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Review Paper

Living in a cold and damp home: frameworks for understanding impacts on mental well-being

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ABSTRACT

Objective: To carry out a review of recent studies that have explored relationships between mental well-being and how this may be affected by living in cold and damp homes. Attention is focused on intervention studies in which heating and insulation improvements were carried out and impacts on well-being assessed.

Study design: Drawing mainly on a Cochrane Review published in 2013, nine studies of sound methodology are identified and significant effects discussed.

Methods: The review outlines the current frameworks for understanding mental well-being which prevail in psychology and psychiatry, describing the distinctions that can be made between mental well-being and its elements, namely positive mental health and negative mental health (the latter also known as mental disorder). The review then organizes findings from nine studies into the separate domains of positive and negative mental health, giving due consideration to the quality of the research, instruments used to measure mental health, methodological, and ethical issues.

Results: These first nine studies indicate early consensus. Living in cold and damp housing contributes to a variety of different mental health stressors, including persistent worry about debt and affordability, thermal discomfort, and worry about the consequences of cold and damp for health. Improvements to energy efficiency are often associated with significant improvements in mental well-being.

Conclusions: Impacts affect both positive and negative mental health. A cumulative stress framework is hypothesized, within which the mental health impacts of improved energy efficiency can be better understood.

Introduction

The association between living in a cold/damp home and human health has been known for more than a century.[1] However, the majority of empirical studies have focused on *physical health* impacts, particularly on diseases where cold and damp exacerbate symptoms (such as cardiovascular and respiratory ailments). Occasional speculation about the links

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between cold and damp homes and *mental well-being* has also featured since the 19th century.[2] However, empirical evidence linking the two has emerged only very recently, with almost all relevant investigations being published in the last ten years.[3] This paper explores the quality and consistency of that evidence, and uses it to develop a hypothetical causal model that embodies multiple pathways from cold homes to impaired mental well-being.

Defining mental well-being

Mental well-being encapsulates two related but independent dimensions: *mental health and mental disorder*. The most commonly quoted definition of mental health is the World Health Organization's[4(p6)]:

> *Mental health is conceptualized as a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community.*

In this definition, *mental health* is construed as an inherently positive state; this is in contrast to the concept of *mental disorder*. *The Diagnostic and Statistical Manual of Mental Disorders* (DSM-V), is psychiatry's primary diagnostic tool, and this defines mental disorder as:

> *a syndrome characterized by clinically significant disturbance in an individual's cognition, emotion regulation, or behaviour that reflects a dysfunction in the psychological, biological, or developmental processes underlying mental functioning.*[5(p20)]

Perversely, mental 'health' has been more commonly measured through tests that measure symptoms of mental disorder than through tests that probe for evidence of coping, vitality, and resilience. This only began to change quite recently, after a landmark publication entitled *The Mental Wealth of Nations*.[6] This argued that *mental health* is more central to human functioning, since it encompasses a range of positive features which are routinely brought to bear on coping with difficult living conditions, permitting the negative effects of adversity to be minimized. Mental health, the authors argued, allows people to make use of *mental capital*, a term derived from the much older concept of social capital i.e. a resource that can be drawn upon in times of stress, providing coping mechanisms and/or solutions to adversity:

> *Mental capital encompasses both cognitive and emotional resources. It includes people's cognitive ability; their flexibility and efficiency at learning; and their 'emotional intelligence', or social skills and resilience in the face of stress. The term therefore captures a key dimension of the elements that establish how well an individual is able to contribute to society and to experience a high quality of life.*[6(p10)]

A growing consensus has since emerged, that the *absence of mental health* places people at risk of succumbing to other environmental adversities, regardless of whether they also show symptoms of anxiety or other mental disorders.

