; 95% CI: 0.87 to 1.81). However, the effects on fire-related injuries following counselling were not evaluated. In two non-randomised studies fire related injuries were reduced following provision of free smoke alarms. A randomised controlled trial of free smoke alarm distribution among 20,050 households in London is currently underway. (DiGuseppi, Slater et al. 1999)

Specific housing recommendations arising from the a review of fall prevention in the elderly include regular monitoring by community services and appropriate environmental modification.(1996) Apart from physical safety modifications, interventions which reduced the risk of falling included exercise, balance training and tailored interventions for those on sedative/hypnotic drugs or suffering from postural hypotension. Three subsequently published relevant studies were also identified. Two controlled studies found that an exercise and balancing programme reduced the number of falls. (Campbell, Robertson et al. 1999; Steinberg, Cartwright et al. 2000) The third study monitored the number of self-reported falls, scalds and burns in 141 elderly people 6 months before and 6 months after a variety of environmental modifications were introduced, i.e. removing clutter and electrical cords, securing rugs, installing hand rails. Reported falls were reduced by 60%. (Plautz and Beck 1996)

3. A Systematic Review of Housing Intervention Studies: Aims and Methods

Aims

To provide policy makers and researchers with a summary of the evidence regarding health impacts of housing interventions derived from experimental and non-experimental studies of housing interventions.

To make methodological recommendations for future research needs in the area.

Objectives

- Identify and review current evidence of housing interventions and their effect on health

Searching

The following databases were searched: ASSIA (1987-2000), CAB Health (1973-2000), DHSS-DATA (1983-2000), EMBASE (1974-2000), HealthSTAR (1975-2000), MEDLINE (1966-2000), PAIS (1976-2000), PSYCINFO (1887-2000), SIGLE (1980-2000), Social SciSearch (1972-2000), Sociological Abstracts (1963-2000), Social Science Citation Index (1981-2000), Urdisc/Acommpline (1970-2000), Cochrane Controlled Trials Database 2000 Issue 2, IBSS (International Bibliography of the Social Sciences), SPECTR (searched December 2000), and the World Wide Web. Full details of the search strategy are in appendix I.

Other sources of information

Bibliographies of all reports, papers and text books reviewed were searched for further intervention studies or systematic reviews regarding housing and health.

An e-mail was circulated to all subscribers of Housing Studies Association newsletter and the Health Action Zone discussion group requesting information of unpublished and ongoing studies relevant to the review. In addition a printed request for study details was printed in the newsletter. Project managers at The Joseph Rowntree Foundation were asked to inform the reviewers of any relevant ongoing work, and delegates at a major international housing conference were asked for details of any further suitable studies, either completed or ongoing.

An internet search of the following sites was carried out:

Scottish Poverty Information Unit- <http://spiu.gcal.ac.uk/home.html>

Housing Corporation Innovation & Good Practice and Research Database- <http://cig.bre.co.uk/igp.html>

The Joseph Rowntree Foundation- <http://www.jrf.org.uk/>

Projects funded by the joint DH/DETR/MRC research programmes on air pollution-

<http://www.update-software.com/National/nrr-frame.html>

<http://www.doh.gov.uk/hef/airpol/researchprojects.htm>

UK National Research Register- <http://www.doh.gov.uk/nrr.htm>
United States Department of Housing and Urban Development, Office of Policy Development and Research (US)- <http://www.huduser.org/>
Regard: National Database on Social Science Research (UK)- <http://www.regard.ac.uk>
National Centre for Social Research (UK)- <http://www.natcen.ac.uk>
OHN in Practice database- <http://www.ohn.gov.uk/database/database.htm>
Current Controlled Trials- <http://www.controlled-trials.com/>

Housing and health research may be based in health departments, academic or health authority, housing departments of higher education, local authorities or housing associations, social policy or local enterprise companies. The reviewers went to considerable lengths to uncover previous and ongoing work within these groups. In addition to searching the database of 'grey' literature this involved many phone calls following up leads.

Inclusion criteria

We sought primary studies in any language of the effects of housing improvements which used experimental or quasi-experimental approaches, including randomised and non-randomised controlled trials and observational studies which used prospective or retrospective measures of health. For the purposes of the review, outcome measures were based on a social model of health, and included socio-economic and wellbeing changes as well as illness-based outcomes. Housing interventions were defined as rehousing and all physical changes to housing infrastructure, for example heating installation, insulation, double glazing and general refurbishment.

Exclusion criteria

The review did not include interventions to improve the indoor environment by means of furniture or indoor equipment, (such as vacuuming, mattresses, and air purifiers) unless the evaluation measured changes in residents' health and the measures were part of a package of interventions which included improvements to the house itself. Environmental studies of the adverse effects of lead, urea formaldehyde foam, air quality, allergen reduction or radon were not included. These studies were thought to assess the impact of exposure to the potential hazard rather than its impact as a housing improvement. In addition, evidence of the harmful effects of radon, lead and asbestos is now accepted. (Wilkinson 1999) However, systematic reviews and meta-analyses on these topics identified as a result of the search strategy were noted and have been discussed in the introduction of this report.

Validity assessment & data abstraction

At least two reviewers independently screened all abstracts for inclusion. Three reviewers critically appraised the included studies according to a set of methodological criteria (see Box 2); those graded as C were not considered in the final assessment of the evidence. Data was abstracted by one reviewer and checked by a second reviewer. Where data on the specific group of interest to the review was not available in the publication it was recalculated where possible (e.g. new p values were calculated). Given the broad range of outcome measures used across the studies included, a meta-analysis was not possible.

Box 2: Criteria by which studies were graded

Strength of evidence (A,B,C)

- Level A:**
- Prospective study, follow-up of >80%, 6 months or more of follow-up
 - Randomised controlled trial, or controlled study with comparable control group
 - Objective assessment of health outcome(s)
- Level B:**
- Prospective study with control group
 - Limited control of confounding; but appropriate assessment of health outcomes
- Level C:**
- Other study designs: prospective and retrospective studies that failed to adjust for confounding factors
 - Studies with biased assessment of health outcomes

Adapted from framework used in systematic review of water fluoridation (CRD 2000).

4. Results

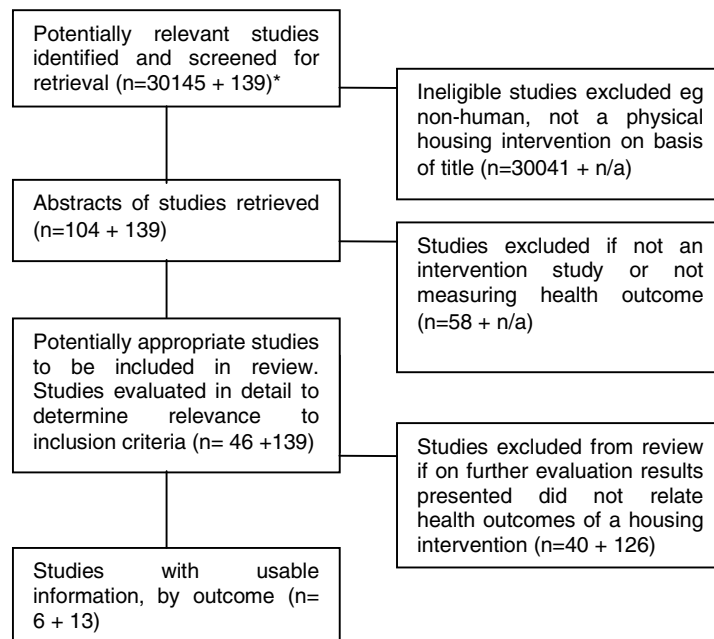
A total of 30,145 citations were identified [Box 3] from the searching. Most citations were excluded on the basis of information within the title. Most commonly excluded citations were animal studies, toxicology studies, commentary on housing policies, studies of population groups with special housing needs or cross-sectional studies. Figure 1 illustrates the stages at which studies were excluded. A list of selected excluded studies is provided in Appendix II, and further details of the search results and excluded studies is available from the authors.

