

Published: LITTLEWOOD J.R. ZHANG, X. KARANI, G. 2023. A Pilot Study to Evaluate Occupant Quality of Life in Optimised Retrofit Dwellings in Wales, UK. Chapter 32. In: Sustainability in Energy and Buildings 2022, Smart Innovation, Systems and Technologies, Vol 336. Springer, Singapore. https://doi.org/10.1007/978-981-19-8769-4_32.

A Pilot Study to Evaluate Occupant Quality of Life in Optimised Retrofit Dwellings in Wales, UK

Littlewood J.R. ¹ [0000-0002-0351-9954], Zhang, X. ¹ [0000-0000-0000-0000], Karani, G. ² [0000-0000-0000-0000]

¹ Cardiff Metropolitan University, The Sustainable & Resilient Built Environment Research group, Cardiff. CF5 2YB, UK.

² Cardiff Metropolitan University, The Environmental Public Health Research group, Cardiff. CF5 2YB, UK.

jlittlewood@cardiffmet.ac.uk

Abstract. This paper discusses an investigation into quality of life (QoL) as a pilot study from a sample of occupants living in existing dwellings, that have been (2021) or will be retrofitted in 2022 and 2023, funded by the Welsh Government's (WG's) Optimised Retrofit (OR) project. The pan Wales OR project aims to retrofit close to 2000 existing social housing dwellings targeting nearly-zero/zero operational energy standards, to alleviate occupant fuel poverty and reduce energy costs and carbon emissions and increase occupant comfort and QoL. The methodology presented builds on two previous research projects undertaken and completed by two of the authors in 2010 and 2020, to adapt and create a hybrid Short Form-36 (HSF36) health survey, accompanied by the established RAND analysis system. The HSF36 questionnaire survey has been further refined for the OR project and has been used to collect occupant data through face-to-face interviews and online surveys. The occupants live in dwellings managed by one of Wales's largest registered social housing landlords (RSL's) with circa 8000 dwellings. The challenges and solutions for undertaking occupant engagement for surveys during Covid19 restrictions are illustrated. Once dwelling retrofits are completed in 2022 and 2023, the intention is to conduct a second and third phase of occupant engagement.

Keywords: occupant engagement, quality of life, fuel poverty, optimised dwelling retrofit, Wales.

1 Introduction

This paper discusses the WG funded OR project [1] led by Sero Life and Pobl Housing Association [2]. Researchers from Cardiff Metropolitan University are leading two sub-projects as part of the OR project, specifically to investigate occupant comfort and QoL, and a pilot study for one of these projects is discussed. Context to the need to retrofit and improve the operational energy performance of existing social housing in Wales is discussed, as is the methodology and the results of the occupant engagement assessing comfort and QoL. The research builds on two previous research projects that mapped

the relationships between improvements in occupant thermal comfort and QoL and alleviation from fuel poverty from dwelling retrofit [3, 4].

2 The Need for Optimised Dwelling Retrofit for Quality of Life

2.1 Carbon Reduction Targets for UK Housing

Mitigating and reducing global, national, and local climate change is one of the biggest challenges facing humanity for current and future generations [5]. The UK government has legislated the world-leading climate change commitment to significantly reduce carbon dioxide (CO₂) emissions by 78% by 2035 from 1990 levels, taking the UK more than three-quarters of the way to achieving net zero by 2050 [6]. The WG has also set carbon reduction targets in its Net Zero Carbon Plan for organisations, of 37% (2025), 63% (2030), 89% (2040), and net zero carbon by 2050 [7]. There are numerous challenges. The buildings and construction sector are responsible for 36% of the global final energy consumption and 37% CO₂ emissions related to energy use [8]. In the UK, the housing stock consumes a significant amount of energy accounting for 29% of anthropogenic carbon emissions. The Welsh dwellings account for 21% of the national CO₂ emissions, indicating the high level of emissions from industry in Wales, and increasing the challenge of achieving the carbon budgets [9]. Indeed, the housing stock in Wales is among the oldest and least energy efficient in Western Europe, with 32% of homes built before 1919, and just 6% built in the last 35 years, increasing energy demand for heating and reducing comfort. In 2022, the current rate of new build housing stock is 0.4%, meaning that more than 90% of the current dwellings will still be in use by 2050 [10]. So, new build housing will not have a major impact on the decarbonisation targets in a short term. In addition, despite the Welsh Government's energy efficiency initiatives, nearly a quarter of households are still facing fuel poverty, resulting in potential detrimental impacts on health and well-being of the occupants [11]. Furthermore, since the Covid-19 pandemic started in the UK in 2020 [12], more people have stayed at home or started working from home, leading to an increase in CO₂ emissions from the housing sector, with a growth rate of 1.8% in 2020 [13].