At the same time, clinicians in mental health were arguing increasingly in favour of Positive Psychology, which stipulated that mental disorder and mental health should be distinguished from one another. Mental health, they proposed, should not be equated with the absence of mental disorder. This view was soon adopted by organisations such as the European Psychiatric Association (EPA), whose Guidance on Prevention of Mental Disorders states:

> *Mental disorder and mental health are not simply opposite ends of a spectrum. Instead, mental disorder and mental health are distinct though related dimensions so that the absence of one does not imply the presence of the other.*[7(p68)]

Some authors e.g. Ref. 8 distinguish health from disorder through the shorthand terms of *positive* (mental health) and *negative* (mental disorder) mental health. These emerge from research studies as largely independent constructs, as illustrated on Fig. 1.[9]

Mental health, the EPA argues, is associated with a range of positive outcomes, including improved educational attainment, greater productivity, wider social participation, better physical health, a longer lifespan, reduced likelihood of risky behaviours such as smoking, and an increased resilience to adversity. Hence, to be at risk of poor outcomes does not require a person to live with a mental disorder (such as depression or chronic anxiety); people could be at risk if their levels of mental health are unusually low too. Protecting people's mental health is, the EPA argue, an effective means of preventing mental disorder emerging in the first place.

These developments in how mental health should be construed and measured underscore the need for surveys assessing the impacts of everyday interventions (such as energy efficiency improvements) to incorporate *positive* mental health indicators, since these measure much more everyday aspects of people's mental health. Some EU Member States have already begun to measure positive mental health in Census and Survey studies, replacing more traditional indices that assessed symptoms of mental disorder.[10]

Exploring the links between cold and damp living conditions and sub-optimal mental well-being, but using measures

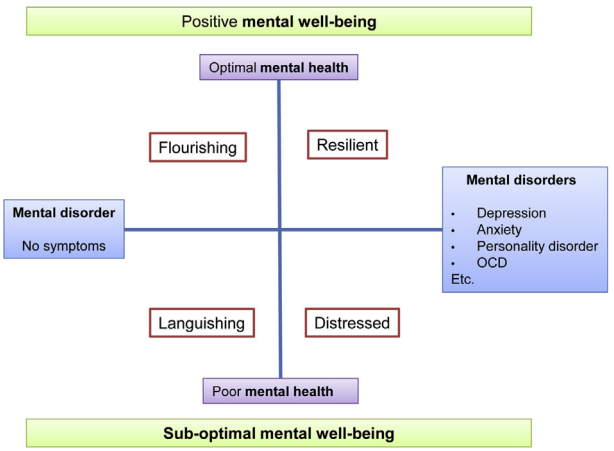

Fig. 1 – The relationship between mental health, mental disorder, and mental well-being.

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of mental health rather than measures of mental disorder, could open fruitful understandings of how links between poor housing and sub-optimal mental well-being come about, and how best – therefore practitioners can intervene to prevent such links being made.

Evidence for an association between improved domestic energy efficiency and mental well-being

In 2013, Thomson and colleagues published a Cochrane Review of the health impacts of housing improvements.[11] The *interventions* they considered included those related to improving domestic energy efficiency, but were not confined to these. The *impacts* were derived from measures of physical and mental well-being. What follows is a description of the findings of seven studies drawn from the Cochrane Review, all of which explicitly assessed the associations between energy efficiency improvements and *adult* mental well-being, whether from the perspective of mental health and/or mental disorder.

In 2005, Allen published two studies from the UK's Housing for Healthier Hearts Project. The interventions included heating installation/repair, reroofing, and replacement windows. The first study utilized an uncontrolled before and after design ($n = 32$ had outcome data).[12] Mental health was measured using the four mental health subscales of the SF-36, and mental disorder was measured using the Hospital Anxiety and Depression Scale. Significant improvements were reported for the mental health component of the SF-36. Although anxiety levels did not improve significantly, depression scores did.

The second study was smaller ($n = 16$), of similar design, and used the GHQ12 as a measure of mental disorder.[13] A statistically significant reduction in GHQ scores was reported following the intervention, indicating a reduction in symptoms.

Four studies were published in 2007. Barton et al. published data from the Watcombe Housing Study ($n = 119$) which had made improvements to homes through installing central heating, insulation and better ventilation, as well as re-wiring, and re-roofing homes.[14] Utilizing a randomized controlled trial (RCT), two dimensions of well-being were assessed:

- Mental disorder (MD) assessed using the GHQ-12; and
- Mental health (MH) assessed using the Short Form Health Survey (SF-36); this assesses health-related quality of life using eight subscales, namely; *physical functioning, role functioning physical, role functioning emotional, vitality* (energy/fatigue), *emotional well-being, social functioning, pain,* and *general health*.

One other item examined perceptions of overall changes in health. Although, the intervention resulted in homes that were warmer, drier, and more energy efficient, no statistically significant impacts on overall well-being were demonstrated.

