A Health Impact Analysis of the Affordable Warmth Programme: 2014-2018

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Published version

MCKENZIE, Paul, GREEN, Geoff, GILBERTSON, Janet, STAFFORD, Bernard and COOK, Sally (2020). A Health Impact Analysis of the Affordable Warmth Programme: 2014-2018. Project Report. Sheffield Hallam University, Centre for Regional Economic and Social Research.

A Health Impact Analysis of
the Affordable Warmth Programme:
2014-2018

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Executive Summary

Fuel poverty has a significant impact on the health and wellbeing of people living in cold, damp houses. While low indoor temperatures, damp and mould have a deleterious effect on physical health conditions, such as asthma and arthritis, there is a concomitant effect on mental health conditions. People living in fuel poverty often experience financial stress and anxiety due to the cost of achieving comfortable temperatures within their home. Consequently, interventions that aim to reduce the cost of heating homes can have a beneficial effect on the physical and mental health of those living within the home. Furthermore, “social benefits” or “co-benefits” need to be considered as a significant part of energy efficiency measures.

This report analyses Northern Ireland’s Affordable Warmth Programme (AWP) from 2014 to 2018. A methodology is presented that uses the Housing Health and Safety Rating Scheme (HHSRS) to estimate improvements in physical health from a range of energy efficiency measures. Furthermore, the benefits to mental health are considered alongside reduced unemployment and the impact on economic output. The monetary value in improved wellbeing and reduced use of NHS services from AWP is also presented.

- 16,119 properties had energy efficiency measures installed.
- A threshold of £1,800 was used to differentiate between minor and major retrofits. AWP provided major retrofits in in 13,557 households and minor retrofits in 2,258 households.
- The AWP database recorded the total grant for 15,815 properties. Grants ranged from around £50 (e.g. loft insulation, draught proofing) to a maximum of £10,000 (solid wall insulation, cavity wall insulation, conversion of heating).
- The total amount of grants awarded was £66,206,343 with an average grant value of £4,186.30 per property.
- The UK Census from 2011 was used to estimate the number of children (0-15), adults (16-64) and elderly (65+) living in homes benefitting from AWP. It was estimated that 8,891 children, 26,708 adults and 6,197 elderly people benefitted from AWP, an estimated tot al of 41,796.
- Using Standard Assessment Procedure (SAP) data from 2015 it was estimated that the average SAP score for AWP properties before interventions was 56.4. The 2011 and 2016 House Condition Surveys estimated mean SAP in Northern Ireland to be 59.6 and 65.8 respectively.
- It is estimated that 3,550 households experienced temperatures below 18°C prior to energy efficiency measures and that at least 400 households are lifted above the 18°C threshold, with greatest benefits occurring in the coldest properties. This increase in indoor temperature is estimated to have a significant impact on health, most notably for those living with cardiovascular disease.
- Installation of double-glazed windows was estimated to increase indoor temperatures in 317 properties although this is a very conservative estimate due to insufficient data.

- We estimate that heating and insulation measures from AWP reduced the prevalence of damp and mould in at least 559 properties. Information on the number of windows provided per property was insufficient to make accurate calculations. A combined reduction of 876 households with damp and mould is expected, with greatest gains expected for child respiratory conditions, most notably asthma.
- It is estimated that Common Mental Disorders (CMD) will be reduced in 823 households.
- Gains in wellbeing from AWP are estimated to equate to at least £93.37 million while reductions in NHS costs are estimated to equate to £4.09 million. The value of improved mental health conditions on increased working days is estimated to be £4.95 million. The cost-benefit ratio is conservatively estimated to be 1.59.
- Estimates are calculated using the HHSRS protocol of “at least one person” per dwelling benefitting from interventions. With an average of 2.6 people per dwelling in the AWP sample, the gains are expected to be higher than those reported.

This Cost-Benefit Analysis has identified considerable “social benefits” from the Affordable Warmth Programme, with a favourable ratio of benefits to costs despite the conservative nature of the estimates used. It is expected that many of the most vulnerable people in Northern Ireland will enjoy greater health and wellbeing as a result of the Affordable Warmth Programme.

1.0 Fuel poverty – a definition.

Fuel poverty occurs when a household spends more than 10% of its income on staying warm (Boardman, 1991). The main causes of fuel poverty are low household income, high energy prices and sub-optimal energy efficiency of the home. The Northern Ireland House Condition Survey (NIHCS, 2016) estimated fuel poverty rates to be in excess of 40% since 2009 yet the 2016 estimate was reduced to 22% (NIHCS, 2016). The NIHCS was based on a sample of 3,000 homes and was conducted between May and November 2016 when fuel prices were significantly lower. Using the Sutherland Tables the price of home heating oil (HHO) in April 2016 was approximately 80% lower than prices in April 2018 (Sutherland Tables, 2016 and 2018). The percentage of homes using HHO was estimated to be 68% by both Walker et al. (2015) and therefore the lower cost of HHO in 2016 is likely to have led to the lower estimation of fuel poverty. BRE (2018) developed a fuel price “ready reckoner” to determine how rates of fuel poverty would react to increases in fuel price. The report suggested that a 25% increase on 2016 fuel prices may lead to fuel poverty rates of 37.9% while an increase of 50% in fuel prices may lead to 52.1% of homes potentially experiencing fuel poverty. As such, while the rates of fuel poverty may be lower than 2009 levels, the rates are still particularly high within the UK. Healy and Clinch (2002) noted that in Northern Europe, the UK and Ireland had particularly high incidences of fuel poverty.

Since Northern Ireland has a particular problem in relation to fuel poverty, the impact of fuel poverty on householders must be considered. Houses that are cold and damp lead to a range of physiological problems that can range in severity from mild asthma to myocardial infarction and death. Furthermore, living in a cold, damp home has a significant impact on mental health conditions with inhabitants experiencing stress in paying for high fuel bills. The following review presents findings from studies investigating the impact on physical and mental health from living in cold homes.

1.1 Fuel poverty and human health – a review of evidence

Excess Winter Mortality has often been considered to be the main risk to people living in cold homes. Rates of Excess Winter Mortality are high in countries with inefficient buildings that are difficult to heat during winter months (Healy, 2003). While Excess Winter Mortality rates are a critical issue related to living in cold homes, a range of other impacts on physical and mental health need to be considered. The National Institute for Clinical Excellence (NICE, 2015) published guidelines on the reduction of health risks associated with living in a cold home. The guidelines identified a range of health conditions that made inhabitants particularly at risk from living in a cold home (Table 1).

Table 1: People vulnerable to living in cold homes (Adapted from NICE Guidelines, 2015).

Condition
Cardiovascular conditions
Respiratory conditions (Chronic Obstructive Pulmonary Disease and childhood asthma in particular)
Mental health conditions
People with disabilities
Elderly (those aged 65 and older)
Households with young children
Pregnant women

High rates of Excess Winter Mortality are strongly linked to cardio-vascular disease (CVD) and living in cold conditions. Wilkinson et al. (2001) linked deaths from CVD to data from the 1991 English House Condition Survey and found a significant relationship between CVD and older properties that had poor energy efficiency and low indoor temperatures. More recent evidence from the WHO (2018) has also identified strong associations between cold indoor temperatures and a range of circulatory problems including ischaemic heart disease, cerebrovascular events and CVD. Shiue and Shiue (2014) analysed data on health, demographics and living conditions for 17,253 people across Scotland. The analysis identified a statistically significant relationship between high blood pressure and those people living in homes with temperatures below 18^{o}C and the relationship increased further when indoor temperature dropped below 16^{o}C. Saeki et al. (2014), in a study of 868 elderly people in Japan, found that a drop of 1^{0}c in indoor temperature was significantly associated with higher blood pressure which was likely to lead to increased cardiovascular mortality. As such, there is a considerable health risk imposed on residents living in houses with low indoor temperatures. This is exacerbated by the fact that Northern Ireland and other regions in the UK have low temperatures throughout the year. Liddell et al. (2016) showed that from 1980 to 2006, Northern Ireland had only 9% of months with temperatures above 15.5^{0}C, thus highlighting the low temperatures faced by Northern Ireland residents even outside of winter.

While low indoor temperatures are often associated with CVD and Excess Winter Mortality, the effect of damp and mould on health can also be substantial. Green et al. (2000) identified that in residential tower blocks in Sheffield, damp and mould was mainly the result of condensation rather than leaks. In a study of self-reported housing conditions and health, Evans (2001) found strong correlations between damp and poor health, most notably asthma and long-term illnesses.

In a similar study into the relationship between indoor dampness and resident health, Mendell et al. (2011) identified a strong association between indoor dampness and mould growth and a wide range of respiratory or allergic health conditions. While the study did not find a strong causal link between indoor conditions and poor health, there was evidence to suggest that children living in homes with dampness or mould had exacerbated asthma. A comprehensive study of children (Barnes et al., 2008) used the Families And Children Study (FACS) from 2001 to 2005 to investigate health among children living in “bad housing” (referring to overcrowding, poor state of repair and inadequate heating). The study found that children living in cold homes over three years or more had greater respiratory problems than children living in warmer homes. Free et al. (2010) investigated the effect that a warmer home had on school attendance rates for children with asthma. The study found that indoor temperatures were raised slightly for warmer households and air quality was also better. School absenteeism dropped by 21% for children living in intervention homes. It is important to take note of the wider impact of home interventions, such as reducing school absenteeism, on the population as these are considered to be “social benefits” (section 1.2).

Living in cold, damp conditions is not only associated with problems of physical health but also has a profound effect on mental health. Hernandez et al. (2016) used a mixed-methods approach to investigate the link between poor living conditions and stress. The study identified that people living in cold homes with low energy efficiency often experienced financial pressures and poor health, all of which interacted to exert further stress on the householder. Hernandez (2013) identified that increased stress from this “trifecta of insecurity” (p. e1) exacerbates existing health conditions and can compound existing medical conditions in the young and old. These findings are similar to those published by Harris et al (2010) who found that people with Common Mental Disorders (CMD) experienced significant financial stress from maintaining adequate warmth in their home. These financial pressures led to colder homes, more damp and mould and greater financial stress than those people who had no CMD.

In a recent review, Thomson et al. (2017) investigated the relationships between health, well-being and energy poverty from 32 European countries using the 2012 European Quality of Life Survey (EQLS) which was targeted at adults. The study identified that householders living in energy poverty have a greater risk of self-reported poor health and well-being and greater rates of depression than households not in energy poverty.

In summary, a large number of studies over the last two decades have identified that people living in cold, damp homes often experience physical and health conditions as a result of their living conditions. In response, many government programmes have sought to improve the energy efficiency of homes. To evaluate the benefit of energy efficiency measures on human health it is important to consult those studies that specifically consider the impact of energy efficiency measures on health. While many studies exist that assess health before and after interventions, there are many caveats such as lack of control groups, reliance on self-reported conditions, limited information on the house and its inhabitants and assessment too soon after interventions have been installed (Liddell and Morris, 2010). Nevertheless, it is important to identify the main changes in health as a result of energy efficiency measures being installed in cold homes.

Research (Gilbertson et al., 2012; Liddell and Guiney, 2015; Jiang et al., 2015; Hernandez et al., 2016; Grey et al., 2017) has suggested that there are two main pathways between warmer home initiatives and improvements in health (Figure 1).