These statistics show that Welsh housing is the most important and challenging part of the UK to achieve the goals of housing decarbonisation, and dwelling retrofit plays a more significant role in reducing future energy consumption and CO₂ emissions than ever before [14].

2.2 Optimised Retrofit Programme: Pathfinder and Quality of Life

The OR Programme (ORP) was launched in 2020 by the WG, funded as part of the Innovative Housing Programme, aiming to decarbonise existing Welsh homes [15]. The aim is to develop effective, practical pathways to take the housing stocks to their lowest achievable carbon footprint and to develop a customised plan allowing for scale economies, standardisation, and to demonstrate how data analysis may optimise costs, improve performance outcomes, and provide vital lessons towards the decarbonisation for

a wider programme [16]. It is a “whole house, pragmatic, approach to decarbonising existing homes”, which considers the fabric or materials used in the housing stocks, along with how they are heated and how energy is stored and delivered [ibid].

Pobl Housing Group and Sero Life lead one of five OR projects known as Pathfinder, to retrofit 1768 existing homes managed by 27 registered social landlords (RSLs) in Wales [2], with a consortium of 68 partners including Cardiff Metropolitan University. The ethos of Pathfinder has developed pathways to Zero and is designed to support incremental home upgrades over multiple steps, in a coordinated way, enabling delivery of a more comprehensive level of genuine zero carbon, with anticipated lower costs, by aligning with the decarbonisation of the UK energy grid [ibid].

There are 30 mini research projects in Sero Life’s OR project, two of which are led by Cardiff Metropolitan University. The first mini project, which is the focus of this paper, is entitled “Are you comfortable Quality of Life (QoL) assessments” is investigating the impacts of dwelling retrofit on occupant QoL by capturing occupant data at both pre-retrofit and post retrofit stages on a variety of parameters. These include physical and mental health, indoor temperature, relative humidity and CO₂ levels. The second mini project entitled “Retrofit measure studies & analysis”, is measuring how unwanted air leakage from/through the building fabric can impact on occupant mental wellbeing from sound transmission. Plus, also on physical wellbeing due to unwanted heat loss or gain and pathways for fire, smoke and toxic gas in the event of a building fire. This second project builds on previous research by Cardiff Met but is not the focus of this paper [17, 18].

These two mini projects will gain a better understanding of how to assess residents’ health and wellbeing through a combination of occupant questionnaires and spot measurement of environmental conditions.

3 Methodology for QoL Engagement in OR Dwellings

3.1 Refinement to HSF36 Questionnaire

Since 2021, a structured questionnaire has been refined based on an adapted (hybrid) short form 36 (HSF-36) Health survey, which has been refined following a previous research project engaging with occupants [4]. It was piloted from March to May 2022, with the aim to examine the effectiveness of the occupant engagement approach and to identify the challenges and limitations that needed to be addressed.

The SF-36 questionnaire is “a set of generic, coherent, and easily administered QoL measures” [19], with indicators that rely on patient self-reporting, which are now commonly used by managed care organisations and Medicare for routine monitoring and assessment of adult patient care outcomes. The HSF-36 questionnaire enables researchers to assess eight QoL parameters of occupants living in dwellings that are part of retrofit programmes [20]. They are physical functioning and health, role limitations due to physical health, emotional health and wellbeing, role limitations due to emotional health, physical energy and fatigue, social functioning, pain, and general health. The data collected from the occupant engagement are converted into the eight dimensions listed above using a scoring algorithm. Using this scale, the respondent's health is

transformed from zero to 100, where 0 indicates the worst possible health and 100 indicates the best possible health for the respondent [21].