Howden-Chapman et al. reported results concerning associations between well-being and home improvements in households from seven low income communities in New Zealand.[15] Utilizing an RCT design, households ($n = 1350$) were randomly allocated to intervention and control groups. The intervention consisted of ceiling and floor insulation and draught-proofing. Only one dimension of well-being was examined, namely mental health, which was assessed using three of eight subscales from the SF-36 (*role functioning physical, role functioning emotional, and social functioning*). Additionally, three single items – one each drawn from three of the other subscales were included. Results (adjusted for baseline, age group, gender, ethnicity, household and region) indicated that occupants in homes that received energy efficiency measures:

- reported significantly less 'poor or fair general health';
- had significantly lower odds for being classified as having poor mental health; and
- reported significantly higher scores in all three of the full subscales deployed.

The authors concluded that improving insulation in poorer quality homes was effective in enhancing quality of life.

In the same year, Platt et al. published results from Scotland's Central Heating Programme using a controlled before and after design.[16] Free central heating and other thermal measures (such as cavity wall and loft insulation) were installed, predominantly in the homes of residents of pensionable age ($n = 1281$). Outcomes were compared with a comparison group which were matched across key demographic and other characteristics. Mental health was the only dimension of well-being examined and was assessed using two subscales of the SF-36, both of which were predominantly concerned with how people were coping with the deteriorations in physical health often associated with ageing (i.e. *physical functioning and general health*). Although some small but significant improvements were demonstrated in favour of the intervention group, the authors concluded that their evidence did not demonstrate a 'clear and systematic' influence on health (p. 3).

Finally from 2007, Shortt and Rugkåsa utilized a controlled before and after design in Northern Ireland to evaluate the influence of a heating and insulation programme on well-being.[17] Mental disorder, described as *mental illness and stress*, was the only dimension of well-being examined, although no information is provided on the instrument used. Results indicated that the prevalence of stress/mental illness in the intervention group ($n = 54$) decreased from 10.8% to 4.3% pre- to post-intervention, although the change was not statistically significant. In contrast, the control group ($n = 46$) showed a significant increase in stress/mental illness post-intervention (1.8%–14.5%). Whilst this is the only study to report an increase in the prevalence of mental disorder among controls post-intervention, the control and experimental groups lived in the same streets, with controls having declined the opportunity for free efficiency measures. It is possible that an increase in symptoms of stress and mental illness derived from a sense of missed opportunity once the scheme had been successfully rolled out.

In 2008, Braubach and colleagues examined data from the WHO Frankfurt housing intervention project utilizing a controlled before and after design with 104 controls and 131

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intervention participants.[18] Interventions included thermal insulation of all building facades, roof/ceiling of highest residence, and basement/floor of lowest residence. Additionally, windows and heating systems in homes with deficient systems were replaced. Mental disorder (depression) was the only dimension of mental well-being examined, and was assessed using four questions that addressed sleep disturbance, loss of appetite, lack of motivation/interest and lack of self-esteem. Depression was categorized at three levels from 'strong' "to 'slight'. The authors concluded that the intensity of depressive symptoms decreased, although no statistical data is reported.

The above comprise the seven studies cited in the Cochrane Review. Two studies published since then provide further evidence of associations between well-being and domestic energy efficiency. In 2012, Gilbertson and colleagues published data from the Warm Front Scheme in England to determine the associations between a heating and insulation intervention and well-being.[19] Utilizing an RCT design, households ($n = 2685$) were randomly allocated to an intervention ($n = 1987$) and control group. Both dimensions of well-being were examined. Mental disorder was assessed using three metrics: a stress indicator, and two quality of life metrics, namely the GHQ-12 and EuroQol 5D; the latter measures five dimensions of quality of life, namely *mobility, self-care, usual activities, pain/discomfort, and anxiety/depression*). Mental health was assessed using an amalgam of scores drawn from the mental health subscales of SF-36. The results were presented as a series of odd Ratio's (OR's) adjusted for a variety of potential confounders (e.g. area, age, gender, tenure, education, time of interview). After all other constructs in the model had been accounted for, only one well-being measure demonstrated a direct effect i.e. two of three intervention groups were significantly less likely to report high scores on the GHQ-12. The authors also report numerous indirect effects, for example:

- Participants residing in homes that were cold, and draughty reported higher scores on the GHQ-12, higher anxiety (EQ-5D) and low mental health scores based on the SF-36 mental health amalgam; and
- Difficulty in paying fuel bills was related to poorer well-being as measured by their stress measure, GHQ-12, EQ-5D and the SF-36 mental health amalgam.