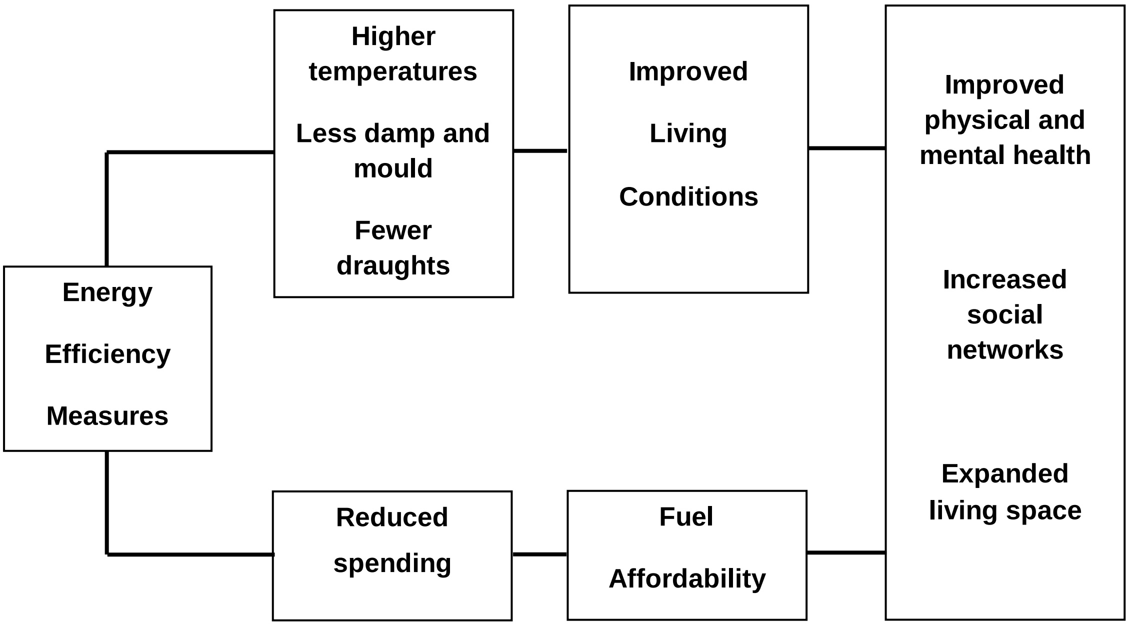

Figure 1: Pathways to improved health from energy efficiency measures.

Shortt and Rugkasa (2007) conducted a survey in Northern Ireland to investigate if a householder’s health improved after energy efficiency measures had been installed in the home. The post-intervention study took place one year after the measures were installed and the survey was conducted in 54 intervention homes and 46 control homes. The respondents in intervention homes reported significant improvements in arthritis, rheumatism and other forms of illness while respondents in control homes experienced more chest infections, other forms of illness and increased stress. This self-reported improvement in physical health is corroborated with other published studies (Strusberg et al., 2002; Bonnefoy et al., 2004; WHO, 2007). While the authors identified a significant increase in mental health problems in control households, there was a non-significant improvement in mental health conditions in intervention homes. The authors suggest that housing interventions may lead to muted improvements in health, but are likely to halt the deterioration of health conditions. The study also identified a significant reduction in reported use of health services after the installation of measures in intervention homes. The study highlights that while physical health conditions may be difficult to quantify, there are gains in mental health conditions, less use of health services, reduced damp and mould and greater financial security through increased benefit uptake.

In a similar study in New Zealand, Howden-Chapman et al. (2012) reviewed a series of trials that had been carried out in homes including insulation and more effective heating. These interventions led to improvements in self-reported health, less absence from school and work and fewer use of health services, particularly for respiratory conditions. In an earlier study, Howden-Chapman et al. (2007) identified significant improvements in mental health after interventions were installed in homes.

Liddell and Morris (2010) reviewed evidence of the impact of fuel poverty on human health from 2000 to 2009. While the review identified improvements in self-reported general health, direct improvements on adult health from living in warmer homes were unclear. The review did identify significant benefits for children with fewer school absences due to cold-related respiratory illnesses and asthma. Additional evidence showed that children in warmer homes had "higher weight-for-age scores and lower nutritional risk for depressed growth" (p. 2992) along with improved developmental status. Liddell and Morris (2010) identified much stronger impacts on the mental health of both adults and young people.

Gilbertson et al. (2012) conducted a health impact assessment of the Warm Front Scheme in England using pre-intervention and post-intervention surveys. The work did not focus solely on self-reported health but also assessed changes in household humidity and temperature using data loggers. The survey identified that respondents receiving heating and insulation measures reported improvements in mental health though not on self-reported physical health. People benefitting from interventions enjoyed higher temperatures, fewer draughts, less variable heating and improved thermal comfort. These improvements in turn have been found by other studies to have positive impacts on conditions such Chronic Obstructive Pulmonary Disease (COPD, Osman et al., 2008) while improvements in thermal comfort can reduce symptoms of arthritis and rheumatism (Liddell and Morris, 2010). In the Warm Front study, living in cold, damp and draughty homes was generally connected to higher levels of anxiety, greater use of health services and lower levels of self-reported general health. The authors noted that financial stress was more likely to lead to self-reported poor health than living in a cold home. Therefore, those living in fuel poverty had lower levels of health than those who were not in fuel poverty.

Bennett et al. (2016) assessed health impacts from the 'Warm at Home' programme which ran from 2015 to 2016. The report identified reductions in condensation, damp, mould and draughts in those homes receiving interventions. Furthermore, there was greater satisfaction in the standard of housing, indoor temperature and indoor humidity levels after interventions alongside reduced financial stress. Interventions led to improvements in self-reported health although it was found that interventions costing more than £1,000 led to greater reductions in "very bad or bad health". When the cost of intervention was lower than £250, there was a negligible reduction in "very bad or bad health" among participants.

Grey et al. (2017) conducted a study in Wales of 364 intervention homes (418 control homes) between 2013 and 2015 to assess how health was affected by energy efficiency measures. The study found an improvement in respiratory symptoms, asthma and physical health scores although the changes were not statistically significant. However, the study did find a significant improvement for subjective wellbeing after the measures were installed. Recipients of the energy efficiency measures reported less financial stress, improved food security, improved thermal satisfaction and less social isolation. The study shows clear improvements for those people benefitting from energy efficiency measures installed in their home. While the study did not find significant improvements in physical and mental health, the post-intervention data were collected shortly after intervention, thus allowing limited time for gains to be realised. Furthermore, the study focussed solely on adults who may have lived with poor health for many years. Liddell and Morris (2010) identified that changes in adult health are more muted but benefits for children and young people are more significant.

A more recent review by Elsharkawy and Rutherford (2018) evaluated the Community Energy Saving Programme (CESP) in Nottingham. The CESP is part of the UK Government's Heat and Energy Saving Strategy (HESS) which sought to reduce carbon emissions and reduce domestic energy use. The study reviewed CESP energy efficiency measures installed in a deprived ward between 2009 and 2012. The scheme was worth £2.8 million and it sought to deliver solid wall and internal wall insulation, loft insulation, draught proofing, double glazing, new heating controls and upgrades of inefficient boilers across 1,500 social and private tenancy homes. The review used a mixed-methods approach to identify customer satisfaction (N=150) with the scheme and how their behaviour had changed as a result of the energy efficiency measures. Respondents reported reductions in damp, mould, condensation and overall coldness as a result of the intervention although draughts were still reported, largely due to inefficient external doors. Only 16% of the respondents reported improved health after the intervention although there was greater use of all rooms (less spatial shrinkage) and greater thermal comfort in the home. The study concluded by identifying that there are many variables that impact on indoor temperatures that require qualitative and quantitative data.

The research points to significant improvements in subjective wellbeing, improved mental health for adults and young people along with benefits in physical health for children. There is a clear need for robust longitudinal studies that assess physical, mental and social health of all people in homes that are set to benefit from energy efficiency measures. The health of residents must be measured during the installation of measures but also at regular points afterwards, in order to identify how health is improved in the short term but also in the long term.

1.2 Social Return on Investment (SROI)

There is a growing body of evidence that identifies wider benefits from improvements in energy efficiency. These wider benefits include reduced school absenteeism for children, increased social networks and reduced "spatial shrink" with people using more of their homes due to more control over heating. A number of studies have identified these wider gains which have recently been termed as Social Returns on Investment (SROI). The WHO (2017) identifies investment for health as one of four measures critical for implementing the 2030 Agenda for Sustainable Development. Nicholls et al. (2009) define "a framework for measuring and accounting for this much broader concept of value; it seeks to reduce inequality and environmental degradation and improve well-being by incorporating social, environmental and economic costs and benefits" (p. 8). Hamelmann et al. (2017) suggest that SROI promotes stakeholder engagement, measuring impact and social value. As such, SROI is a prime method by which to integrate policy makers, architects, health professionals and wider society to identify the wide range of benefits that emanate from home interventions.

A number of studies have identified these social returns on investment and have sought to monetise these impacts. In an early evaluation of the benefit of interventions in Sheffield, Stafford (2014) calculated the monetized one year social costs from different types of harm to health. The study identified that losses in "quality of life" dominated the social cost due to mortality and illness. The impact of cold homes on mental health was substantial with concomitant effects on loss of earning and loss of Gross Domestic Product (GDP). Stafford identifies that intervention policies may "fail fiscal-rate-of return test[s] but pass a more encompassing and arguably more satisfying cost-benefit test" (p. 254).

Chapman et al. (2017) reviewed two home intervention studies from New Zealand in order to develop a Cost Benefit Analysis (CBA) of the work carried out. The study focussed on the "co-benefits" that emerged from intervention measures (e.g. reduced use of health services, lower absenteeism, greater financial security) rather than simply restricting benefits to a single household and its inhabitants. There were significant cost savings in terms of carbon reduction through reduced energy use, improved mental health (44% reduction of mental health problems for people living in retrofitted properties), reduced mortality risk and associated use of health services.

In a similar study, Fenwick et al. (2013) reviewed 25 studies where housing interventions had been implemented in homes across the world. The report identified considerable difficulties in assessing costs due to the varied approach in reporting costs and benefits from work. Almost 40% of the studies reviewed had not reported any form of economic evaluation while others had reported costs and some benefits for householders though did not report benefits to health as part of the economic evaluation. However, studies all reported benefits from reduced absenteeism from school and work and reductions in CO_2 emissions. Fenwick et al (2013) state the need for studies to implement longitudinal monitoring in order to detect health gains after intervention, focusing on co-benefits and wider social impacts and rigorous economic evaluations using the best data and calculations.

Threlfall (2011) sought to identify the costs and benefits from the 'Affordable Warmth Access Referral Mechanism' (AWARM) programme in Manchester. Threlfall reported on Quality Adjusted Life Years (QALYs) which are a measure of the quality of a person's health – one QALY equates to one year of life in perfect health (NICE, 2018). The study reported 30.7 months gained for 82 people benefitting from insulation, heating and combined measures. The greatest gains were experienced from modelling changes in anxiety and depression after the provision of energy efficiency measures. The report concluded that "warm housing interventions are less of a 'win-win' situation and more of a 'cannot lose' situation" (p. 32). Threlfall does identify that the methods of estimating gains can be subjective and therefore there is a need, as identified by Fenwick et al. (2013), to standardise approaches to data collection and cost benefit analysis.

A recent report by Ambrose et al. (2018) for Lambeth identifies a coherent pathway by which to report on housing intervention gains. The Lambeth report outlines gains from warmth and comfort, security, health, use of health services, reduced absenteeism and gains in the Criminal Justice System. The Lambeth report forms the main basis on which the following review is conducted; however the main focus is on warmth and comfort.

2.0 The Affordable Warmth Scheme – a background

The Affordable Warmth Scheme (AWS) replaced the Warm Homes Scheme in the autumn of 2014. The Warm Homes Scheme was an energy efficiency scheme that provided eligible households with heating improvements for minimal cost. The scheme was restricted to homes that were privately owned or rented and where householders were in receipt of "passport benefits". Passport benefits were used as a measure of vulnerability and implied that the householder was on a low income or had some other form of vulnerability (e.g. Disability Living Allowance was paid to people with a long term disability or with impaired mobility). Householders applied for Warm Homes grants through a process of self-referral (Northern Ireland Audit Office, 2008) and benefit entitlement checks were also carried out in order to increase overall household income. By tackling income and household energy efficiency, the scheme was designed to address two of the main causes of fuel poverty. However, the reliance on social criteria and self-referrals led to inclusion and exclusion errors (Beckerman, 1979; Walker et al., 2013; Marz, 2018). Inclusion errors occur when a household is provided with a grant, even if they are not fuel poor. Exclusion errors occur when fuel poor homes are not provided with assistance. Walker et al (2013) also noted that the Warm Homes scheme did not focus on the properties with low energy efficiency, nor did it seek to raise energy values to a specified level. As such, a more targeted approach was developed for AWS.