Nineteen completed intervention studies of any design were identified [Table 1]. (McGonigle and Kirby 1936; Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Wambem and Piland 1973; Carp 1975; Carp 1977; Cole and Farries 1986; Elton and Packer 1986; Iversen, Bach et al. 1986; Elton and Packer 1987; Baba, Baba et al. 1994; Halpern 1995; Ambrose 1996; Hopton and Hunt 1996; Woodin, Delves et al. 1996; Smith, Alexander et al. 1997; Green and Gilbertson 1999; Somerville, Mackenzie et al. 1999; Walker and Bradshaw 1999; Ambrose 2000; Ellaway, Macintyre et al. 2000; Green, Ormandy et al. 2000; Somerville, Mackenzie et al. 2000; Wells 2000; Blackman, Harvey et al. 2001) the earliest dating from 1936. (McGonigle and Kirby 1936) Only six of the 19 studies were identified by electronic databases [Box 4]. Three studies examined the health impacts of medical priority rehousing, (Cole and Farries 1986; Elton and Packer 1986; Elton and Packer 1987; Smith, Alexander et al. 1997) 12 examined health effects of rehousing or refurbishment and renovation in the general population, (McGonigle and Kirby 1936; Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Wambem and Piland 1973; Carp 1975; Carp 1977; Baba, Baba et al. 1994; Halpern 1995; Ambrose 1996; Woodin, Delves et al. 1996; Walker and Bradshaw 1999; Ambrose 2000; Ellaway, Macintyre et al. 2000; Wells 2000; Blackman, Harvey et al. 2001) and 4 assessed energy efficiency measures. (Iversen, Bach et al. 1986; Hopton and Hunt 1996; Green and Gilbertson 1999; Somerville, Mackenzie et al. 1999; Green, Ormandy et al. 2000; Somerville, Mackenzie et al. 2000)

Eight (McGonigle and Kirby 1936; Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Wambem and Piland 1973; Halpern 1995; Ambrose 1996; Woodin, Delves et al. 1996; Walker and Bradshaw 1999; Ambrose 2000; Blackman, Harvey et al. 2001) of the 19 studies assessed housing improvement in the context of area or community regeneration.

Fourteen ongoing [Table 2] UK-based studies of housing intervention studies were also identified. These are evaluating similar

Figure 1: Trial Flow



*(citations identified by electronic database searching + citations identified by other searches, see methods)

interventions to the completed studies.

Box 3: Total number of hits by database

Database Name	Total Number of Hits
SPECTR	11143
Social Science Citation Index (1981-)	5482
EMBASE (1974-)	3723
HealthSTAR (1975-) & MEDLINE (1966-)	3311
PsychINFO (1887-)	1660
Social SciSearch (1972-)	1220
Sociological Abstracts (1963-)	1182
CAB Health (1973-)	1035
DHSS-DATA (1983-)	686
PAIS (1976-)	359
ASSIA (1987-)	144
SIGLE (1976-)	89
Urbadisc/Acompline (1970-)	76
IBSS	35
Cochrane Controlled Trials Database (2000)	0
Total	30145

Box 4: Included studies and their database sources at the time of the search

	Medline	Embase	Soc Citat	Sci	How we got it?
Ambrose (2000)					Newspaper report & e-mail contact
Baba et al. (1996)					Other database
Blackman et al. (2001)	IN PRESS WHEN IDENTIFIED				Personal communication
Carp (1975)	✓		✓		
Carp (1977)	✓				
Cole & Farries (1986)	✓	✓	✓		
Ellaway & Macintyre (2000)					Personal communication
Elton & Packer (1987)	✓	✓	✓		
Elton & Packer (1986)	✓	✓			
Green & Gilbertson (1999)					Personal communication
Green & Gilbertson (1999)					Personal communication
Halpern (1995)					Cited in bibliography
Hopton & Hunt (1996)			✓		
Iversen et al. (1986)					Other database
McGonigle & Kirby (1936)					Cited in bibliography
Smith et al. (1997)		✓			
Somerville et al. (1999)	UNPUBLISHED REPORT				Cited in bibliography
Somerville et al. (2000)		✓	✓		Personal communication
Walker & Bradshaw (1999)					Personal communication
Wamben & Piland (1973)	✓				
Wells (2000)	CONFERENCE PRESENTATION				Conference attendance
Wilner et al. (1958)					Cited in bibliography
Wilner et al. (1960)					Cited in bibliography
Woodin et al. (1996)	UNPUBLISHED REPORT				Personal communication

Medical priority rehousing

All three studies of medical priority rehousing reported improvements in self-reported physical and mental health; however the only prospective study was small (n=56) (Elton and Packer 1986; Elton and Packer 1987) and no study had controlled for the effects of possible confounding variables [Table 1]. One retrospective study examined effects on health service use; no clear pattern was observed. (Smith, Alexander et al. 1997)

Rehousing/refurbishment plus relocation from slum area or community regeneration

Eight (McGonigle and Kirby 1936; Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Wambem and Piland 1973; Halpern 1995; Ambrose 1996; Woodin, Delves et al. 1996; Walker and Bradshaw 1999; Ambrose 2000; Blackman, Harvey et al. 2001) of the 11 studies of rehousing included some level of area regeneration. Two of the six prospective controlled studies reported beneficial health effects, including improvements in mental health. (Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Carp 1975; Carp 1977) Only one of these studies had controlled for confounding factors. This study showed an initial increase in illness episodes in the intervention group at 9 months, but at 18 months a greater reduction in illness episodes compared to the control group was reported, though the absolute difference was small (difference=29 episodes per 1000 people) and the follow-up rate is not stated. Improvements in mental health were also reported in this study. (Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960) The other prospective study also reported improvements in mental and physical health, though the intervention group in the study was small (n=62), it is unclear how applicants for a move were selected and no baseline data on the comparability of the control groups is provided. (Carp 1975; Carp 1977) In addition, this study was among an elderly population and measured changes in rates of failing health rather than health improvements.