Gilbertson et al. have cautioned that the cross-sectional design of this study makes it difficult to draw conclusions on causality or on the direction of relationships among constructs. However, the results consistently demonstrate that energy efficiency measures are associated with well-being both directly (GHQ-12) and indirectly (EQ-5D, GHQ-12, SF-36 mental health amalgam). They further argue a possible route to greater well-being is via reduced fuel poverty (i.e. a lower energy expenditure need), reduced stress, more disposable income, and greater thermal comfort, a pathway which is further discussed in a later section of this paper.

Bond et al. examined the relationship between well-being and perceptions of housing and neighbourhood regeneration in participants that were part of the 'GoWell' longitudinal regeneration study in Glasgow.[20] This observational 'natural' experiment utilized a repeat cross-sectional controlled before and after design ($n = 3911$). Mental health was the only dimension of well-being examined, using the Warwick Edinburgh Mental Well-being Scale (WEMWBS), a 14-item one-dimensional measure of positive mental health. Adjusting for confounding sociodemographic and other housing quality variables, results indicated that better mental health was associated with completion of external repairs and internal insulation.

Improving the energy efficiency of homes and its association with mental health: summarizing the evidence

When exploring the associations between energy efficiency and mental well-being, nine intervention studies of sufficient rigour were identified. Three studies examined both mental disorders and mental health.[12,14,19] Three studies examined only mental health[15,16,20] and three studies examined only mental disorder.[13,17,18]

In summary, Table 1 indicates that 16 of 25 separate tests of statistical significance indicate robust evidence of improved mental well-being after intervention, meaning that improvement in mental well-being is reported on roughly two-thirds (64%) of occasions. For tests of mental health, 57% (8 of 14) were significant; for mental disorder, 73% (8 of 11) were significant. Given the many methodological and psychometric limitations embedded in the studies,[a] this suggests a moderately strong likelihood of improved mental health being associated with installing energy efficiency measures.

The study carried out by Bond and her colleagues is especially informative, being one of a suite of publications separating the impacts of housing improvements from neighbourhood renewal. Carried out in Glasgow, it disaggregated the associations between.

- mental health and aspects of *people's homes* (e.g. quality of insulation, external appearance, etc.); and
- mental health and aspects of *neighbourhood* (e.g. attractiveness and desirability).

Both were independently associated with mental health. Among the significant predictors in people's homes:

> *The strongest effects after mutual adjustment were related to the external appearance of the home and the front door (both an aesthetic and a security- or control-related item): highly positive views of both these items more than doubled the likelihood of high well-being. Good insulation (a warmth and comfort issue) was the next most important dwelling item.*[20(p7)]

Taken as a suite, their results suggest that area-wide renewal programs might yield the most beneficial impacts on mental health, since the associations with optimal mental health involved both people's perceptions of the status of their residential neighbourhood and of their home. In other words,

[a] See next subsection on Quality of Evidence for more details of these limitations.

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Table 1 – Impacts of improving energy efficiency on mental well-being: summary of evidence base.

First author	Qual[a]	Scale[b]	Mental health (MH) or mental disorder MD)?	Improvement[c]
Allen [12]	C	SF-36	Sum of scores from 4 MH subscales (MH)	Yes
Gilbertson [19 d]	A	SF-36	Role-emotional subscale (MH)	Yes
Barton [14]	A	SF-36	Role-emotional subscale (MH)	No
Howden-Chapman [15]	A	SF-36	Role emotional subscale (MH)	Yes
Platt [16]	A	SF-36	Role emotional subscale (MH)	No
Gilbertson [19 d]	A	SF-36	Social function subscale (MH)	Yes
Barton [14]	A	SF-36	Social function subscale (MH)	No
Platt [16]	A	SF-36	Social Function subscale (MH)	No
Gilbertson [19 d]	A	SF-36	Vitality subscale (MH)	Yes
Barton [14]	A	SF-36	Vitality subscale (MH)	No
Howden-Chapman [15]	A	SF-36	Vitality subscale (MH)	Yes
Platt [16]	A	SF-36	Vitality subscale (MH)	No
Howden-Chapman [15]	A	SF-36	Happiness subscale (MH)	Yes
Gilbertson [19 d]	A	GHQ-12	MD	Yes
Barton [14]	A	GHQ -12	MD	No
Allen [12]	C	GHQ-12	MD	Yes
Allen [12]	C	HADS	Depression subscale (MD)	No
Braubach [18]	A	Own	Depression (MD)	No
Gilbertson [19 d]	A	EQ-5D	Anxiety subscale (MD)	Yes
Allen [12]	C	HADS	Anxiety subscale (MD)	Yes
Gilbertson [19 d]	A	Own	Stress (MD)	Yes
Shortt [17]	B	Own	Stress (MD)	Yes[e]
Gilbertson [19 d]	A	Own	Cold-induced stress (MD)	Yes
Shortt [17]	B	Own	Cold-induced stress (MD)	Yes
Bond [20 d]	A	WEMWBS	Wellbeing (MH)	Yes