The AWS is an area-based targeting approach that identifies small census zones based on a range of relevant criteria. For instance, data on oil prices, gas availability, age and type of properties, energy efficiency scores and temperature can be spatially integrated within a Geographic Information System (GIS). Area-based targeting approaches have been developed in the past although they tended to be restricted to coarse spatial scales, incomplete data and static models. The Fuel Poverty Index (FPI – CSE, 2003) and work in Wales (Fahmy and Gordon, 2007) analysed fuel poverty at the Super Output Area (SOA) scale, which contains an average population size of approximately 400 households and around 1500 residents. SOAs hide significant variations in housing and may cause considerable waste of resources. Sefton (2002) suggested that 78% of eligible households for the Home Energy Efficiency Scheme (HEES) in England and Wales were not fuel poor, and advised that improved targeting could reduce fuel poverty by 33%. More recent evidence from the Audit Offices of Northern Ireland and Scotland indicate misdirected targeting levels of 30% and 50% respectively. Furthermore, early area-based targeting approaches relied heavily on census data and data specific to one locality that were not transferable across the UK (Morrison & Shortt, 2009). There also tended to be a lack of empirical evidence about the role of energy prices or temperature in targeting areas of fuel poverty despite their substantial impact on fuel poverty levels (DECC, 2009). The area-based targeting approach developed for the Department of Social Development (subsequently renamed the Department for Communities) integrated a wide range of variables that related to household income, building energy efficiency measures and fuel prices. Figure 2 below shows the variables used along with their weightings for the 2014 AWS. The 2014 area-based targeting scheme was produced for the 4,537 Small Areas (the equivalent of the Output Area in Great Britain) which represent the smallest census unit for the 2011 UK Census. Each SA in Northern Ireland has an average of 400 people and 155 households (NISRA, 2013).

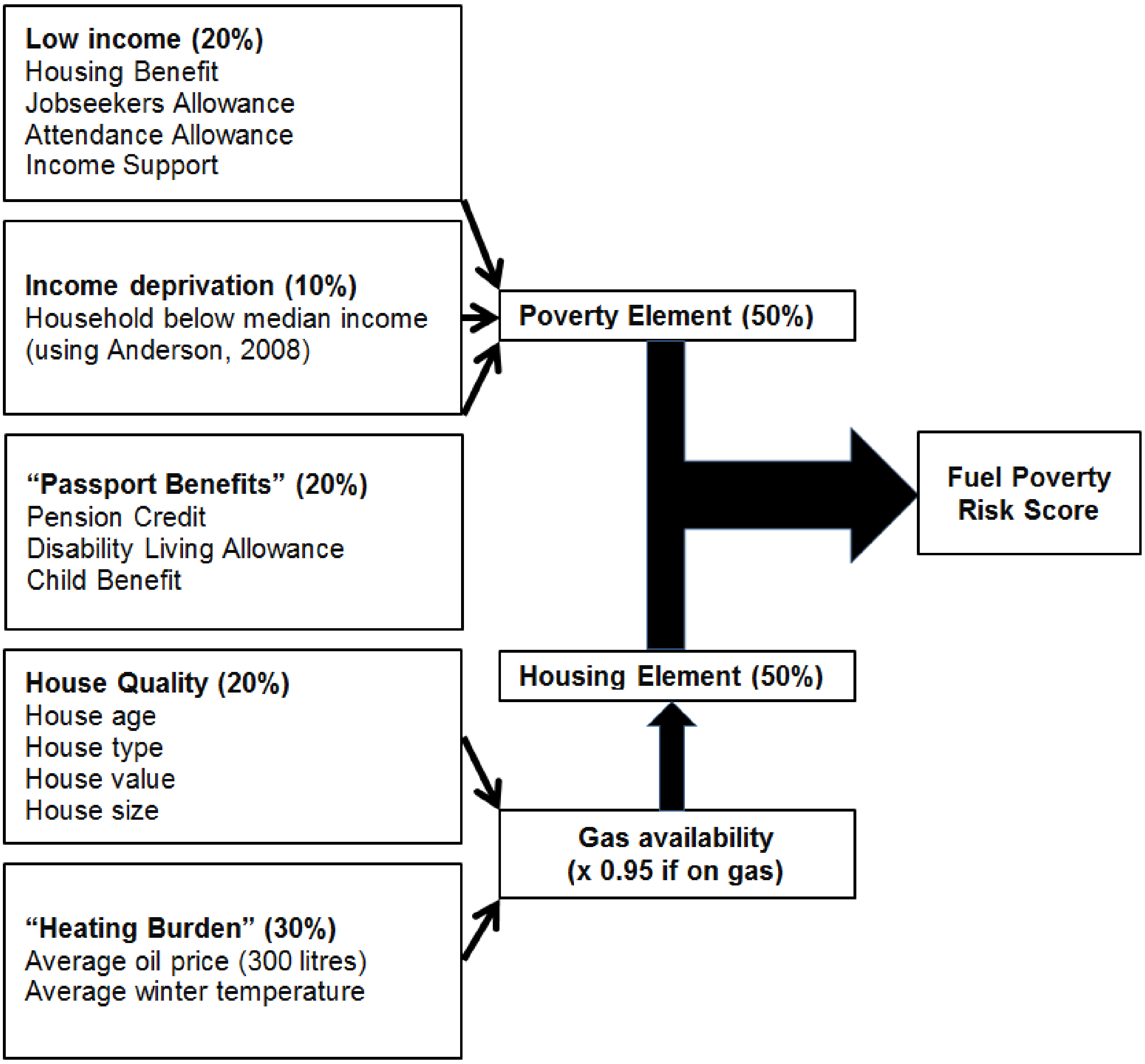

Figure 2: Fuel poverty model used for area-based targeting in 2014 (adapted from Walker et al., 2013, p. 767).

The area-based approach hides individual details while identifying small spatial units with relatively homogenous blocks of housing. Furthermore, due to the ability to target groups of housing in a small geographical area, homes can be visited efficiently by intervention teams with minimal travel required between homes. Developing an area-based targeting approach has been identified as best practice in a number of published studies. März (2018) used area-based targeting to identify fuel poor households in Oberhausen, Germany and concluded that area-based approaches are effective in targeting resources to those in greatest need. Robinson et al. (2018) also highlighted the value of area-based targeting for mapping variations in fuel poverty across regional scales.

McKenzie-Mohr (2011) advocated community-based social marketing (CBSM) whereby local networks of trusted representatives could overcome local barriers to schemes. In a similar way, the AWS is administered in partnership with the 11 Councils across Northern Ireland and the Northern Ireland Housing Executive (NIHE). Each Council is provided with a list of addresses from eligible Small Areas in that Council's area. These addresses should be predominantly owner occupied or privately rented as social housing was removed through GIS analysis. Figure 3 shows an example SA with all domestic properties, for which address lists would be compiled.

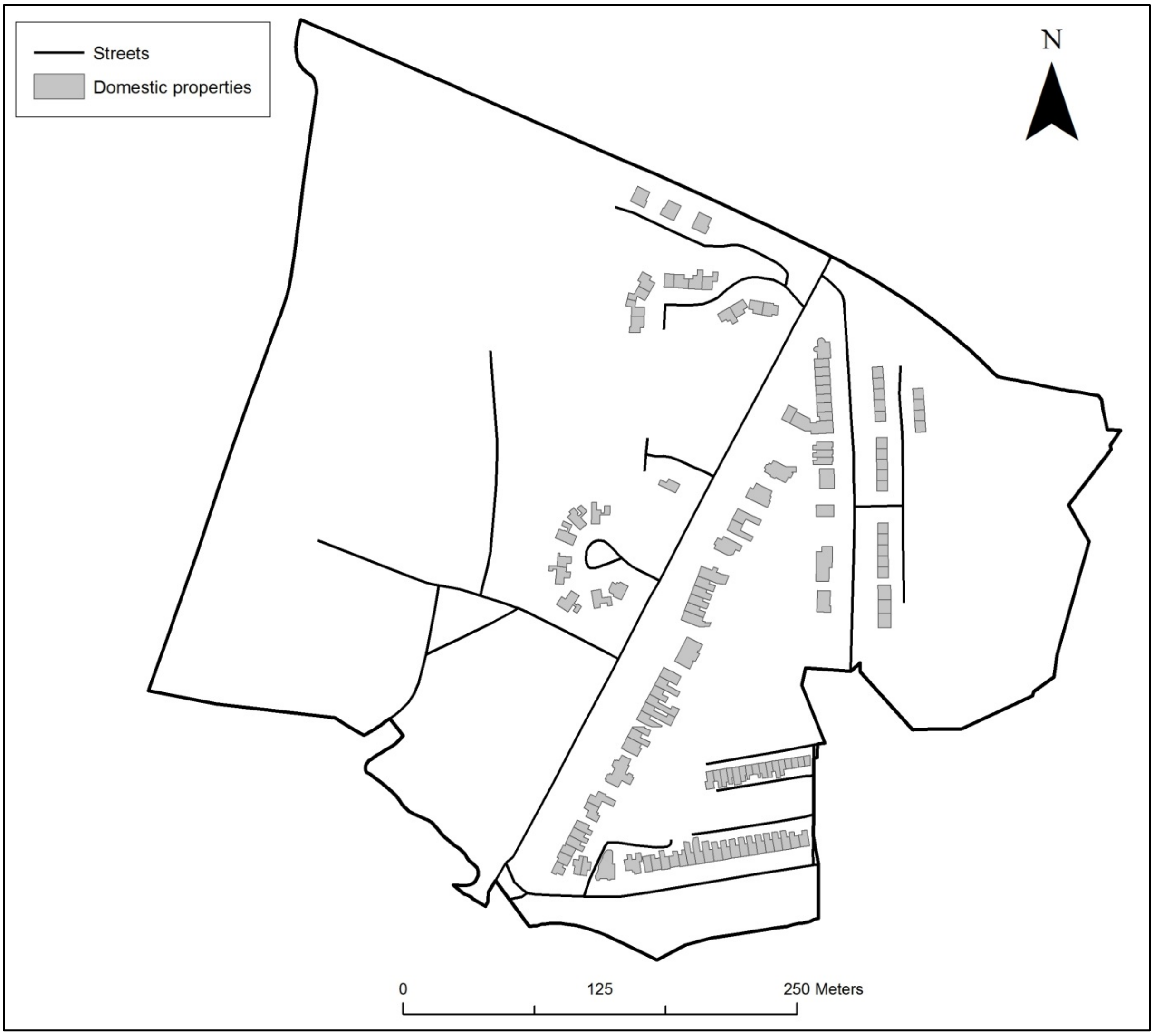

Figure 3: Domestic properties in a Small Area identified as having a high eligibility for the Affordable Warmth Scheme.

Each Council subsequently contacted each address in the identified Small Area in order to verify household income and conduct a short survey. Morton et al (2018) identified clusters of houses availing of Green Deal grant in England, highlighting the need for schemes to be targeted to small local areas in order to increase uptake. Gillich et al (2018) also found that when installations were targeted in small areas, contractors were able to enjoy “higher profit margins per job, a higher volume of jobs” (p. 772). Council assessors would also ask permission to refer householders for Benefit Entitlement Checks in order to maximise household income. Households with a total gross income of less than £20,000 were approved by the Council assessors and were subsequently referred to the NIHE for energy efficiency measures. Staff from the NIHE conducted a technical assessment in order to identify the most suitable energy efficiency measures that could be installed in the home. Subsequently, the householder would be provided with a statement of works that outlines the measures that would be installed in the home. The householder then contacted contractors to carry out the work and the contractor was paid directly by the NIHE. It is important to note that at any stage, the householder may withdraw from the process, leading to a cancellation. This multi-faceted approach ensures the homes that benefit from measures are low income homes (less than £20,000 gross income) and situated in areas that have high eligibility for energy efficiency measures.

3.0 The Affordable Warmth Programme – analysis of retrofit data from 2014-2018

The database of measures from the Affordable Warmth Programme (AWP) contained 19,346 records dating from November 2014 to October 2018. Of the data supplied, 87 records had address data that required manual geocoding using the Pointer data from Land and Property Services (LPS, MOU NIMA S&LA 577.319). A further 28 records had no address data and could not be mapped.

The AWP database recorded both a cancellation date and the reason given for cancellation. As these properties had no measures installed, any records with cancellation details were removed from the database. The database had 3,195 records with details of cancellations. Table 2 below highlights the main reasons for cancellation in the database. As a result, 16,119 properties had energy efficiency measures installed from November 2014 to October 2018 (Figure 4).

Table 2: Main reasons for cancellations in the AWP database (records above 5% are shown).