Adverse effects were identified in three studies where residents had been rehoused. These included increases in chronic respiratory conditions, reduced ratings of good health and increased mortality rates. (McGonigle and Kirby 1936; Ambrose 1996; Ambrose 2000; Blackman, Harvey et al. 2001)

Energy efficiency measures

We found seven studies (Iversen, Bach et al. 1986; Heatwise 1992; Heatwise 1994; Kosmina and Sheldrick 1995; Hopton and Hunt 1996; Green and Gilbertson 1999; Somerville, Mackenzie et al. 1999; Green, Ormandy et al. 2000; Somerville, Mackenzie et al. 2000) of the impact of fuel efficiency measures on house temperature, fuel costs and residents' satisfaction, but only four incorporated a measure of health or well being. (Iversen, Bach et al. 1986; Hopton and Hunt 1996; Green and Gilbertson 1999; Somerville, Mackenzie et al. 1999; Green, Ormandy et al. 2000; Somerville, Mackenzie et al. 2000) The studies included in the review suggest that these interventions result in small improvements in respiratory and other symptoms. Two studies adjusted for potential confounding variables. High (69%) (Iversen, Bach et al. 1986) , or unreported (Green and Gilbertson 1999; Green, Ormandy et al. 2000) rates of attrition in these and most other studies may limit the generalisability of these findings.

Some studies also assessed the impacts of housing improvement on health service use; with reported findings including decreased GP visits, reduced likelihood of inpatient and outpatient use of health services, and reduced prescribing of hypnotic and respiratory drugs. None of the evidence for these impacts came from methodologically robust prospective controlled studies. Broader social impacts of housing improvement were also reported in some studies, including improvements in social outcomes, such as perceptions of safety and social and community participation. (Halpern 1995; Woodin, Delves et al. 1996; Ambrose 2000) One small study reported a small increase in a measure of social support after the intervention, (Halpern 1995) and two studies which examined the effects of housing improvement in the context of area regeneration reported that residents' concerns about local crime were reduced. (Woodin, Delves et al. 1996; Ambrose 2000) Another small study reported that fewer days were lost from school due to asthma after heating improvements (Somerville, Mackenzie et al. 2000).

Summary of health effects

It is not possible to produce a clear summary of effect sizes describing the nature and size of health effects, but an overview of the effects arising from prospective controlled studies is presented here. Self-reported health (mental and physical) improved and illness episodes reduced (Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Carp 1975; Carp 1977) but effects on symptoms were inconsistent, demonstrating a small positive effect in one study (Iversen, Bach et al. 1986) and no effect in another. (Hopton and Hunt 1996) Self reported measures of health service use in an elderly population increased more for those residents who had not been rehoused ($p=0.03$). (Carp 1975; Carp 1977) Nine studies included a measure of mental health; all of these, except one, reported improvements. In one study a validated, objective measure of mental health demonstrated improvements. (Elton and Packer 1986; Elton and Packer 1987) In another prospective controlled study the size of psychological improvement was directly related to the extent of housing improvement experienced by the tenant, demonstrating a dose response effect. (Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960) One study found an increase in mortality rates; this was attributed to a doubling in rent in the new houses which, in turn, effected the households' ability to buy food (McGonigle and Kirby 1936).

5. Generating Evidence for Healthy Housing Policy

In line with the aims of the review we now address some of the methodological issues raised by this review.

Despite a wealth of data from cross-sectional studies there is a dearth of housing intervention studies. Although this is disappointing, there may be reasons for this. In addition, there may be lessons to be learnt from the intervention studies completed which can help to improve the quality of future research in this area.

5.1 A review of methods used to evaluate the health effects of housing improvements

Obstacles To Housing Intervention Studies

From a methodological perspective there are many difficulties with assessing the health effects of housing interventions. The relationship between housing and health is characterised by multi-factorial interactions and untangling causal relationships or applying experimental conditions is not straightforward. For example, within populations it is generally the more vulnerable groups, the elderly, sick, unemployed, mothers and young children, who spend the most time indoors resulting in much higher levels of exposure to potential hazards. It may be unhelpful to control for factors individually associated with increased morbidity, for example Graham (Graham 1987) explains cigarette smoking in terms of mediating the stress effects of deprivation and poor housing. The growing interest in the 'spill-over' effects of poor housing suggests that poor housing itself may generate other social problems in an area. (Maclennan and More 1999) In addition, housing interventions rarely occur in isolation, and often a major refurbishment or new build initiative will be accompanied by other community regeneration activities. This may effect the socio-demographics of an area and could make before-and-after comparisons problematic.

There are also pragmatic restrictions on housing research methodology. It is not always feasible to impose an experimental model; for example, it is not possible to blind groups to changes in their housing, resulting in high levels of recall bias (Rothman and Greenland 1998). There may be a time delay between exposure to a housing hazard and the emergence of a health effect. Furthermore, housing studies naturally focus on areas of deprivation where populations are highly mobile, levels of attrition are high and it is difficult to select a population which is relatively homogenous yet large enough to detect small changes in morbidity.

More generally the experimental approach to housing research has been criticised for being reductionist, and ignoring the multi-factorial nature of causality in housing, deprivation and health (Hunt 1993). However, broad generalisations about the link between deprivation and ill health may have only a limited role in informing specific policy decisions (Thunhurst 1993).

Political obstacles to conducting housing research may also have impeded high quality research work in the area and similarly impeded informed decision making by policy makers (Maclennan and More 1999). This lack of evidence and the

methodological limitations of existing studies may have been used by governments to absolve them of responsibility to improve housing on health grounds.

Study designs and methods used

Eleven of the reviewed studies were prospective, of which 6 (McGonigle and Kirby 1936; Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Carp 1975; Carp 1977; Elton and Packer 1986; Iversen, Bach et al. 1986; Elton and Packer 1987; Hopton and Hunt 1996) employed control groups. Three (Wambem and Piland 1973; Green and Gilbertson 1999; Walker and Bradshaw 1999; Green, Ormandy et al. 2000) of the 8 retrospective studies had used a control group for comparison [Table 1]. One study of rehousing and refurbishment used qualitative methods. This study was retrospective, uncontrolled and reported difficulties with obtaining a representative sample (Ellaway, Macintyre et al. 2000).

Seven of the ongoing studies are prospective and controlled. One of these is employing a randomised stepped wedge design (Somerville 2000). Only two of the ongoing studies identified are using interviews, though it is unclear if these will be suitable for qualitative analysis.

The validity of data from retrospective studies is often a problem due the introduction of recall bias. These studies are not able to report on previous health state and difficulties of blinding residents to housing changes introduce further bias. Prospective controlled studies would provide stronger evidence. However, given the range of interventions covered and small sample sizes, and low follow-up rates, it is difficult to generalise from these.

Outcomes used in existing studies

The type of outcome measure used to assess health impacts may provide another source of study bias. Health indicators reported by these studies ranged from self-reported illness/symptom episodes, and feelings of wellbeing to validated mental and general health measures and routine data on infant and adult mortality data. Some studies also assessed the impacts of housing improvement on health service use, with reported findings including decreased GP visits, reduced likelihood of inpatient and outpatient use of health services, and reduced prescribing of hypnotic and respiratory drugs. Broader social impacts of housing improvement were also reported in some studies including improvements in social indicators, such as perceptions of safety and social and community participation (Halpern 1995; Woodin, Delves et al. 1996; Ambrose 2000).