Notes accompanying table

a. Quality of study, based on sample size, design, statistical treatments etc. Derived from Thomson et al., 2013. A = best quality.
b. **SF-36**: The Short Form (36) Health Survey has 8 scales; 4 measure physical health and 4 measure mental health. A composite score for *Mental Health* (summing scores from all 4 sub-scales) is also an option. http://www.sf-36.org/tools/SF36.shtml
GHQ-12: General Health Questionnaire. One scale measuring mental disorder.
http://www.nwph.net/lifestylesurvey/userfiles/mental/things/GHQ12.pdf

HADS: Hospital Anxiety and Depression Scale. A 14-item scale, with seven items each measuring anxiety and depression respectively, and considered a measure of psychological distress.
http://www.sandbachgps.nhs.uk/uploaded_files/files/ashfields/HADS.pdf
EQ-5D: Consists of 5 health scales, one of which measures anxiety and depression, the others measure physical health.
http://www.euroqol.org/fileadmin/user_upload/Documenten/PDF/Folders_Flyers/EQ-5D-3L_UserGuide_2013_v5.0_October_2013.pdf
Own: researchers constructed their own item or items to measure their construct.
WEMWBS: Warwick and Edinburgh Mental Wellbeing Scale. 14-item scale measuring mental health.
http://www.healthscotland.com/documents/1467.aspx
c. Significant improvement at statistical test, using $p < .05$
d. Author's own summary. All other studies from Thomson et al., 2013.
e. Control group experienced more stress post-retrofit, whilst intervention group did not.

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where improving energy efficiency in people's homes can be part of a wider neighbourhood renewal, benefits for mental well-being can be maximized.

Most recently, authors have used results from studies such as those cited here to model the strength of association between energy efficiency improvements and mental health, using tools such as centrality indices. These estimate the relative strength of impact generated by different elements of an intervention, drawing on results from as many relevant studies as can be identified in the scientific literature. Strength of impacts range from −1 (negative impacts) through 0 (no discernible impact) and on to +1. In the most recent of these studies,[21] the authors assign a centrality index score of 0.36 to the association between energy efficiency improvements and mental health; by comparison they assign an index score of 0.84 to the association between EE improvements and reduced risk of cardio-respiratory illness and death. In other words, they assert that cold and damp conditions are more central to impaired physical health, but are nevertheless also moderately central to mental well-being. These attempts to synthesize evidence from a variety of sources offer a helpful way of illustrating the wide-ranging network of impacts that energy efficiency improvements can be associated with at the same time, even though some of these impacts are more central (or powerful) than others.

Quality of evidence

As Thomson and her colleagues note, and as reflected on Table 1, the evidence testing the link between mental well-being and energy efficiency improvements is mostly of high quality – considerably higher than in other areas of health and human housing research. However, though of uniformly high standard, only nine studies currently exist, meaning that the evidence base is unusually sparse.

Furthermore, while the SF-36 features strongly, there is little consistency in the choice of sub-scales related to mental health which research teams deployed:

- Four studies used *Role Emotional* and *Vitality* sub-scales;
- Three studies used the *Social Functioning* sub-scale;
- One used the *Happiness* sub-scale; and
- Two used the composite *Mental Health* score.