Cancellation Reason	**Number of properties**	**% of cancellations**
Income over £19,999.00	960	30
Failure to respond	729	23
All scheme measures present	562	18
Work not commenced	215	7
Resident not interested	180	6

Table 2 highlights the value of income checks on targeted homes with 30% of homes earning more than the threshold of £20,000. Furthermore, the need to engage homeowners fully is of critical importance with almost a quarter of homes not responding to offers of assistance. This relates to recent studies that have assessed public uptake of energy efficiency schemes. Elsharkawy and Rutherford (2018) found that only 30% of respondents were aware of an energy efficiency scheme in Nottingham. Gillich et al (2018) also identified the potential of local networks and word of mouth to promote uptake of energy efficiency schemes. Clearly there is capacity to increase resident interest in the AWP through increased promotion of the scheme by capitalising on favourable community networks.

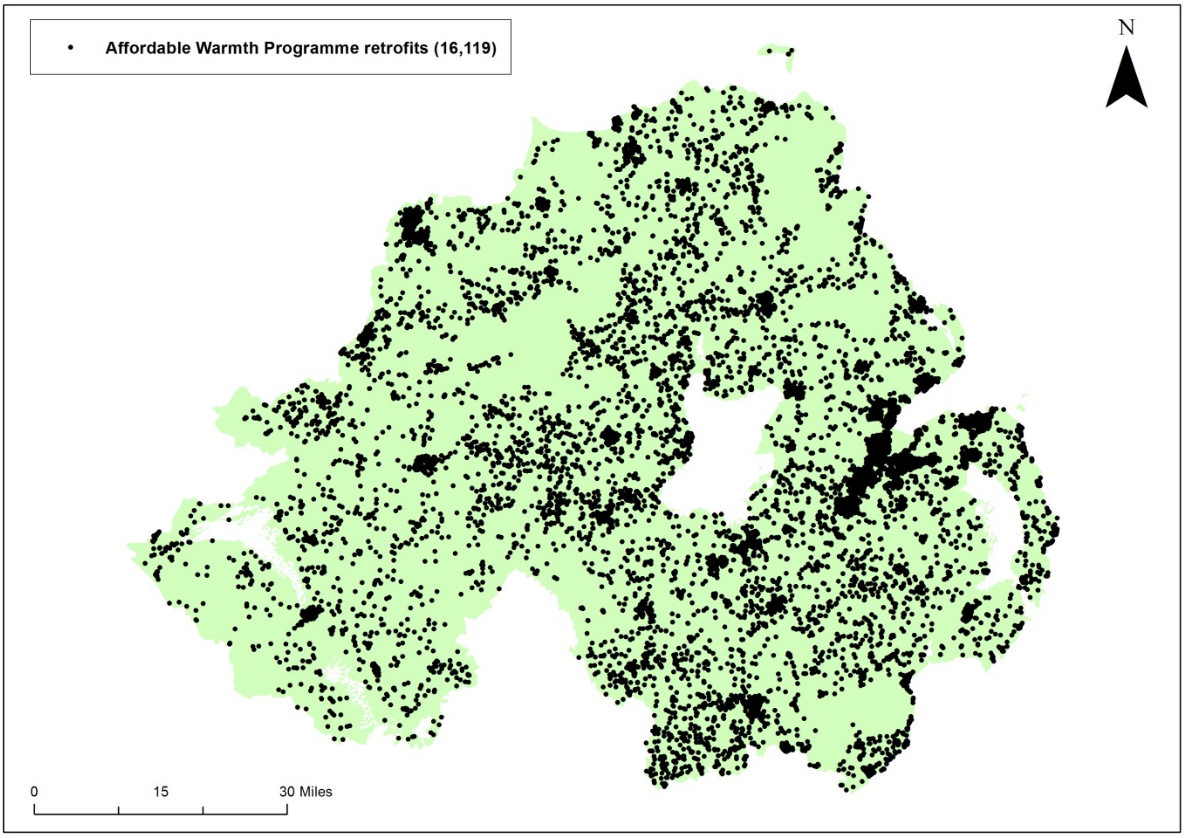

Figure 4: Spatial extent of retrofits.

Table 3 indicates the number of retrofits and cancellations in each of the 11 Council Areas. The average number of retrofits per Council was 1,465 while the average number of cancellations per Council was 290.

Table 3: Retrofits and Cancellations per Council

Council	**Retrofits (N)**	**Retrofits (%)**	**Cancellations (N)**	**Cancellations (%)**
Antrim & Newtownabbey	1,199	7.4	260	8.1
Armagh, Banbridge & Craigavon	1,606	10	219	6.9
Belfast	1,614	10	351	11
Causeway Coast & Glens	1,556	9.7	462	14.5
Derry & Strabane	1,591	9.9	520	16.3
Fermanagh & Omagh	1,389	8.6	262	8.2
Lisburn & Castlereagh	1,349	8.4	240	7.5
Mid & East Antrim	1,213	7.5	212	6.6
Mid Ulster	1,587	9.8	230	7.2
Newry, Mourne & Down	1,607	10	158	4.9
North Down & Ards	1,408	8.7	281	8.8
Total	16,119	100	3195	100
Average per Council	1,465	9%	290	9%

The AWP database recorded the grant allocated per property although 304 records had no value provided, leaving a total of 15,815 properties with grant information (cancelled retrofits were obviously excluded). Grants ranged from around £50 (e.g. loft insulation, draught proofing) to a maximum of £10,000 (solid wall insulation, cavity wall insulation, conversion of heating). The total amount of grants awarded was £66,206,343 with an average grant value of £4,186.30. Average and total grants provided per Council area are provided in Table 4 below:

Table 4: Grants awarded per Council.

Council	**Number of grants**	**Average grant (£)**	**Total grant (£)**
Antrim & Newtownabbey	1,175	3,414	4,011,576
Armagh, Banbridge & Craigavon	1,574	4,762	7,494,737
Belfast	1,590	3,550	5,644,433
Causeway Coast & Glens	1,540	4,413	6,796,282
Derry & Strabane	1,574	4,211	6,628,517
Fermanagh & Omagh	1,368	4,640	6,347,343
Lisburn & Castlereagh	1,313	3,762	4,939,312
Mid & East Antrim	1,193	3,746	4,469,158
Mid Ulster	1,570	4,675	7,339,793
Newry, Mourne & Down	1,549	4,804	7,442,115
North Down & Ards	1,369	3,720	5,093,076
Total	**15,815**		**66,206,342**

The distribution of retrofits in individual households is shown in Figure 5. This report uses the threshold of £1,800 to differentiate between minor and major retrofits (Walker et al., 2013). In this report, the majority of households received a major intervention (13,557 households or 85.7% of samples). Only 2,258 households (14.3%) received a retrofit of £1,800 or less. The differences between the previous Warm Homes spending and AWP are considerable with the mean cost of retrofit of WH equating to £1,439 and AWP equating to £4,186.

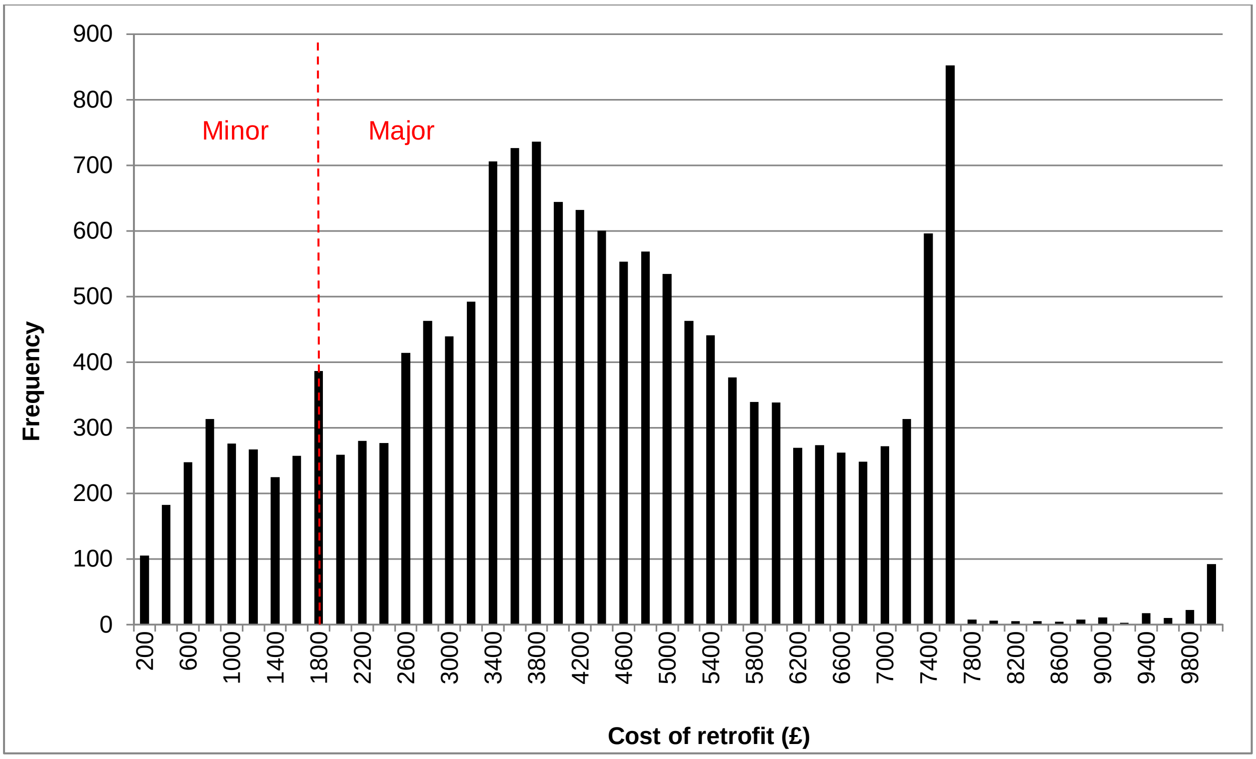

Figure 5: Retrofit costs of AWP measures (N=15,815).

Bennett et al (2016) identified that grants in excess of £1,000 per home led to greatest improvement in self-reported “very bad or bad health”. Grants of up to £2,500 were provided as part of the English Warm Front Scheme with an average grant of £445 in 2002 (Gilbertson et al., 2012). Fenwick et al. (2013), in their review of 25 global studies, found a range of average grants per household as summarised in Table 5. As such, the AWP delivered substantial grants to each household with evidence of a “whole house” approach being delivered.

Table 5: Average value of grant per household (Adapted from Fenwick et al., 2013, p. 838)

Author	Date	Location	Mean cost of intervention (£ converted in relation to date)
Halpern	1995	UK	£10,000 - £15,000
Green et al	1999	UK	£28,000
Blackman et al	2001	UK	£8,000
Allen	2005	UK	£5,800
Gilbertson et al	2005	UK	£445
Cattaneo et al	2006	Mexico	£82 (2006 rate of 0.543 $USD)
Warm Front Study Group	2006	UK	£2,500
Howden-Chapman et al	2008	New Zealand	£1,153 (2008 rate of 0.384 $NZ)
Heyman et al	2011	UK	£727

The AWP database contained information on the range of energy efficiency measures that were installed in each property. A number of measures also had an approximate cost associated with them e.g. the cost of converting a property from central heating to gas was £2,330. However, a number of measures, such as windows, were priced in respect of quantities and not a total price. For instance, upgrading windows to double glazing was priced at £116 per square metre. It was therefore not possible to identify the total spend of these items per household due to the lack of information on window area installed. Table 6 presents the main measures that were installed along with the average price per measure.

Table 6: The number of measures installed in AWP along with the average cost (£) per measure

Intervention type	Measure	Number of households	Average cost (£)
Heating	New boiler (any type)	1,636	2,939
	Convert to gas	2,199	2,330
	Convert to oil	5,859	3,130
Insulation	Loft insulation (all)	11,520	6.83/m^2
	Cavity wall insulation	5,351	9.67/m^2
	Solid wall insulation	163	90/m^2
	Draught-proofing	2,420	120
Windows	Replace deflective glazing	2,768	79.28/m^2
	Replace Windows	18,659 *(>1 window per house)*	255.40
	Upgrade Existing Windows	40	116/m^2
	Replace Pitched Roof Windows	198	687.86
Minimal	Replace hot water tank jacket	367	27

Based on Liddell and Guiney (2015), the ratio of major to minor retrofits (November 2014 to October 2018) was 1:0.2 indicating significant targeting of major retrofits to vulnerable homes (Table 7). The ratio for 2014 – 2018 suggests that the most recent version of AWP was a significant improvement on both Warm Homes and AWP2, a pilot version of the Affordable Warmth Programme, with the majority of households receiving major retrofits.