Four studies used routine health service data (McGonigle and Kirby 1936; Wambem and Piland 1973; Somerville, Mackenzie et al. 1999; Walker and Bradshaw 1999; Somerville, Mackenzie et al. 2000) ; two of these studies used linked individual routine data. (Wambem and Piland 1973; Somerville, Mackenzie et al. 1999; Somerville, Mackenzie et al. 2000) In one study, routine prescription data for hypnotic drugs were reduced following housing refurbishment; however data were not linked to individuals and there were reports of changes in the population demographics. (Walker and Bradshaw 1999) Another study found increases in mortality rates which were then explained by increases in rents which in turn impinged on the households' ability to purchase an adequate diet.

Routine data can be an invaluable source of information. If used at an area level it can be easy to collect and is generally regarded as an objective measure of mortality,

morbidity, service use or provision. However, as illustrated in Walker & Bradshaw's study of routine practice prescribing data, changes in population demographics may be obscured. (Walker and Bradshaw 1999) Use of routine data which is linked to individual records produces data which is more sensitive to potential effects, however routine record linkage is labour intensive and may not always be possible.

Multi-disciplinary studies

Housing research has been criticised for not taking a multi-disciplinary approach. (Smith 1989) Few of the previous studies have been collaborative efforts or have used a mixed method approach. The number of current multi-disciplinary housing studies, however, does imply a greater willingness to employ collaborative approaches although it is not often clear exactly what collaboration entails (Hayes, Hood et al. 2000).

5.2 Housing study design: some recommendations

Difficulties in observing the effects of improved housing may be an inherent problem in evaluating social interventions. Social interventions such as housing are characterised by their complexity and their interactions with peripheral factors which are not well described or understood. What may seem an intuitively good intervention may produce adverse effects and the effectiveness of an intervention may be maximised by assessing the existence and nature of adverse effects and taking action to minimise them. Evaluations of housing improvements must be open to the possibility of wider adverse effects so that future housing investment can at least do no harm and that the potential for health gains is maximised.

Evidence of the effectiveness of interventions, or 'what works', needs to be derived from experimental or quasi-experimental study designs. Some intervention study models are, however, at risk of attempting to use aggregate data to explain relationships at an individual level. (Robinson 1950) The investigation of complex relationships which are known to be influenced by social factors requires a broader perspective, combining quantitative and qualitative methods. (Baum 1995) This can be achieved to some degree by:

- using a definition of health which recognises the importance of social factors.
- avoiding relating aggregate data to individual cases, and
- using qualitative methods to explain some of the processes involved in identified associations.

We would suggest that with careful planning of a flexible, quasi-experimental design, it is possible to elicit measures effectiveness of housing and other social interventions. Although, there is long a tradition of this type of evaluation in the USA it has rarely been attempted in the UK. (Oakley 1998) The studies in this review may be few in number, but they demonstrate that it is possible to apply these methods to housing research, ideally to design prospective studies with matched control groups. Many ongoing studies are drawing on both bio-medical and social science expertise and deploying quasi-experimental methods. Studies using qualitative and quantitative methods were less evident.

As well as careful study design, rigorous sample selection, analysis and reporting, this type of housing research requires intensive efforts and associated resources to ensure large enough sample sizes and successful follow-up rates. It is clear that successful follow-up of populations is possible over periods of a few years; high levels of follow-up can add considerable weight to study findings. However, achieving high follow-up rates over long periods is labour intensive and there are important resource implications for funders to consider.

It is apparent that major housing refurbishment or rehousing in an area is often accompanied by area regeneration. Many of the studies identified in this review, completed and ongoing, were set in the context of area regeneration and it may be difficult to tease out the effects of housing itself. One study reported that there had been a population shift following the regeneration making before and after comparisons of less relevance. (Walker and Bradshaw 1999) Elliot et al (Elliott, Landes et al. 2001) have produced an overview of evaluations of regeneration projects. They provide frameworks for evaluation models and emphasise the need for rigorous summative, mixed-method approaches which use indicators that recognise the residents own experiences of regeneration as well as more objective measures.

Selecting a control group

Matching control groups can control for area or individual factors which may change over time regardless of the intervention. Studies with well-matched control groups for example are able to isolate changes in health status due to housing improvements from other causes such as regression to the mean and the influence of confounding variables. However, matching for area rather than individuals may not control for confounders between individuals, such as age and social class. The need for a control group which is similar to the intervention group at baseline is clear; if groups are dissimilar at baseline, then differences in health status at follow-up may not be due to the intervention but to pre-existing differences in health.

Matched control groups were used in both retrospective and prospective studies identified in this review. However, even when authors report matching the control group, data on comparability of the groups should be checked. Photographs from Wamben & Piland's (1973) (Wambem and Piland 1973) study for example show stark differences in baseline housing conditions between the control and intervention group. Seven studies we identified selected the control group from the same population, (Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Carp 1975; Carp 1977; Iversen, Bach et al. 1986; Hopton and Hunt 1996; Smith, Alexander et al. 1997; Green and Gilbertson 1999) though in two of these studies (Carp 1975; Carp 1977; Hopton and Hunt 1996) the control groups were selected from those who did not volunteer for the intervention and this may have introduced selection bias.

5.3 The research contribution to evidence based healthy housing policy

The current evidence base for healthy housing policy

The distinct lack of evidence of the positive health effects of improved housing may be surprising; there is little evidence that improved housing can improve physical health. One startling finding was of the adverse socio-economic effects of increased

rents in new housing. (McGonigle and Kirby 1936) It is possible that this and other unknown adverse effects minimised the potential for health gains and that these effects were not detected due to methodological or study design problems. This finding highlights the need for housing evaluations to be open to possible adverse effects and to encompass a broad set of explanatory variables.

The most valuable study of housing improvements is likely to be that which collects both individual and area level data and includes subjective and objective health measures– with health interpreted broadly enough to encompass wider social impacts of housing interventions. The cost and difficulty of collecting this information makes it unlikely that any significant or robust evidence-base in this area will be assembled in the near future. Six large ongoing prospective controlled studies have been identified, their results will be a valuable addition to the evidence base.

Broadening the evidence base

Although quasi-experimental studies are a powerful method of evaluating the health effects of a housing improvement this design may not be appropriate or be the design of choice for all aspects of housing. In addition, in the absence of evidence from intervention studies it may be necessary to develop a more inclusive evidence base.