Four other classic measures of mental well-being feature in the studies (GHQ-12, HADS, EQ-5D and WEMWBS). Additionally, three authors created their own measures of mental health though gave scant detail of these. Comparison across studies is made difficult by this combination of scant evidence and such a variety of tests having been deployed to measure mental well-being.

Notably, none of the studies provide information on the reliability or factor structure of the scales they deployed, which is surprising since it breaks with convention in peer-reviewed publications. This makes it impossible to compare the quality of the data across studies. For example, the WEMWBS is a 14-item scale which purports to measure a single factor; all 14 of the items should correlate strongly with one another, with an overall correlation (or alpha coefficient) higher than 0.7.[22] Internationally, most studies confirm this single factor structure and report coefficients of 0.7 or higher. However, on occasion, even the most trusted scales can yield unusual factor structures or low alpha coefficients. Hence, when using any scale, authors usually report the results of factor analysis (which checks that their factor structure resembles what should emerge from using a particular test), as well as their alpha coefficients. This provides reassurance that the scales deployed are providing results that truly reflect what the scale is intended to measure. Without this information whether the scales deployed in the studies discussed here provided results of equal scientific quality cannot be established. If they did not, then it is not possible to assess which of the scales offers the best combination of robust structure and consistent reliability in the measurement of mental health impacts emerging from improvements to energy efficiency. Bond and colleagues argue strongly in favour of the WEMWBS,[20] a measure which focuses exclusively on mental health. Four of the SF-36 subscales offer the same advantage, and it is likely that one or both of these instruments will prove the most useful in future research.

Other issues of weakened methodology must also be borne in mind. Many of these are inevitable consequences of real-world research. For example, several of the studies cited here are randomized control trials (RCT's), often considered the gold standard for establishing the effects of an intervention. Among these, however, there is scant information on the extent to which the experimental and control groups became contaminated over time, and whether an intention to treat model was adopted (in which control participants remain in their original group even if they gave up waiting and bought insulation and heating themselves during the trial). Amongst control households in one of the studies, for example, 26% installed insulation and heating measures before they were followed-up.[16] Additionally 7% of the intervention group did not, ultimately, receive heating and insulation. All of them remained in their respective control and experimental groups for the purposes of statistical analyses; this meets with the conventional protocol for an RCT, but nevertheless makes impacts somewhat harder to estimate. In that particular study it is, perhaps, one of the explanations for the failure of any of the tests of mental health impact to attain significance.

Studies have also repeatedly reported that residents often choose to save on their energy bills by continuing to underheat the home after intervention, even though new heating and insulation measures mean that they could achieve much warmer and drier conditions for the same cost as before e.g. Refs. 14,19. Studies suggest that few households choose to achieve the standards of warmth which the World Health Organization recommend, even when doing so would cost them no more than they were paying using their old and less efficient heating systems.[23] Hence the potential for mental health improvements through a reduction in thermal stress may be somewhat limited, although the simultaneous reduction in worry about energy affordability issues may work to counteract this dampening effect.

Given the lack of consistency in measures used, and the wide variation in treatments (from topping up longstanding depths of roof insulation through to installation of central heating and insulation into homes that had none beforehand), the current evidence base offers reasonable grounds for

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accepting a link between energy efficiency improvements and improved mental well-being. This is starting to be reflected in review articles of the risk factors associated with mental health in Europe, where housing generally, and fuel poverty in particular are now both being listed as key risk factors e.g. Ref. 24.

Causal pathways linking energy efficiency improvements with improved mental well-being

It is seldom sufficient to demonstrate a link between an intervention and an effect on human well-being, since effects are not always simple or direct. It is conceivable, for example, that the association between energy efficiency improvements and mental well-being is confined mainly to people who are already prone to anxiety or stress. Should this be the case, then an argument could be made for targeting energy efficiency investments towards households with sub-optimal mental health. On the other hand, it could be that the primary mental health benefits are to be found among households with pre-existing medical conditions (e.g. better respiratory health status in winter improves mood and reduces stress). In that case, efforts could be best targeted towards those with pre-existing health conditions that become worse when people are cold, so that improved physical health can trigger better mental well-being. Understanding the causal pathways that link improvements in energy efficiency to improved mental well-being is essential for developing targeted strategies.