Table 7: AWP2 installations, Warm Homes installations and AWP3 installations along with the ratio of major to minor retrofits from each programme.

Measure	AWP2 N=549 (%)	Walker et al. (2013) N=58,868 (%)	AWP N=15,815 (%)
Minor retrofits (<=£1,800)	485 (88.3%)	39,088 (66.2%)	2,258 (14.3%)
Major retrofits (>£1,800)	64 (11.7%)	19,957 (33.8%)	13,557 (85.7%)
Ratio of major to minor retrofits	1 : 7.6	1 : 1.9	1 : 0.2

3.1 Household types benefitting from AWP3

The type of household benefiting from retrofits was recorded for 14,891 (N=15,864, 93.8%) properties. Using GIS it was possible to match each property in the AWP database to the Pointer dataset for Northern Ireland. Pointer records the class of each property and was used to update missing values in the AWP database. There were minor discrepancies between the type of property recorded by AWP and Pointer (Table 8).

Table 8: Number and type of properties receiving retrofits.

Property Type	Pointer Total	%	AWP Total	%	Average %
Detached	6132	38.65	6204	39.10	38.88
Terraced	5577	35.15	4979	31.38	33.27
Semi Detached	3730	23.51	3347	21.10	22.30
Apartments, flats	398	2.51	356	2.24	2.38
Errors/blanks	28	0.18	979	6.17	3.17
TOTAL	**15,865**	**100**	**15,865**	**100**	**100**

From Table 8 the main property type receiving retrofits was detached homes (~ 39%) with terraced homes receiving around 33% of retrofits. Flats received the smallest number of retrofits (~ 2%) which may reflect the low number of private sector landlords availing of the scheme. Of the 15,865 properties, 86.8% were owner occupied and 4.6% were rented. A further 4.6% were classed as “Life Interest” which relates to a spouse remaining in a property following the death of the title deed holder. The remaining 4% were either blank or irrelevant to AWP.

3.2 Census geography

The UK Census provides population counts, age breakdowns, household types and many other socioeconomic data at a range of geographies. AWP was targeted at Small Area (SA) level as this represents a sufficiently detailed spatial scale while also providing many datasets and preserving anonymity. There are 4,537 SAs in Northern Ireland and each has an average of 400 people and 155 households (NISRA, 2013). The AWP targeting algorithm used socioeconomic data from government datasets since 2013 due to the high resolution of data provided by the Census. In order to obtain socioeconomic and demographic data on each household receiving a retrofit, each property was mapped to the SA in which it was located. As the area-based targeting approach uses SAs as the base geography, multiple households receiving retrofits may have existed in one SA.

Each of the 15,865 properties receiving retrofits was mapped on SAs across Northern Ireland in a GIS. Of the 4,537 SAs in Northern Ireland, 3,839 (84.6%) SAs contained at least one retrofitted property (Figure 6).

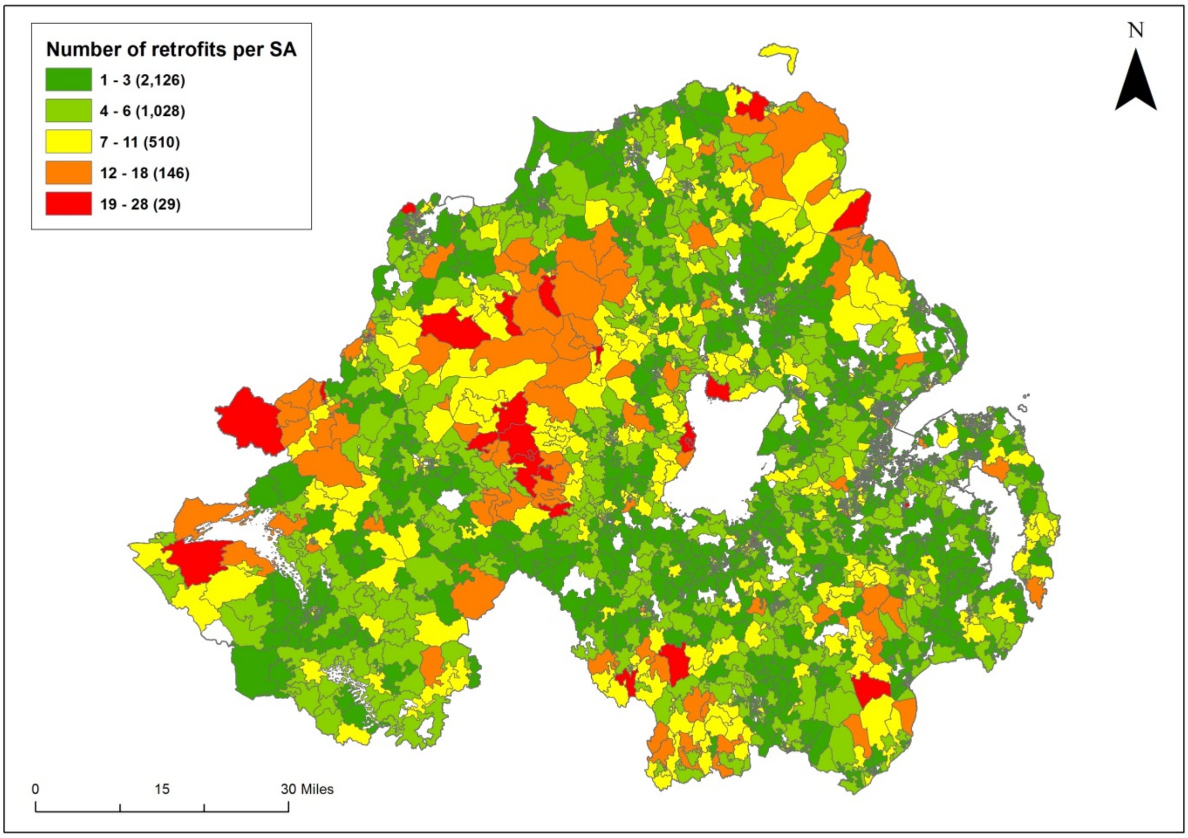

Figure 6: Spatial extent of retrofits across Small Areas.

Over 55% of SAs had between 1 and 3 retrofits with the majority (35%) taking place in “Large towns”. Over 26% of SAs had between 4 and 6 retrofits with over 32% taking place in “Open Countryside” and over 30% taking place in “Large towns”. Around 13% of SAs had between 7 and 11 retrofits with the majority (38%) taking place in “Open Countryside”. Almost 4% of SAs had between 12 and 18 retrofits with the majority (55%) of these taking place in “Open Countryside”. Less than 1% of SAs had more than 19 retrofits with Castlederg (SA = N00004459) receiving the highest number of retrofits (28). Of the 29 SAs receiving 19 or more retrofits, the majority (66%) were in “Open Countryside”. The average number of retrofits per SA was 4.1 and the majority of retrofits were done in “Large towns” (31.8%) followed by “Open Countryside” (25.9%).

The number of households in each SA was determined from the Census. It was therefore possible to determine the proportion of households in each SA that had AWP measures installed. The average percentage of homes treated in a SA was 2.6%, although the percentage ranged from 0.11% (Duncairn, SA= N00001131) to 20.15% (West ward, SA=N00004536).

3.3 Population benefitting from AWP3

The AWP database of retrofits contained some rudimentary data on the population living in homes with retrofits. For example, any households containing a child were coded. From the database, 1,315 homes (8% of households) had a child. However, no information on the number of children, or their ages, was recorded in the AWP database. In order to estimate the number of people who benefitted from retrofits, it was necessary to augment the AWP database with socioeconomic data from the 2011 UK Census.

For each of the 3,839 SAs that contained at least 1 retrofit, population data were acquired from the Census. The mean population for each SA was 408 people ranging from a minimum of 118 people (Ballyloran ward, SA= N00003081) to a maximum of 3,075 people (Derryaghy ward, SA= N00003308). Three age groups were calculated for each SA to identify the main population groups occurring in the sample (Table 9).

Table 9: Age groups per SA where retrofits occurred.

Category	Average number per SA	Minimum number per SA	Maximum number per SA
Population aged 0–15 years	86	5	1142
Population aged 16-59 years	241	44	1844
Population aged 60+ years	80	9	428
Total Population	408	118	3075
Total Households	168	59	1037

The total number of retrofits in each SA was calculated in order to estimate the average number of people per retrofitted property (Table 10).

Table 10: Average number in each age group per household (N=3,839 Small Areas).

Category	Average population per household	Minimum population per household	Maximum population per household
Population aged 0–15 years	0.53	0.03	1.40
Population aged 16-64 years	1.65	0.48	5.72
Population aged 65+ years	0.39	0.02	1.40

Using the average number of children (0-15), adults (16-64) and elderly (65+) it was possible to estimate the total number of people benefitting from retrofits. For instance, in Swatragh ward (SA= N00003588) there were 4 properties in the final AWP database that benefitted from retrofits totalling over £17,666. From the 2011 Census, this SA had 622 people with 181 children (0-15), 382 adults (16-64) and 59 elderly (65+). There were 170 dwellings in the SA which equated to an average of 1.06 children, 2.24 adults and 0.34 elderly people per property. It is therefore possible to use these estimates to calculate figures of 4.25 children, 8.98 adults and 1.38 elderly people living within the 4 retrofitted properties. Using these average numbers of people per age group per retrofitted property it is possible to estimate the number of people per demographic group benefitting from retrofits (Table 11).

Table 11: Estimated number of people benefitting from AWP retrofits (N=3,839 Small Areas).

Category	Estimated population benefitting from AWP
Population aged 0–15 years	8,891
Population aged 16-64 years	26,708
Population aged 60+ years	6,197
Total Population	**41,796**

Using GIS it is also possible to calculate the amount of grants allocated for each SA (N=3,839). The average grant per SA was £4,115, ranging from a minimum of £147 to a maximum of £10,000. Figure 7 shows the average grant spend per SA for Northern Ireland.

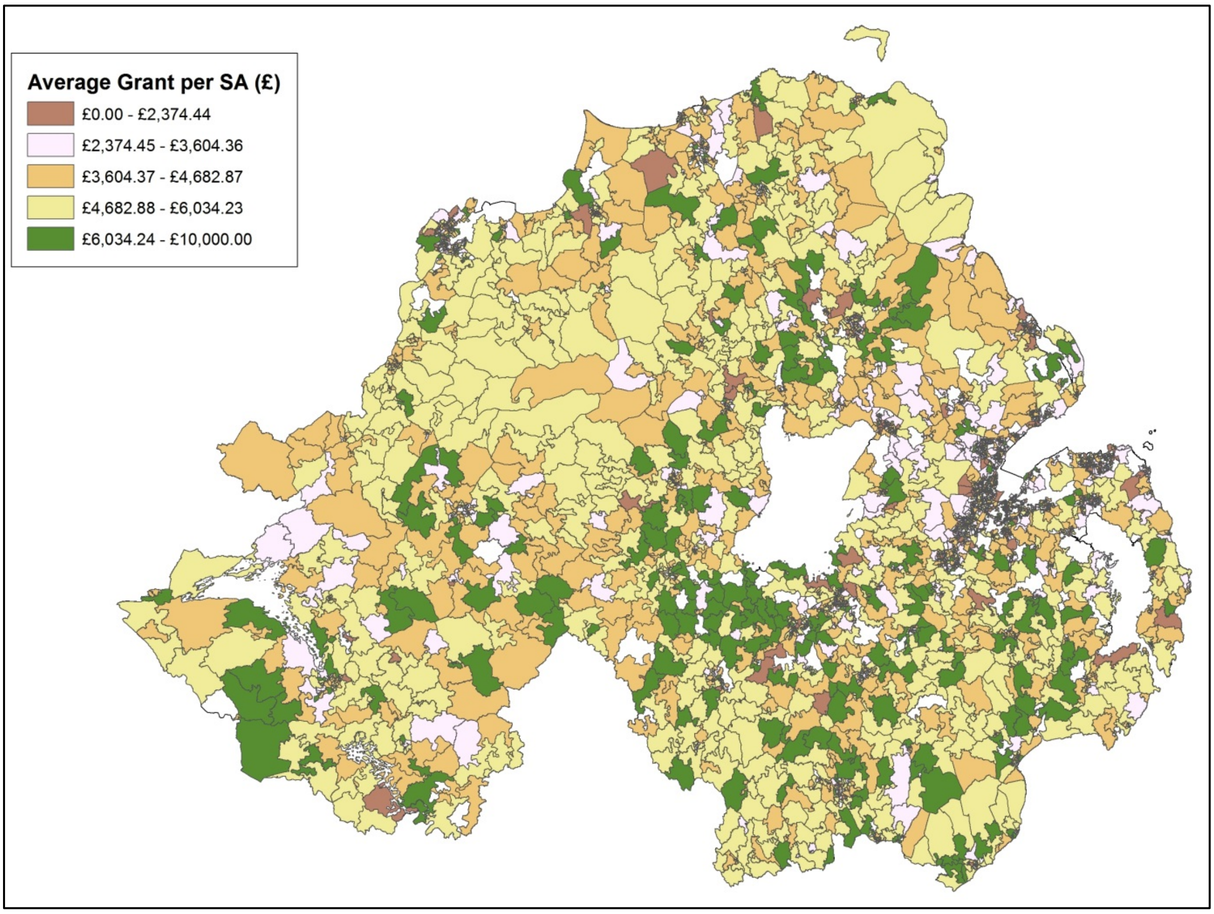

Figure 7: Average grant spend per Small Area.