The main methodological challenge to this probably lies in maximising use of existing observational evidence and integrating it with the few existing intervention studies. As the results of ongoing studies become available, estimates of the nature and size of the health impacts of housing can then be refined. Well-conducted, large scale observational studies can be used to inform intervention needs, study designs, likely indicators and can generate hypotheses. They can also be used to complement data from intervention studies. (Black 1996; Lewsey, Leyland et al. 2000)

Longitudinal studies have been recommended as a useful, if expensive, study design in evaluating complex interventions such as housing. Longitudinal studies have the advantage of being able to follow residents over long periods of time, therefore elucidating possible temporal effects of poor housing and health in later life. ^(Smith 1989) As an example, the National Childhood Development Study (NCDS) was able to look specifically at the impact of housing on health and the temporal relationship of poor housing and poor health over the first 33 years of life. The authors conclude that poor housing does cast a shadow on health in later life and demonstrated a dose-response relationship, with multiple housing deprivation leading to greater risk of disability or severe ill health in later life. (Marsh, Gordon et al. 1999) Data from the Boyd-Orr cohort also suggests that childhood housing conditions have an effect on adult health independent of the effects of socio-economic deprivation. (Dedman, Gunnell et al. 2001) Longitudinal data collection can be built into intervention studies but response rates over time are liable to fall.

There is also scope for further research into the relationship between health selection and housing conditions, which investigates the direction of the relationship between health and housing. Some data on this highlights housing careers that are adversely effected by poor health. (Smith 1990) The risk of mortgage indebtedness associated with home ownership complicates the positive relationship between health and housing tenure. Robinson also suggests that poor health is a barrier for homeless people attempting to re-enter into the housing system. (Robinson 1998)

6. Discussion

There have been few studies of the effectiveness of housing improvement as a measure for improving health. Existing studies have, however, reported improvements in overall self-reported physical and mental health and reductions in symptoms following housing improvement. Improvements in mental health are consistent across studies and have been related to degree of housing improvement, thus strengthening this relationship. There is some evidence of reductions in health service use, and some studies have shown improvements in broad indicators of social inclusion such as fear of crime and neighbourliness. However, a number of studies of rehousing and regeneration have reported adverse effects, such as increased symptoms and increased mortality rates. In addition, because of the methodological limitations of many of these studies, the evidence that health improvements result from housing improvement is limited. In particular there are few large prospective controlled studies, and many studies are now quite old. A summary of effects from the higher quality studies reviewed (McGonigle and Kirby 1936; Wilner, Price-Walkley et al. 1958; Wilner, Price-Walkley et al. 1960; Carp 1975; Carp 1977; Elton and Packer 1986; Iversen, Bach et al. 1986; Elton and Packer 1987; Hopton and Hunt 1996) suggests that there can be real health gains observed following housing improvement. However, the range of interventions and outcome type is wide, and some of the better studies are limited by small numbers in the final sample. Overall there is little robust evidence at present that housing improvement can act as an effective or cost-effective tool for the reduction of health inequalities.

The level of heterogeneity in intervention and outcomes used among the studies limits our ability to synthesise the evidence or to draw clear conclusions. Effect sizes arising from retrospective and uncontrolled studies also need to be interpreted with caution. The possibility of publication bias also needs to be considered; given the small effect sizes and small final sample sizes in many of the studies it is possible that these studies may overestimate the actual effects of housing improvements.

Review methods

This review has gathered and synthesised the available evidence that housing improvements have the capacity to influence the health status of residents. The review covers evidence from around the world, published in all languages. Worldwide information for on-going studies was difficult to obtain (Kreiger 2000; Walda 2000; Walda 2000). We found very few high quality, intervention studies which address the impact of housing and health. The methods for this review have implications for methods of other reviews of non-health sector interventions. It is important to note that only 6 out of the 19 included studies were identified using electronic databases. The high proportion of studies identified using more time-consuming methods would suggest that systematic reviews of non-clinical interventions need to develop specially tailored search strategies.

7. Conclusion

It is encouraging to note the apparent shifts in housing research. Increased political interest in funding housing research and demand for evidence of effectiveness have appeared to facilitate this. There would also appear to be growing acceptance of quasi-experimental methods applied to evaluations of social interventions such as housing. Despite previous recommendations to incorporate a mixed methodology using qualitative work, it is unlikely that any of the ongoing studies will include in-depth interviews.

Although we strongly advocate the use of quasi-experimental evaluations it is important that other sources of evidence are also used. Observational data can be used to prioritise by risk association though methods of synthesising these data are not well developed. There is still much to be understood about the mechanism of interaction of social factors and the effects of poor housing over the lifecourse. Longitudinal and qualitative research is also required to investigate the direction of the relationship between housing and health and to determine what it is about housing that effects health either negatively or positively

Evidence on costs and effects of housing investment is likely to be of most value to policy makers and housing providers, and could be used to add substance to the development of policies to reduce health inequalities. (Maclennan and More 1999) Assembling such evidence requires an holistic approach, combining quantitative and qualitative methods and taking into account a range of possible influences and mechanisms. (Baum 1995) There is also a lack of comparative information on the costs and effects of specific housing improvements, such as central heating or major refurbishment. In addition to methodological considerations to generate evidence which can inform housing policy, it is essential that housing studies are adequately resourced in order to overcome the pragmatic difficulties of small sample sizes and high attrition rates often encountered.

Large scale studies which investigate the wider social context of housing improvements and their comparative effectiveness and cost-effectiveness are now required.

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Table 1: Controlled and uncontrolled intervention studies of the health impacts of housing

Study, country	Study methods, length of follow-up, number of participants (intervention/control)	Intervention	Health and social outcomes	Sample selection	Were potential confounding factors controlled or adjusted for?	Blinded assessment of outcomes	Main results (Response rate/follow-up rate at end point)	Strength of evidence
Medical Priority Rehousing (MPR)								
Elton & Packer (1987) ^{59, 60} Salford, UK	Prospective controlled observational study (within a randomised controlled trial). Interview and questionnaire before, 6-8 and 52 weeks after (n=28/28)	Prioritised rehousing by council on mental health grounds	Mental health, by Foulds and Bedford Personal Disturbance Inventory and Scales (DSSI/sAD) and Present State Examination (PSE).	Yes	None	No	6-8 weeks after initial interview 23/28 of the intervention group and 6/28 of the control group had been rehoused. <i>Health outcomes:</i> Greater reduction in anxiety and depression in those rehoused, based on comparison of 11 matched rehoused/non-rehoused pairs (anxiety -6.5 v -0.6, p=0.0003, depression -6.0 v -1.5, p=0.005) (100% at 1 year)	B
Smith et al. (1997) ⁶¹ North, Midlands, and South of England	Retrospective cross-sectional study. Interviews at 3 sites 1-12 months after application for rehousing. (n=349/189)	Rehousing by council on mental health grounds	Self-reported general health status by Nottingham Health Profile (NHP); health service use	Yes	None	No	<i>Health outcomes:</i> Movers show improved NHP scores compared to those awarded priority but not yet moved (NHP energy: 44.8 v 63.4; pain 30.6 v 44.4; emotion 26.2 v 44.5; 39.2 v 52.2; 21.1 v 31.1, all p<0.05). Of those with mental health problems 56% reported an improvement in their mental health since the move <i>Health service use:</i> Movers reported GP use was increased for 21% and decreased for 22%; Similar patterns for contact with consultants (14%, 24%), outpatient departments (14%, 22%), and time in hospital (14%, 30%). Improvements in general health were reported by 61% of MPR movers (no control data available). (76% at 1-12 months)	C