Specifying how improved energy efficiency might generate improved mental well-being is a formidable challenge, not least of all because of the range of mental health outcomes that appear to be associated with living in cold and damp conditions. This range incorporates chronic thermal discomfort,[19] worry about energy bills,[25] the experience of falling into debt (or the fear of it),[26] concern that cold is damaging physical health,[26] 'spatial shrink' from living in only one or two rooms that can be affordably heated,[3] stigma within one's community,[25] damage to possessions from damp and mould,[28] and the absence of any solution or sense of control over the problem.[29] Many of these are reflected in qualitative studies which have focused on people's experiences of living in fuel poverty:

> *I get stressed out about fuel costs, I am very conscious of my electricity usage and I get really stressed out about not being able to keep warm.*[27(p9)]

> *I can't stay in a cold condition. I get depression from cold. I need continuous heating to stay warm. I am often sad if I can't heat the flat to a warm level. I also fear my health could get worse if I stay long in the cold.*[27(p9)]

> *I have constant problems with mould and damp in the living room. You can see for yourself (Ms. G pulls away sofa from wall, damp is rising up the wall and mould has stained the back of the sofa). I papered the walls to get rid of it, but the paper has come off. It was expensive paper, and I had to pay a decorator on top of that. It was a waste of money. It's going to ruin all my furniture.*[28(p35)]

Only one empirical study so far has attempted to test a causal model linking energy efficiency interventions to mental health outcomes.[19] In it, Gilbertson and colleagues confirm independent associations linking:

- poor thermal comfort to psychosocial stress; and
- perceived affordability of heat to psychosocial stress.

The model proposed by these authors is illustrated in Fig. 2, and gives an early indication of the need for a multiple pathways model, in which stress plays a key role.

This concords with recent WHO speculations on stress:

> *While psychosocial stress is not the only route through which disadvantage affects outcomes, it does appear to be pivotal. Psychobiological studies provide growing evidence of how chronic low level stress 'gets under the skin' through the cardiovascular and immune systems. Thereafter, health-damaging behaviours may be survival strategies in the face of multiple problems.*[4(piii)]

Drawing together WHO's speculation and Gilberston et al.'s model, Fig. 3 illustrates a more embellished model for testing. The model identifies a cycle of risk that is initiated by living in homes that are routinely cold and damp as a consequence of energy needs not being affordable.

This hypothesized model is consistent with *cumulative stress theory* (first posited by Rutter and colleagues in 1975),[30]

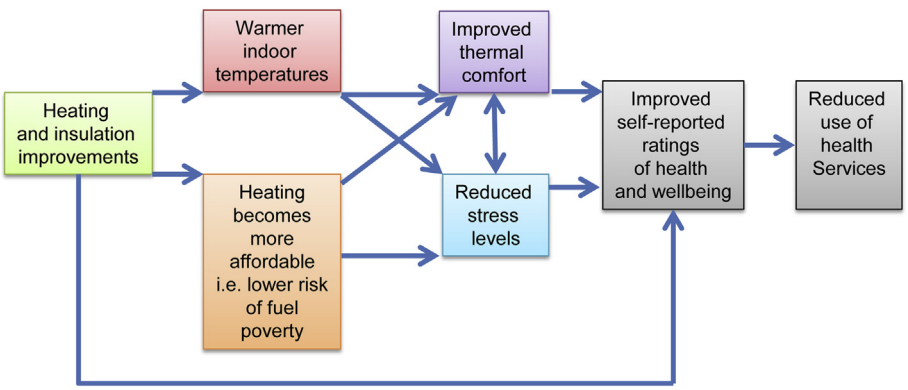

Fig. 2 – Energy efficiency improvements, stress, and pathways to positive health outcomes.[19]

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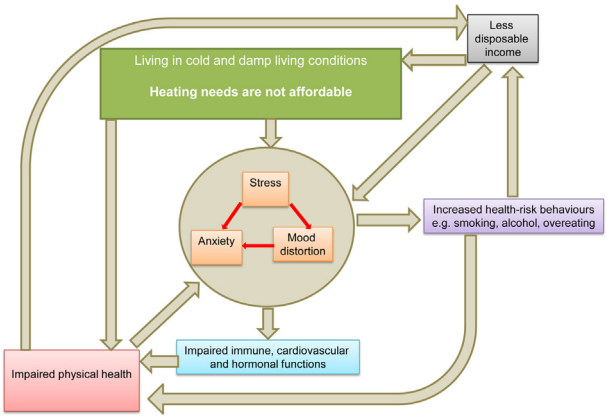