4.0 Impacts on living conditions and health

The following section follows health impact assessments (HIA) done in Lambeth (Ambrose et al., 2018), Sheffield (Stafford, 2014) and the study of Warm Front in England (The Warm Front Study Group, 2006). The Northern Ireland Affordable Warmth Programme (AWP) is a more comprehensive energy efficiency programme than the Warm Front programme in England. However, the coefficients and reductions developed for the Warm Front programme represent the most robust calculations currently available and these have been largely replicated in this study. While the gains reported from Northern Ireland’s AWP are likely to be very conservative, the calculations used in this report are the most efficient technique by which to estimate gains in the absence of self-reported health gains.

Using Figure1, the AWP benefits intervention homes through two pathways, namely greater thermal comfort and reduced financial stress (Grey et al., 2017). While numerous studies have identified that householders in receipt of energy efficiency measures can raise indoor temperatures and heat more rooms (Hamilton et al., 2011; Threlfall, 2011; Elsharkawy and Rutherford, 2018), they may feel less financial pressure and enjoy warmer homes which in turn impact on physical and mental health. The authors produced a simplified model to estimate cost-benefits from the AWP programme (Figure 8) using the model developed by Ambrose et al. (2018).

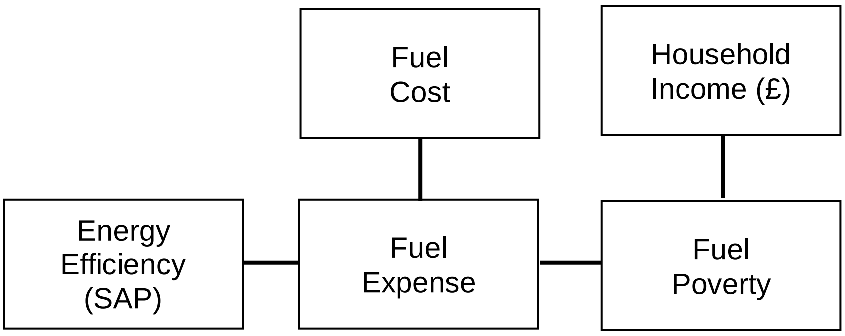

Figure 8: Estimating baseline fuel poverty to calculate the impact of AWP.

Primary data on gross household income was available for 15,602 of 15,865 beneficiary households (98%) from the AWP database. In order to identify the risk of fuel poverty in relation to income bands, the authors used the 2011 Northern Ireland House Condition Survey (NIHCS, 2011) to establish an estimate of fuel poverty. The 2016 Northern Ireland House Condition Survey was not used as it was completed at a time when fuel prices were significantly lower which had an impact on the fuel poverty rates in 2016. The Fuel Poverty ratio for five income bands is based on fuel expenditure exceeding 10% (as Northern Ireland did not adopt the Hills “Low Income, High Cost” (LIHC) model and 10% is considered as the main threshold for fuel poverty (DfC, 2011)). Table 12 below shows the percentage of fuel poverty for each income band across Northern Ireland using the NIHCS estimates from 2006 to 2011 with income bands altered slightly in 2016.

Table 12: Estimated percentage of properties in fuel poverty in respect of gross income (Adapted from NIHCS, 2011, p. 70 and NIHCS, 2016, p. 62).

Annual household income	***% FP (2016)***	**% FP (2011)**	**% FP (2009)**	**% FP (2006)**
< £10,000 *(<£10,399)*	*55%*	79%	81%	66%
£10,000 - £14,999 *(<£10,400 - £15,599)*	*33%*	64%	64%	41%
£15,000 - £19,999 *(<£15,600 - £20,799)*	*23%*	41%	42%	26%
£20,000 - £29,999 *(<£20,800 - £31,199)*	*7%*	19%	15%	8%
£30,000 > *(<£31,200 - £46,799)*	*1%*	5%	3%	3%
£46,800 >	*<1%*	--	--	--
OVERALL RATE OF FUEL POVERTY	***22%***	**42%**	**44%**	**34%**

Gross income values for each retrofitted property were provided in the AWP database of retrofits from 2014 to 2018. Reported income bands for 15,602 beneficiary households are shown in Table 13 below along with the proportion of homes in each income band across the AWP sample. The authors assume the ratios for those households not providing income data will be the same. The baseline estimate of the number of homes in fuel poverty is also presented (8,989).

Table 13: Percentage and number of homes in each income band from AWP.

Annual household income	**% of AWP homes**	**Number of households**	**Fuel Poverty % for income band (2011 NIHCS estimates)**	**Estimate of baseline fuel poverty** (2011 FP % x Number of homes)
< £10,000	19.6%	3,125	79%	2,468
£10,000 - £14,999	35.6%	5,648	64%	3,614
£15,000 - £19,999	44.7%	7,092	41%	2,907
Total	100%	15,865	--	8,989

It is assumed that tenure, type and baseline energy efficiency could all modify the estimate of fuel poverty in beneficiary households. However, comparing the mix of types and tenures of beneficiaries with national profiles does not lead to a significant adjustment. For this review, the Standard

Assessment Procedure (or SAP) was used to indicate household energy efficiency. Households with a low SAP score have lower energy efficiency while households with SAP scores close to 100 have greater energy efficiency. The 2016 House Condition Survey used a modification of the SAP model and estimated mean SAP in Northern Ireland to be 65.8. Using the previous SAP model, the 2011 House Condition Survey estimated the SAP of households to be 59.6. The authors refined this measure further by using postcode level SAP data from 2015 (DoF, 2015) to estimate the mean SAP for each Small Area which had AWP retrofits carried out. For instance, Figure 9 shows an SA with reported SAP values which can be assigned to the AWP properties that exist within that SA.

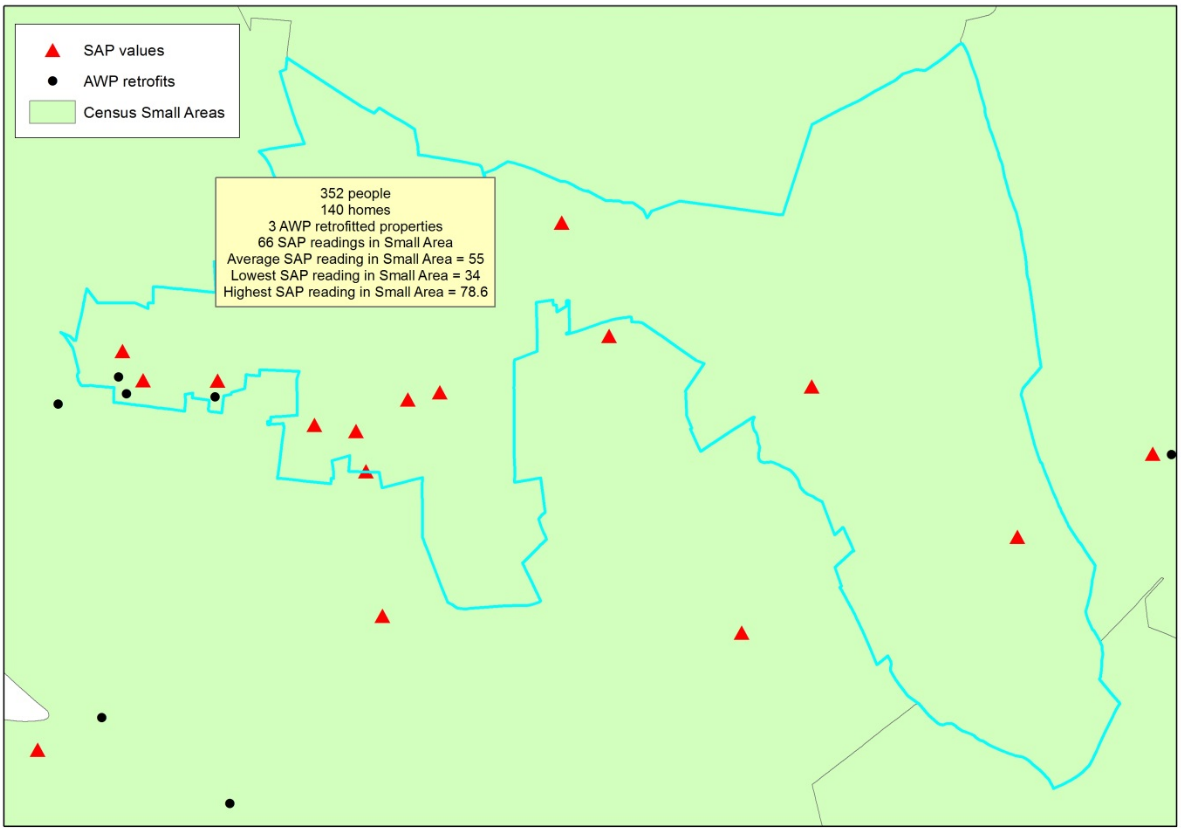

Figure 9: SAP scores in a Small Area that are allocated to AWP properties.

This analysis indicates an average pre-intervention energy efficiency rating of 56.4 for those SAs in which AWP retrofits took place. Taking a SAP score of 56.4 as a proxy for average baseline SAP rating of beneficiary properties, an upward revision of the number of households in fuel poverty was made to 9,520 households (60% of 15,865) from the previous estimate of 8,989. The relationship between energy efficiency and fuel poverty used in this report is explained further in DECC (2016).

4.1 The impact of excess cold

A similar study for the UK government of the impact of Warm Front, England's major domestic energy efficiency scheme, indicated clear pathways from investment in thermal efficiency to improvements in physical and mental health (Figure 1 on page 4). The majority of households in fuel poverty improve thermal comfort by prioritising fuel bills over other essentials such as food (Preston et al., 2016). However, a significant minority of people continue to live in cold conditions with reduced energy bills. The Hills Report (2012) refers to recommended temperatures derived from the World Health Organization of 21°C in the living room and 18°C in bedrooms to provide thermal comfort. These recommendations are debated by Hills and by Ormandy and Ezratty (2011) but it is assumed in this report that a living room temperature below 18°C is likely have a harmful impact on the health of at least one occupant.

The relationship between fuel poverty and temperature is therefore critical to our assessment (see Table 12). Using data from the Republic of Ireland, which has many similarities to Northern Ireland, Healy and Clinch (2002) indicated that 30% of households in fuel poverty have temperatures below 18°C while a further 11% of households not in fuel poverty also experience temperatures below 18°C. A recent analysis of data from the English Housing Survey (Hamilton et al., 2017) also linked temperatures to fuel poverty using the 10% definition. Indoor temperatures were standardised at 5°C outdoor air temperatures following the methodology proposed by Oreszczyn et al. (2006). Mean living room temperature for the fuel poor was 18.2°C which was significantly below the 18.9°C mean for households not in fuel poverty. Mean bedroom temperatures for fuel poor households were 17ºC compared with 18.4ºC for non-fuel poor households, also a significant estimate of low-temperature households. Using the co-efficients from Healy and Clinch (2002), the authors estimate that 3,550 households experienced temperatures below 18ºC prior to energy efficiency measures from the AWP (30% of the 9,520 fuel poor households + 11% of the 6,346 non-fuel poor households). This rounded estimate of 3,550 is consistent with the Hamilton et al (2017) analysis, assuming distributions around the means with a long tail of low temperatures identified by the Warm Front study. We reiterate here that this is a conservative estimate based on scientifically derived coefficients from peer-reviewed publications.