Cole & Farries (1986) ⁶² Bolton, UK	Retrospective cross sectional study. Questionnaire survey of 271 households 2-3 years after rehousing	Rehousing by council on mental health grounds	Self-reported health improvement	n/a	None	No	Health outcomes: 57 (37.7%) reported improvements to health since rehousing. The most common reason (56.5%) given by rehoused residents for health gain due to rehousing was 'lack of stairs'(one third of those rehoused had moved due to osteoarthritis). (59% at 2-3 years)	C
Rehousing/refurbishment plus relocation from slum area or community regeneration								
Wilner et al. (1958, 1960) ^{63, 64} Baltimore, USA	Prospective controlled study. Interviews before and 18 months after (n=400/600)	Rehousing from slum area	Self-reported social adjustment, morbidity and mental health	Yes	Controls matched for; quality of housing, family size, income, welfare, education, employment, age	No	Health outcomes: Greater increase in illness episodes in intervention group at 9 months compared to controls (+301.2 v +261.4 episodes per 1000 persons) but greater reduction at 18 months (-129.9 v -100.9). Social adjustment and mental health improved more among the intervention group (sit and talk +11.1% v +1.9%; positive mood: +13.6% v +10.6; satisfaction with status quo: +23.3% v +19.5%). 56% of the control group moved during follow-up; further analyses showed association between extent of housing improvement and amount of psychological improvement. (unclear follow-up rate at 9-18 months)	B
Carp (1975, 1977) ^{65, 66} USA	Prospective controlled study. Interviews with residents before and 8 years after, (n=127/62)	Rehousing from socially isolated, substandard housing	Self-reported health (diaries), physician contact, mortality rate, morale and life satisfaction (interview)	Yes	None	No	Health outcomes: Ratings of 'good' or 'excellent' health fell more in the control group (-13% v -28%, p=0.02). Increase in those reporting low life satisfaction at 8 years was greater in controls (intervention group: 17% v 18%; controls: 10% v 38%). Health service use: Rates of physician contact in previous year and mortality rate were higher in control group (64% v 79%, p=0.03; 26% v 41%; p=0.045). (84% at 8 years)	C

<p>McGonigle & Kirby (1936)⁶⁷ Stockton-on-Tees, UK</p>	<p>Prospective controlled study. Analysis of routine data for individuals 5 years before and 5 years after (n=710/1298)</p>	<p>Rehousing from slum area</p>	<p>Crude and standardised quinquennial mortality rates</p>	<p>No</p>	<p>Age and sex controlled for in analysis</p>	<p>Yes</p>	<p><i>Health outcomes:</i> Age-standardised mortality rates increased in the rehoused population (22.91 v 26.10 per 1000) but fell in the slum area (26.1 v 22.78). Death rates increased across all age groups, apart from infants, where infant mortality rates fell in both groups but more in those rehoused (-54.8 vs -39.2).</p> <p><i>Other outcomes:</i> Rent in improved area doubled, and impacted on households' ability to buy food. Quantities of different food groups (first class proteins, total protein) fell short of the BMA Scale of Minimum Diets. These deficiencies were most extreme in the intervention group, especially among the unemployed (90% of households in intervention group).</p> <p><i>(routine data set for 5 years)</i></p>	<p>C</p>
<p>Blackman et al (2001)⁶⁸ Newcastle, UK</p>	<p>Prospective uncontrolled study. Structured interviews with 488/791 households before and 5 years after. At 5 years 98 of original households were re-interviewed. Cross-sectional data at 5 years also reported for 230 households (n=166 residents)</p>	<p>Major refurbishment, neighbourhood renewal, security and safety improvements to area</p>	<p>Self-reported health status, respiratory conditions, mental health, smoking health service use, view of area, safety, draughts in house</p>	<p>n/a.</p>	<p>Pre-intervention group data compared with age matched controls post-intervention (children only)</p>	<p>No</p>	<p><i>Health outcomes:</i> Adults ratings of good general health status decreased (53% v 51%, p<0.01), chronic respiratory conditions increased (adults 32% v 44%, p<0.05, children 23% v 26%, p>0.05). Percentage with a self-reported mental health problem decreased (adults 52% v 41%, p<0.05, children 21% v 2%, p<0.05), trouble with nerves (20% v 10%, p<0.05). Percentage of smokers decreased (72% v 28%, p<0.001).</p> <p><i>Health service use:</i> No changes in self-reported use. Percentage prescribed medication for a month or more increased (36% v 47%, p<0.05)</p> <p><i>Other outcomes:</i> View of area as very/quite nice increased (49% v 62%, p<0.05), area seen as very/quite safe (25% v 50%, p<0.001). Percentage reporting seriously draughty house reduced (35% v 20%, p<0.05)</p>	<p>C</p>

<p>Ambrose (2000)^{69,70} London, UK</p>	<p>Prospective uncontrolled study. Interviews with residents before and 1-4 years after intervention (n=70)</p>	<p>Rehousing or housing improvement and area regeneration</p>	<p>Self-reported illness episodes (standardised for days recorded), illness days, use of health services, prescriptions and self-treatment.</p>	<p>n/a</p>	<p>None</p>	<p>No</p>	<p><i>Health outcomes:</i> Illness episodes increased by 56%, (from 0.0036 to 0.0056 per person per day) partly due to flu epidemic. Increase in coughs and colds (42% vs 67%, p<0.0001); no change in dietary and digestive disorders (12% v 15%, p=0.3). Reduction in aches and pains (23% v 12%, p=0.0004), asthmatic and bronchial symptoms (17% v 6%, p=0.0001), stress and depression (6% v 1%, p=0.002).</p> <p><i>Health service use:</i> Reduction in use of general practitioner (74.6% v 59.4%, p<0.0001), prescription use (65.4% v 51.0%, p=0.0002), and use of casualty or outpatients (20% v 5%, p<0.0001); and illness days (per person, per day) decreased (0.37 v 0.05). No difference in purchase of proprietary medicines (25% v 26%, p=0.8).</p> <p><i>Other outcomes:</i> Increases in feeling of safety (46.7% v 72.0%, p<0.0001); also significant improvements in sense of belonging to community and social networks, and significant reductions in concerns about criminal activity and behaviour of young people. Residents also reported significantly decreased access to health and hospital services.</p> <p>(71% at 4 years)</p>	<p>C</p>
<p>Wells (2000)⁷¹ Michigan, USA</p>	<p>Prospective uncontrolled study. Interviews before, 5 months, and 2 and 3 years after (women only) (n=23)</p>	<p>Rehousing</p>	<p>Psychological wellbeing (using Psychiatric Epidemiological Research Instrument, PERI), neighbourhood atmosphere.</p>	<p>n/a</p>	<p>None</p>	<p>No</p>	<p><i>Health outcomes:</i> Reduction in psychological distress at first follow-up (mean PERI score 31 v 22.6, t=4.00, p<0.001). Changes in housing quality contributed 12% of the variance in distress. At 3 years mean PERI score was 23.22, not significantly different to the post-move average of 22.26 but significantly different to the pre-move mean of 31, t(22)=4.19, p<0.001.</p> <p>(74% at 3 years)</p>	<p>C</p>