Fig. 3 – Hypothesized cycle of risk, initiated by living in a cold and damp home.

which asserts that vulnerability increases exponentially (rather than in a linear fashion) when people experience an accumulation of stressors from multiple sources (e.g. thermal discomfort from a cold home + financial worries caused by high energy prices + stigma). An exponential effect is found when one stressor is added to another but does not simply double the risk of maladjustment – instead risk increases four-fold; adding a third stressor can increase risk ten-fold rather than simply tripling it. Many psychological studies (though not linked to energy efficiency) have corroborated this concept. Reviewing progress since the 1970's, Thoits states[31(pS247)]:

> *..mounting evidence revealed that cumulative stress exposure explained far more variance in…distress and disorder than investigators initially realized, and that the accumulations of stressors were greatest in lower status, disadvantaged social groups. It would not be sufficient to bolster the individual's psychosocial resources…In order to lessen people's lifetime accruals of events and chronic hardships, policies would need to target "upstream" macro-level structural inequalities. Research converged on a fundamental policy conclusion: to reduce health inequalities, the structural conditions that put people "at risk of risks" …should be the focus of ameliorative programs and policies.*

By virtue of there being many sources of stress stemming from a cold and damp home, (e.g. discomfort, stigma, debt), its very nature makes it a prime source of cumulative stress. Fig. 3 hypothesizes that – for most people - living in a cold and damp home is a consequence of heating needs not being affordable. The combination of financial constraints and cold and damp living conditions can lead directly to both physical health problems and to stress. Once activated, stress, anxiety and mood distortions operate in a reverberating cycle that can impair immune, cardiovascular and hormonal functions. These in turn lead to further deterioration in physical health, which further exacerbates the stress/anxiety/mood distortion cycle, and may incur a reduction in disposable income through disability, unemployment, and medical costs. When sufficiently elevated, stress may in some instances also trigger health-risk behaviours such as increased smoking, eating, or alcohol intake. These in turn result in less disposable income, further reducing the affordability of heating. A multiple pathways model in which escalating stress levels are harmful in themselves, but can additionally initiate supplementary circles of risk associated with understandable but maladaptive coping responses, will almost certainly provide the best model linking the multidimensional concept researchers define as a *cold and damp home* with the multidimensional concept they know as *well-being*. As Thoits reminds researchers and practitioners alike, very few of the solutions which can dislocate these causal pathways are ones which reside in people themselves. They reside upstream.

Conclusions

It is evident that:

- cold and damp living conditions are typically of multidimensional origin;
- the impacts of these conditions on well-being are wide-ranging, incorporating stress, positive mental health and mental disorder;
- each of these aspects of well-being are equally diverse constructs.

Despite this complex matrix, there is consistent evidence linking cold and damp homes with mental well-being. However, there are currently no more than nine studies of sufficient rigour and quality on which to base this conclusion. More studies are needed. Before they are started, there may be opportunities to agree a standard set of mental health measures through which to assess impacts. Given that cold and damp living conditions are generally associated with reduced quality of life rather than with clinical risk, these may well be measures that focus on well-being (e.g. the four sub-scales of the SF-36, or the WEMWBS) rather than measures of mental disorder.

To date, sufficient evidence exists to conclude that:

- cold and damp homes are associated with sub-optimal mental well-being;
- the association comes about through the stressors associated with being unable to afford solutions to these adverse living conditions;
- these stressors are multiple and diverse, and usually include low income, fear of debt, damage to possessions from mould and damp stains, stigma, and social isolation;
- equally diverse are the risks to well-being that they generate, encompassing both positive and negative aspects of mental health.

In this context, a multiple pathways approach to causal modelling will be required in order to more fully understand how cold and damp living conditions create difficulties for people's well-being.

Finally, it is worth noting that all of these studies derive from high income countries in the industrialized world. There are no studies of impacts of thermally inefficient homes deriving from low and middle income countries.[11] In a rapidly

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industrializing global economy, where housing is often a low priority for governments and town planners, this is a gap which will hopefully be filled soon. It almost certainly means that the burden of cold and damp living conditions on human well-being worldwide is presently under-estimated.

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Ethical approval

Being a review paper, ethical approval was not applied for.

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Competing interests

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