All the main measures installed in the AWP are expected to increase indoor temperatures. Analysis of the equivalent scheme in England by Oreszczyn et al. (2006a) confirmed that heating measures were effective, insulation measures less so and a combination of heating and insulation measures were most effective in raising temperatures. As is shown in Table 6 and Figure 5, the majority of AWP interventions were "major" retrofits with heating and installation measures installed.

Oreszczyn et al. (2006a) suggested that living room and bedroom temperatures increased by a small amount (p. 248) - from 17.9°C to 19.6°C in living rooms and from 15.9°C to 18.3°C in bedrooms – with the result that an estimated 10% of properties were lifted above the 18°C threshold which avoids the risk to health of at least one household member. Oreszczyn et al. (2006a) also reported a 2.5°C temperature increase in the coldest properties compared with a 1°C increase in the warmest homes. When the 10% coefficient is applied to AWP properties, it is estimated that at least 345 households benefit from temperatures now above 18°C. It is suggested that these are conservative estimates based on evidence from Warm Front and the number of properties benefitting from higher temperatures is likely to be higher due to more interventions in AWP. In the absence of primary data on the properties, our best estimate is that 400 households are lifted above the 18°C indoor temperature threshold by AWP, with greater improvements in the 'tail' of very cold properties. Again this is suggested as a conservative estimate and reflects other relevant studies which generally report modest household temperature increases (Wilkinson et al., 2006; Shortt and Rugkåsa, 2007). Figure 10 indicates the general increase in post-intervention temperatures reported by Oreszczyn et al. (2006a).

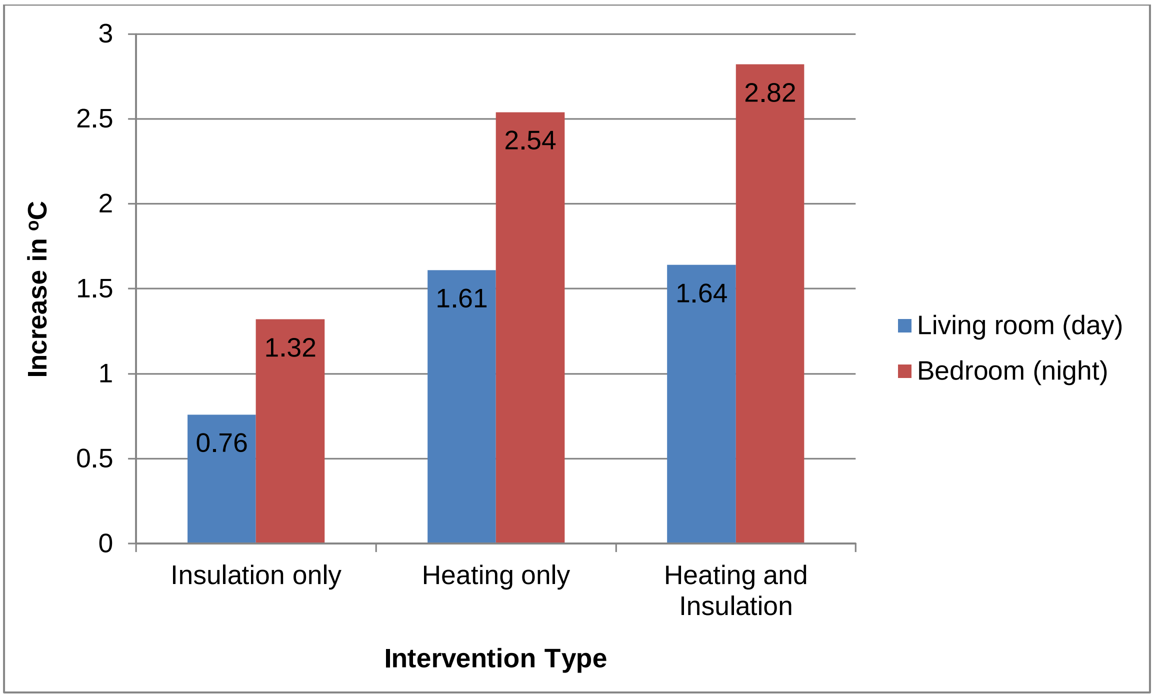

Figure 10: Temperature increases following interventions (Adapted from Oreszczyn et al, 2006a, p. 248).

Evidence supporting the Government's Housing Health and Safety Rating System (HHSRS, 2014) indicates that excess cold has a significant impact on health, primarily heart disease. This is confirmed by Shiue and Shiue (2014) who identified that people living in cold conditions(<18°C) are twice as likely as the general population to suffer high blood pressure – a risk factor for heart disease (Wilkinson et al., 2001; Saeki et al., 2014). According to the government's HHSRS Operating Guidance, at least one person in each of the 400 beneficiary households now living in temperatures above 18°C is less likely to suffer harm to health (Table 14).

Table 14: Reductions in 'harms to health' from warmer homes.

	Households		Number of Occupants
	In Fuel Poverty	At Risk (Temperature <18°C)	At Risk (Temperature <18°C)
Before AWP	9,519	3,550	3,550
After AWP		3,150	3,150
Reduction		**400**	**400**

According to the HHSRS Operating Guidance, severity of this harm falls into four classes, from death and regular severe pneumonia in Class I to minor conditions like occasional mild pneumonia or frequent coughs and colds. This report follows that of Ambrose et al. (2018) in that the percentage of Class I harms was reduced while the percentage of Class II harms was increased to account for the reducing trend of deaths from heart disease and stroke since the statistics supporting the Operating Guidance were compiled (Public Health England, 2015). We have also increased the percentage of Class IV harms following the Marmot review (2011) to account for indirect impacts of cold homes on health. Lau et al. (1995) identified a statistically significant relationship between mean daily minimum temperature and rates of hip fracture in young and old people. Liddell and Morris (2010) identify that symptoms of arthritis become worse in cold and damp houses while mobility can decrease with lower temperatures. However, as yet there is no clear evidence which allows this report to definitively quantify those elderly occupants at risk. Estimates are provided in Table 15.

Table 15: Reductions in ‘harms to health’ across classes of harm.

		Spread of harm			
15,865 Beneficiary households	Temperature <18°C Risk of harm	Class I (most severe) 30%	Class II 10%	Class III 20%	Class IV (least severe) 40%
Before AWP	3550	1065	355	710	1420
After AWP	3150	945	315	630	1260
Reduction 1 year	400	120	40	80	160

4.2 The impact of damp and mould

Dampness is the second of three hazards covered by our report. Green et al. (2000) identified that the principal cause of damp and mould growth is condensation rather than water penetration. Condensation is caused partly by lifestyle, partly by lack of ventilation and predominantly by low temperatures. A number of epidemiological studies has demonstrated how damp is strongly associated with a range of symptoms, particularly respiratory problems, including asthma (Shortt and Rugkasa, 2007; Barnes et al., 2008; Free et al., 2010; Mendell et al., 2011). The pathway of cause and effect is via airborne mould spores which grow in damp conditions and the prevalence of dust mites which thrive in humid conditions. But whereas cold conditions have most impact on older people, damp conditions (as confirmed by the HHSRS and other published literature) are strongly linked to childhood illness.

Oreszcyn et al. (2006b) identified that 12.0% of Warm Front recipient households previously lived in mouldy dwellings. Applying this coefficient to the 15,865 beneficiaries of AWP, we estimate that 1,900 households previously experienced mould conditions. The impact of Warm Front measures varied, but where heating systems were upgraded in combination with insulation measures (only a minority of Warm Front cases) the incidence of mould reduced to 8.2%, while in properties receiving insulation only the incidence of mould reduced to 8.9%. We estimate that for the AWP scheme, 9,694 properties had a heating intervention and that all properties received some sort of insulation measure. It is assumed therefore that 9,694 AWP properties received both heating and insulation measures. Applying the reduction in mould coefficient (3.8%) to 9,694 AWP properties receiving both measures (the majority), and a coefficient of 3.1% to the remaining 6,171 properties which received one measure, reduced the prevalence of mould in at least 559 properties. The installation of double-glazed windows was a major element of AWP (though not Warm Front) and the evidence from Hamilton et al. (2017) and Oreszcyn et al. (2006a) shows they will have contributed significantly to increased indoor temperatures. We estimate the prevalence of mould is eliminated in another 317 (2%) of properties as a result of upgraded windows. However, due to lack of data in the AWP database about the amount of new windows per property, these estimates are conservative. The authors' estimate a combined reduction of 876 households with mouldy living conditions, takes account of the possibility of reduced ventilation from double glazing increasing condensation and mould (Table 16).

Table 16: Reduced likelihood of harm from mould

		Spread of harm			
15,865 Beneficiary households	Mould present	Class I (most severe) 0.0%	Class II 1.0%	Class III 10%	Class IV (least severe) 89%
Before AWP	1900	0	19	190	1691
After AWP	1024	0	10	102	912
Reduction 1 year	876	0	9	88	779

Using a HHSRS convention it is assumed that the likelihood of harm is for at least one occupant of the beneficiary households. Children are the most vulnerable group at risk of harm from damp and mouldy conditions, although all occupants will be affected. It is suggested based on published studies (Calliard et al., 2018) that the AWP could reduce by half the number of children likely to be harmed by living in mouldy conditions. According to the HHSRS, beneficiaries are primarily children who every year would previously have suffered less severe (Class IV) harms such as wheezing and regular coughs and colds.

4.3 Common Mental Disorders (CMD)

The authors have conservatively estimated that 9,520 beneficiary households were in fuel poverty prior to the AWP (60% of 15,865 households). Many will have experienced high levels of financial stress in an attempt to maintain satisfactory levels of indoor comfort (Hernandez, 2016). The research evidence from the Warm Front study shows a very clear pathway from fuel poverty and financial stress to increased levels of common mental disorders (CMD). According to numerous studies (Harris et al., 2010; Gilbertson et al., 2012; Stafford, 2014; Liddell and Guiney, 2015; Hernandez, 2016), financial stress is not restricted to adults or homeowners, but can be transferred to other people in the home and can cause absence from work and reduce overall quality of life.

Fuel poverty has an impact on mental well-being independent of the impact of cold and damp living conditions on physical health. The authors estimate the impact of mental health by ‘triangulating’ evidence from a number of published sources. As a marker of fuel poverty, a survey by NatCen asked if households ‘used less fuel due to worry about costs.’ Of these households, 32% reported symptoms of anxiety and depression (CMD). Applying this ratio to the 9,520 beneficiary households experiencing fuel poverty prior to the AWP, an estimated 3,046 households would have *at least one* occupier with common mental disorder warranting medical attention according to the HHRS. Most of these are assumed to be modest (Class IV) harms to health.

Evidence from the Warm Front study revealed a reduction in households in difficulty paying fuel bills from 32% to 18% for those receiving a combination of heating and insulation measures (Gilbertson et al 2012). By applying this reduction ratio (0.56), it is estimated that the AWP (where the majority of beneficiaries received both measures) will reduce fuel poverty from 9,520 to 5,355 households though this is a very conservative estimate. However, the reduction in fuel poverty is not proportionate as studies identify that some fuel-poor occupiers are depressed by other factors which may endure after alleviating fuel poverty. So, although households in fuel poverty are estimated to fall by 4,165 (44%), we apply the reduction figures from the NatCen study and as a result the AWP is estimated to reduce symptoms in 823 (27%) households where, according to the HHSRS convention, an occupier has symptoms of CMD (Table 17). Most of these are assumed to be modest (Class IV) harms to health.

Table 17: Reduced likelihood of anxiety and depression

15,865 Beneficiary households	Fuel Poverty	Likelihood of CMD	Spread of CMD harms			
			Class I (most severe) 0.0%	Class II 1.0%	Class III 10%	Class IV (least severe) 89%
Before AWP	9,520	3,046	0	30	304	2,711
After AWP	5,355	2,223	0	22	222	1,979
Reduction 1 year	4,165	823	0	8	82	732

Large numbers of the beneficiary households of AWP previously lived in fuel poverty and experienced cold living conditions, mould and stress associated with high fuel bills. The health of well over a thousand residents is improved by the AWP reducing excessively cold living conditions, removing damp and mould and alleviating fuel poverty. The numbers reported (Table 18) here are conservative estimates and the need for better data on the impact of energy efficiency measures in retrofitted homes is critical to identify the full impact of energy efficiency measures on residents and wider society.