Ellaway et al (1999) ⁷⁷ UK	Retrospective interviews with householders, (n=16/12). Focus group with health visitors.	Refurbished or new-build housing.	Health state of household, perceived links to improved housing conditions.	No	None	No	Residents link rehousing to improvements in health and decreased stress levels.	C
Halpern (1995) ⁷² UK	Mixture of cross-sectional and prospective data presented. Structured interview before, & 1 year after (n=55)	Refurbishment and community regeneration	Mental health (Hospital Anxiety & Depression Scale - HADS), self esteem (Rosenberg Scale), neighbourhood involvement	Yes- from neighbouring locality	Age, length of residence, children under 14, employment, income controlled for in analysis	No	<i>Health outcomes:</i> Reduction in anxiety and depression at 1 year (8.2 v 5.8, p<0.05; 5.4 v 3.6, p<0.05). Self-esteem rose non-significantly (53.1 v 57.5, p<0.1). Mean total HADS score fell (11.5 v 8.7). <i>Other outcomes:</i> Following intervention residents more likely to attend Residents Association meeting (3% v 19%) more likely to recognise neighbours (55% v 74%) Social support score increased over time (4.7 v 5.6, p<0.05). <i>(60-70% at 3 years, only 49% of original sample followed up at 3 years)</i>	C
Walker & Bradshaw (1999) ⁷³ Gwent, UK	Retrospective controlled study. Comparison of 2 GP practices to matched control area data, 2-7 years after.	Rehousing and area regeneration	Routine prescribing data over 5 years. Health service providers views on local area and health changes. Interviews with service providers.	Yes- control practices from neighbouring locality	Control practices matched for practice population, Townsend score & social class (from census data)	Yes	<i>Health outcomes:</i> Hypnotic prescribing was reduced in the practices covering the regeneration area (-10.845 v +1.9). Anxiolytic prescribing fell in one intervention practice compared to reference area (Area A:-0.45, Area B:-25.56 v reference area: +16.22). Mixed results for antidepressants (A:+29.88, B:+53.59 v +55.57). No beneficial effect of housing renewal on respiratory prescribing (A: +4.75, B: +18.11 v 4.4). Factors other than area regeneration may account for these changes. <i>(routine data at 2 & 7 years)</i>	C
Wamben & Piland (1973) ⁷⁴ California, USA	Retrospective controlled study. Routine data 18 months before and 12 months after (n=81/86)	Rehousing from slum area	Hospital out-patient visits	No	None	Yes	<i>Health service use:</i> Among children (0-9 years) greater reduction in outpatient visits in those rehoused (all causes, -1.667 v -0.130, p=0.03; housing related visits, -0.963 v +0.0204 p=0.05), no significant differences among other age groups. Significantly greater reduction in housing related visits among rehoused women (-0.538 v +0.120 p=0.02) (though the groups differed significantly at baseline) but not men. <i>(%age follow-up not reported at 1 year)</i>	C

<p>Baba et al. (1996)⁷⁵ Tokyo, Japan</p>	<p>Retrospective uncontrolled study Survey 6-24 months after housing improvement (n=375)</p>	<p>Improvement to housing conditions (ranging from new bed to major renovation)</p>	<p>Change in daily activities, need for home care and hospital based care, by questionnaire</p>	<p>n/a</p>	<p>None</p>	<p>No</p>	<p><i>Health outcomes:</i> 34% of users became more active after house improvement (42% no change, 7% worse). Workload for carer declined in 39% of cases (36% no change, 3% increased). 33.8% of respondents reported an increase in activity levels.</p> <p><i>Health service use:</i> Decreased need for home care reported by 39%, reduced likelihood of hospitalisation by 40.3% (no details on reported increased need for care). Changes in entrances and approaches to the residence were most closely associated with improvement in daily activities.</p> <p><i>(83% at 6-24 months)</i></p>	<p>C</p>
<p>Woodin et al. (1996)⁷⁶ London, UK</p>	<p>Retrospective cross sectional study. Survey of households 6-12 months after rehousing (n=160)</p>	<p>Rehousing and area regeneration</p>	<p>Self-reported health service use, experiences of crime and violence, by questionnaire</p>	<p>n/a</p>	<p>None</p>	<p>No</p>	<p><i>Health service use:</i> Decreased visits to GP after rehousing (before v after: 86% v 69%, p=0.003), frequent users (>6 GP visits per year) reduced (38% v 22%, p=0.01).</p> <p><i>Other outcomes:</i> These include: large reductions reported in sense of isolation (19% v 6%), fear of crime (60% v 16%), and problems with traffic (39% v 22%). Increased involvement in community affairs (14% v 21%).</p> <p><i>(70% at 6-12 months)</i></p>	<p>C</p>

Energy Efficiency Measures								
Somerville et al. (1999) ^{78, 79} Cornwall, UK	Prospective uncontrolled study. Survey of school age children before and 3 months after (n=72)	Central heating installation	Asthma symptoms, time off school. An economic analysis compared health service use, and prescribing is being carried	n/a	None	No	<i>Health outcomes:</i> Respiratory symptoms reduced (e.g., median frequency of nocturnal cough reduced from "most days" to "1 or several days" in previous month; p<0.001). School age children lost less time from school from asthma (9.3 days per 100 school days before, vs 2.1 days after, p<0.01), but not for other reasons (1.4 days per 100 school days before and 3.2 after, p>0.05). <i>(68% at 3 months)</i>	C
Hopton & Hunt (1996) ⁸⁰ Glasgow, UK	Prospective controlled study. Survey of children under 16 years-before, 6 and 12 months after (n=254 households)	Installation of 'Heat with Rent' system	Self-reported symptoms	Yes	Smoking, unemployment, changes in other housing conditions, perceived financial situation controlled for in analysis	No	<i>Health outcomes:</i> No group differences in overall mean number of symptoms reported, or in each of 14/15 symptoms reported; significant increase in reporting of aches and pains in intervention group after installation (9.1 v 25.5, p<0.05) but not in control group (9.1 v 18.2, p=0.1). Change in reported level of dampness was the only significant predictor of change in reporting of runny nose (t=2.41; p<0.01). <i>(30% at 1 year. Not clear of response rate in control group. At follow-up control group differences in smoking and employment disappeared.)</i>	C
Iversen et al. (1986) ⁸¹ Copenhagen, Aalberg, Esberg, Herning and Vejle, Denmark	Prospective controlled study. Survey of residents in private housing before and up to 3-9 months after (n=106/535)	Replacement of windows	Self reported symptom list	Yes	Age, smoking & colds controlled for in analysis- no reported data	No	<i>Health outcomes:</i> Some symptoms significantly reduced in the intervention group; joint pains (OR=0.28), headache (OR=0.72), neck or back pain (OR=0.18) (all p<0.01). Odds Ratio normalised for month when baseline measures were taken. Also adjusted for age, smoking and colds; no data reported. No confidence intervals given or calculable. <i>(31% at 3-9 months- but owing to changes in refurbishment plans only 641 (19%) used in analysis.)</i>	B

Green & Gilbertson (1999) ^{82, 83} Sheffield, UK	Retrospective controlled study. Survey of residents after housing renewal (n=135/140)	Energy efficiency improvements to tower blocks	Health status (SF36)	Yes- but intervention group more likely to be employed (28.2% v 15.7%)	Control group matched for income, housing and area	No	<p><i>Health outcomes:</i> Residents of improved housing had higher SF36 scores on 2 of the 8 dimensions; 'physical role' (mean 87.7 v 73.9, p=0.003), 'energy and vitality' (mean 59.9 v 51.9, p=0.014). No significant differences on physical function, emotional role, social function, mental health, pain, or general health perception.</p> <p><i>(response rate not clear)</i></p>	C
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Key:

Sample selection: Were intervention and control groups from the same population?