Table 18: Impact of AWP on living conditions and health.

	Number of Occupants		
	Excess Cold	Damp and Mould	Fuel Poverty
Before AWP	3,550	1,900	3,046
After AWP	3,150	1,024	2,223
Health Improvement	400	876	823

5.0 The Northern Ireland AWP Retrofit Programme: Social Costs and Benefits

This section of the report presents a summary social cost-benefit analysis (CBA) of the Northern Ireland AWP programme from 2014 to 2018. The nature of the cost-benefit exercise and a brief overview of the estimation methods employed are presented along with the cost-benefit results.

5.1 Scope, Focus and Key Assumptions

The cost-benefit analysis outlined in this report provides a number of key elements. Firstly, estimates of the monetary value of the social benefits arising from the gains in physical and psychological health induced by the AWP retrofit programme are presented. It is reiterated that these are estimates based on published scientific studies and not real values. Secondly, the monetary value of the social benefits is compared with the cost of the programme summarised in a benefit-cost ratio. Further details of the four year £65.7 million AWP programme are provided in section 2.0.

“Social benefit” denotes the gains which accrue both to the immediate beneficiaries of the programme and to members of the wider society. This is in line with the concept of “Social Return on Investment” (SROI) which is outlined in section 1.2. A number of published studies highlight that wider returns on investment can be obtained from energy efficiency measures and these should not be restricted to rate-of-return tests (Threlfall, 2011; Fenwick et al., 2013; Stafford, 2014; Chapman et al., 2017; Ambrose et al., 2018). In this report, the authors assume that “social benefits” comprise, yet are not restricted to, (a) the greater well-being enjoyed by healthier residents, (b) public expenditure savings in the National Health Service arising from reductions in physical and psychological illnesses linked to cold, damp homes and (c) the gain in economic output (GDP) arising from fewer working days lost through the psychological illnesses linked to cold, damp homes.

As a result of the AWP programme dwellings will be warmer and less vulnerable to damp and mould and households will be less vulnerable to fuel poverty. There is strong empirical evidence that these adverse living conditions are associated with three different types of morbidity (section 1):

- cold related cardio-vascular disease (CVD) to which those over 60 years of age are especially vulnerable;
- respiratory illness caused by damp and mould to which children are especially vulnerable;
- Common Mental Disorders (CMD) induced by the stress of living in fuel poverty.

As indicated above, each morbidity gives rise to two elements of social cost: losses in well-being and the quality of life and the cost of NHS treatment.

In the case of Common Mental Disorders (CMD) related to fuel poverty an additional cost arises in the form of reduced economic output. Stafford (2014) proposed that people who are “economically active” (aged 16 to 64 years old) with CMD may suffer a higher rate of unemployment, may be at greater risk of losing employment or have a higher rate of absenteeism from work. In light of this, people with CMD can be assumed to experience losses of Gross Domestic Product (GDP) due to absenteeism or unemployment. It is assumed in this report that the total value of the AWP induced reductions in these three types of costs defines the value of the social benefit of the programme.

The authors make it clear that the cost-benefit analysis presented in this report is not equivalent to a financial or commercial appraisal. This is most clearly seen in the quality of life gain, the value of which has no market determined price and does not appear in any set of financial accounts.

This report assumes that the AWP investments have a length of life of 15 years and that the initial one year social benefit of the programme is replicated in each of the following fourteen years. This would be a questionable assumption if there were evidence of a steady decline in fuel poverty. Data for England for 2003-2016 showed a shallow decline in the extent of fuel poverty measured by Hill's Low Income High Cost (LIHC) metric but an offsetting increase in the severity of fuel poverty measured in terms of the average fuel poverty gap (BEIS, 2018). While comparable trend figures for Northern Ireland are not available, we assume that fuel poverty, while potentially declining, is still high and at risk from fluctuating fuel prices and particularly vulnerable to changes in benefits as introduced by Universal Credit. As is standard practice in cost-benefit analysis (CBA), a discount rate is applied to benefits in more distant years which allows a single discounted present value of the stream of benefits to be calculated, which can be directly compared with the discounted present value of the cost of the programme which is spread over four initial years. We adopt the 3.5% discount rate for investments affecting the risk to health recommended in HM Treasury Green Book (2018).

5.2 An overview of the estimation models

Within the limited resources available it has not been possible to undertake a detailed and full-scale analysis of the value of all induced social benefits based on AWP data from 2014 to 2018. Where possible, this report used local data and elsewhere has imported data from non-local, usually national, sources, and where possible has made adjustments to such data to reflect differences between the relevant national and local profiles. It is important to emphasise that the complex triangulation exercise by which the estimates of social benefit are derived means that they are to be read as plausible estimates of broad orders of magnitude.

The derivation of the AWP induced annual reductions in cases of the three morbidity types is described in sections 4.1 to 4.3. The calculation of estimates of the monetised social benefits flowing from induced reductions in each of the three types of morbidity is summarised below.

The annual value of well-being gains due to reductions in cardio vascular and respiratory illnesses and Common Mental Disorders is derived from the appropriated World Health Organization Disability

Adjusted Life Year (DALY) weights combined with an estimate of the value of one year of healthy life of £30,000. The DALY metric can be interpreted as being equivalent to the more familiar Quality Adjusted Life Year (QALY) metric with the 0-1 calibration reversed. The unadjusted DALY weights for losses are 0.4 for cardio-vascular disease, 0.25 for respiratory illness and 0.2 for Common Mental Disorders. These weights are modified to take account of two factors: the heavy concentration of cold home related morbidities at the mild end of the illness severity spectrum which will give rise to smaller reductions in the quality of life (Tables 15-17); and evidence that those suffering fuel poverty related morbidities would not otherwise enjoy full health. The combined effect of these adjustments is to reduce the weights to 0.30, 0.10 and 0.10 respectively.

The annual saving of NHS expenditures for each morbidity type are derived by multiplying the estimated annual reduction in the estimated number of cases by estimates of the NHS treatment cost per case with the latter derived from Northern Ireland Department of Health Healthcare Resource Group unit costs for 2016 (DoH, 2018) – these costs are available in Table 19 below. National costs on mental health treatment costs were sourced from the UK Department of Health (DoH, 2016) and treatment costs of £258 (low severity), £270 (moderate severity) and £372 (very severe) were obtained (p. 14). These type of health outcomes have been reported by other studies such as BRE (2016) and Liddell (2008).

Table 19: Health outcomes and treatment costs for selected HHSRS hazards (DoH, 2018).

Hazard	**Class of harm outcome**			
	Class 1	**Class 2**	**Class 3**	**Class 4**
Excess cold	Myocardial infarction £486	Pneumonia £436	COPD £435	Single A&E Consultation £138
Damp and mould	NA	Pneumonia £436	Asthma £550	

Both the number of case reductions and the treatment costs per case are disaggregated by four levels of severity. It is assumed that all cases of morbidity are actually treated within the NHS except for Common Mental Disorders for which the most up-to-date evidence is that around 40% of those afflicted received NHS treatment (Bunting et al., 2013; Lubian et al., 2014), the obverse of which being the extensive provision of informal health care by friends and families (Stafford, 2014).

The GDP value of the number of working days saved as a result of fewer Common Mental Disorders due to less fuel poverty is derived by updating the results of Layard et al. (2007), which incorporate the GDP losses arising from both unemployment and absenteeism associated with mental illness. This source estimates that each case of Common Mental Disorder gives rise to a loss of 0.53 months of work through a combination of unemployment and absenteeism. This loss is valued at the 2016 National Minimum Wage rate for those aged 25 and above of £7.20 per hour. The saving of GDP arises only in respect of those suffering a fuel poverty related Common Mental Disorder who are of working age.

5.3 Cost-Benefit Estimates

The calculations described above are used to generate a benefit-cost ratio of 1.59 as presented in Table 20.

Table 20: The cost and social benefit of the AWP retrofit programme

Discounted Present Value of Cost ***£ million 2016 prices***		***Discounted Present Value of Social Benefits*** ***£ million 2016 prices***	
Heating, insulation and window upgrades		**Reduced cold**	
		Well-Being Gain	35.18
		Reduction in NHS Costs	1.30
		Total	**36.48**
		Reduced damp and mould	
		Well-Being Gain	31.11
		Reduction in NHS Costs	1.84
		Total	**32.95**
		Reduced fuel poverty	
		Well-Being Gain	27.08
		Reduction in NHS Costs	.95
		Reduction in Working Days Lost	4.95
		Total	**32.98**
Total	**£64.26**	**Total**	**£102.41**
		Benefit-Cost Ratio	**1.59**

The dominance of gains to well-being in the estimates of social benefit is a reflection of what are conventional (and in this report fairly conservative) assumptions built into the equations used to estimate the monetised value of the quality of life gains. Thus, for example, the gain in well-being from 1 year of life free of a cold home related respiratory illness is worth just over £3,000 per person, whereas the per case NHS treatment costs saved lie in a range between £130 and £550, with a very heavy concentration of illness averted in the least severe category - to which an NHS treatment cost of under £140 per case applies. This very skewed pattern of severity also applies to Common Mental Disorders and a lesser extent to cardio vascular disease. Cold damp homes cause a lot of illness but most cases are at the mild end of the severity spectrum to which relatively low NHS treatment costs apply.

In interpreting the 1.59 benefit-cost ratio, important differences in the nature of the estimates of monetised cost and benefits should be considered. The former are accurate, precise and comprehensive, except perhaps for the omission of the cost of disruption to residents caused by the installation of the AWP interventions. In contrast, the latter represent rule-of-thumb estimates which are incomplete in a number of ways. Firstly, built into the HHSRS from which the estimates of induced health gains are derived, is the assumption that “at least one” person per dwelling suffers from a harm to health in an unimproved dwelling. This arises because the HHSRS is based on a physical survey of dwellings, not on a survey of the residents of dwellings. This means in effect that the AWP induced gains to *other* household members are not estimated and the values can be expected to be greater than those reported in Table 20. From section 3.3 of this report, an average of 2.6 people live in each home within SAs with retrofits. Secondly, research has identified that fuel poverty may undermine educational attainment in response to school absenteeism (Howden-Chapman et al., 2012) which can be expected to result in adverse employment and income outcomes over the life course. However, the evidence on the strength of this relationship is insufficient for these outcomes to be incorporated into a cost-benefit analysis of the AWP programme. Furthermore, the authors assume that those whose could work more due to reduced mental illness will earn no more than the official National Minimum Wage Rate, which means that the estimated GDP gain is a bare minimum. Finally, refurbished dwellings can boost the pride of residents and change the perceptions of others (Ambrose et al., 2018; Elsharkawy and Rutherford, 2018). Such intangible benefits contribute to the social cohesion of the area as a whole but are very difficult to enumerate and evaluate. Thus, although virtually the whole cost of the AWP programme is evaluated, not all of the benefits are.

6.0 Summary

This report has reviewed the Affordable Warmth Programme (AWP) from November 2014 to October 2018. The programme has adopted a “whole house approach” by investing an average of £4,186.30 per property. In the absence of quantitative and qualitative data, we have used published coefficients to estimate the impact that AWP has had on the health and wellbeing of people living in retrofitted homes. It is expected that the reported gains from AWP are very conservative although they are based on scientific equations published in other health impact assessments. It is critical to develop a robust reporting strategy, using qualitative and quantitative data, to identify the impact of energy intervention measures on the physical and mental health of *all* residents in the home. Furthermore, as is evident from scientific studies, reporting should be done for a substantial period of time after intervention in order to identify longer term gains in health along with behavioural changes such as increased employment and reduced school absenteeism. This report highlights that high-resolution monitoring, both spatially and temporally, is critical to evaluate the impact of energy efficiency measures on the health of residents. Developing accurate estimates of gains will require ‘better’ data that show, for example, how real increases in temperature are associated with reduced use of GPs and improvements in self-reported wellbeing. Better data, even from local situations, will have global value as improvements in health can be quantified based on a range of energy efficiency programmes that have significant social and environmental benefits.

7.0 Acknowledgements

This research was funded by the Department for Communities (DfC). The authors would like to thank Roy Cassidy of the Northern Ireland Housing Executive (NIHE) for the provision of the database. Spatial data was provided through the Northern Ireland Mapping Agreement by Land and Property Services, NIMA S&LA 577.319.

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