Blinded assessment of outcomes (e.g. Self-report): Were those assessing health outcomes blind to housing status of interviewees?

Table 2: Ongoing studies of health impacts of housing

Author, and/or study location	Method	Intervention	Outcomes	Expected Completion date
Fife Kingdom HA, UK	Retrospective questionnaire/interview of households relocated to sustainable homes (n=15)	Sustainable and energy efficient homes	Energy measures, housing survey, indoor environmental measures, health measures, health service use, economic analyses	2001
Liverpool Housing Action Trust, Liverpool, UK	Prospective controlled study following residents for 2 years following move (n=225/225)	Moving from hi-rise to low rise flats. Control group matched for age, type and duration of residence, socio-economic status	Health service use, health status (SF36), energy efficiency, quality of life, income, service use	2001
Riverside Project, Cardiff, UK	Prospective study. Questionnaire and routine data from households, 4 months before and 6 months after rehousing (n=150)	Housing renovation and community regeneration	Indoor housing conditions, SF36, quality of life, self-reported respiratory symptom diaries	2001
"Warm Homes" study, Glasgow, UK	Prospective controlled questionnaire and housing survey of households (n=300/200)	Major housing refurbishment	Fuel costs, indoor temperature, physical and environmental living conditions, health service use. Also economic analysis	2001
Willow Park HA, Manchester, UK	Prospective controlled questionnaire and interview survey	Rehousing and regeneration	Mental health (GHQ-12), quality of life, self-reported consulting rates	2001
Eastleigh HA, Hampshire, UK	Investigate local authority practice and health gains from rehousing for health reasons	Rehousing from MPR list	Health gains, local authority practice and procedures, collaborative working with health providers	2002
Sandwell HAZ, Birmingham, UK	Prospective questionnaire to households before and 12 months after	Prescribing central heating and an insulation package to the elderly and children with asthma	SF12, asthma symptom diary, quality of life, health service use, prescriptions, days lost from school	2002
Torbay Healthy Housing Project Torbay, UK ⁹¹	Randomised stepped wedge of rehousing for residents from 142 local authority houses (n=580)	Housing refurbishment	Respiratory, health diaries, health service use, environmental measures	2002
Cordale HA, West Dunbartonshire, UK	Prospective matched control, structured interview before and 1 year after (n=50/100)	Rehousing	SF36, self-reported .symptom list & health service use	2002
Shepherd's Bush HA London, UK	Prospective controlled questionnaire survey (n=600/300)	House refurbishment, new housing and general area reinvestment	Health and health service use, housing measures	2002

Gwent & Mid Glamorgan, UK	Prospective controlled study before and 3 & 9 months after (n=40/40)	Mould eradication	Respiratory health	2003
Medical Research Council, University of Glasgow & Scottish HAs	Prospective controlled trial with follow-up for 1-5 years (n=600 households).	Rehousing as part of a major national investment strategy.	Health and wellbeing, social networks, perceptions of neighbourhood. Qualitative interviews	2006
Rhyymney Valley, Mid Glamorgan, UK	Prospective questionnaire to residents (n=4000)	Area and housing renewal	SF36	2010

Key: HA: Housing Association
 HAZ: Health Action Zone
 MPR: Medical Priority Rehousing
 SF12: Short Form 12- Health Survey questionnaire
 SF36: Short Form 36
 GHQ-12: General Health Questionnaire- 12 item

Appendix I - Search Strategy

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1      322962  randomi* or trial or intervention
2      691251  health or illness or symptoms
3      72000   house* or rehaus* or home
4      2777    #1 and #2 and #3
5      2630   explode "Housing"/ all subheadings
6      3662   housing in ti ab
7      253    living environment* in ti ab
8      1014   living condition* in ti ab
9      29     living quarter* in ti ab
10     2656   dwelling* in ti ab
11     34     owner occupie* in ti ab
12     88     tenant* in ti ab
13     70     homeowner* in ti ab
14     22     landlord* in ti ab
15     30     rehaus* in ti ab
16     281    flats in ti ab
17     6      bungalow* in ti ab
18     26     multistor* in ti ab
19     15     multi-stor* in ti ab
20     76     high-rise* in ti ab
21     1      highrise* in ti ab
22     4      bedsit* in ti ab
23     0      bed-sit* in ti ab
24     393    apartment* in ti ab
25     4      tower block* in ti ab
26     17     overcrowd* in ti ab with homes in ti ab
27     16     crowding in ti ab with homes in ti ab
28     2      refurbish* in ti ab with homes in ti ab
29     38     insulat* in ti ab with homes in ti ab
30     82     heating in ti ab with homes in ti ab
31     30     damp in ti ab with homes in ti ab
32     28     (mold or moldy) in ti ab with homes in ti ab
33     26     (sanitation or sanitary)in ti abwith homesin ti ab
34     158    (mites or rats or mice or cockroaches or vermin
or fleas) in ti ab with homes in ti ab
35     426    "room-ventilation"/ all subheadings
36     10071  #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12
or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or
#22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31
or #32 or #33 or #34 or #35
37     47182  explode "research"/ all subheadings
38     7142   "policy"/ all subheadings
39     5746635 explode "types-of-study"/ all subheadings
40     465    quasi-experimental in ti ab
41     228801 (program or programme or research or policy or
policies) in ti ab
42     1308323 (trials or random* or controlled or study or
intervnetion*) in ti ab
43     5868957 #37 or #38 or #39 or #40 or #41 or #42
44     27979   explode "animal"/ all subheadings
45     3399622 explode "human"/ all subheadings
46     23059   #44 not (#44 and #45)

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47	9120	#36 and #43
48	9060	#47 not #46
49	2530733	reduc* or increas* or decrea* or evaluat* or change* or changing or intervention* or grow*
50	4794	#49 and #48
51	4699	#50 not #4
52	28811	explode "health"/ all subheadings
53	51196	mental* in ti ab
54	302902	health* in ti ab
55	216597	symptom* in ti ab
56	695	wellbeing in ti ab
57	32579	psychological in ti ab
58	51126	illness* in ti ab
59	342501	explode "respiratory-tract-disease"/ all subheadings
60	32620	asthma in ti ab
61	65137	depression in ti ab
62	333168	explode "mental-disease"/ all subheadings
63	9574	alcoholism in ti ab
64	1130370	#52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63
* 65	2313	#51 and #64

Appendix II - Studies of housing excluded from review

Relocation or moving house

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