The initial adapted QoL questionnaire combined the SF-36 questionnaire with general information about the dwelling, such as the property type, size, age, materials of the property and thermal comfort questions related to environmental conditions, such as temperature, relative humidity, ventilation, lighting, noise level and air quality, as well as questions regarding energy use at home and fuel poverty.

After several rounds of discussions, a shorter version of the QoL questionnaire was subsequently developed with property information pre-supplied by the RSLs and with reduced room options for some questions to improve occupant completion of the questionnaire. Besides, to understand occupants' perceptions of their home and energy efficiency as well as their concerns about the retrofit work, additional questions have been made by RSLs and attached to the end of the QoL questionnaire. Therefore, the final version of the QoL hybrid SF-36 questionnaire (HSF36) consists of four parts including occupant general information, indoor comfort and energy use at home, health and wellbeing (SF-36), and additional questions related to retrofit work and energy efficiency.

3.2 Case Study for Occupant QoL Engagement

Pobl Housing Group [22] and Valleys to Coast [23] are two of the 25 RSL partners in the Sero Life OR project provided case studies on two sites (Site A and Site B) totalling 40 dwellings, where most occupants are deemed to be in fuel poverty, i.e., 10% of household income is spent on heating [24]. Several meetings were held with both RSL partners in 2022 to review the HSF-36 questionnaire, leading to further refinement of the questionnaire entitled HSFv2-36 questionnaire. There are four sections covering occupant general information, indoor comfort including lighting and energy use, health and wellbeing, and impacts of retrofit work on daily living.

To commence engagement with the 40 households an information letter was sent to all dwellings by the RSL partners, introducing the OR project, the authors of this paper and the QoL survey. Due to Covid-19, a risk assessment was completed before permission was granted to commence the face-to-face occupant engagement process. The authors undertook visits to the 40 dwellings on several occasions in March and April 2022, at Site A to collate a picture of the dwellings and the occupants. During these visits occupants were offered several data collection options: structured face-to-face interviews (three agreed), postal questionnaires or email, or phone interviews. Ten occupants requested the questionnaire via email, and six by post. Site B residents were contacted directly by the RSL and arranged the face-to-face interview.

To increase the number of respondents the engagement methods were refined, including converting the questionnaire so that it could be completed online through a web-based survey software Qualtrics [25], which was emailed by both RSL partners to any remaining occupants in April 2022.

4 Results

4.1 Participants

Through the occupant engagement, a total of nine information-rich face-to-face interviews across two sites (Site A: n=4; Site B: n=5) were conducted between March and May 2022. However, one occupant at Site A withdrew in May 2022. Most participants were 55 years old or older. The interviews lasted between 45 minutes and one hour 55 minutes, and an average of 50 mins. Two online surveys were received in April 2022 through Qualtrics. Therefore, data from ten households involved in the pilot study are presented in this paper. All the dwellings at Site A (RSL1) are pre-retrofit, and for Site B (RSL2) are post retrofit with a range of retrofit measures including external wall insulation (EWI), loft insulation, rood mounted solar photovoltaic, and door and window replacements. The heating provided at Site A is coal-fired with immersion heaters for hot water, and bottled gas, while mains natural gas central heating with electric showers were used for all properties at Site B. The participants who responded to the data collection options are listed in Table 1.

Table 1. Basic Information of QoL survey respondents

Site	Occu- pant	Sex	Age group	property type	Bed- room/s	Pre/Post retrofit	Survey type
A	A1	F	65+	Semi-detached house	2	pre	Face-to-face
	A2	M	55-64	Semi-detached house	2	pre	Face-to-face
	A3	M	65+	Semi-detached house	2	pre	Face-to-face
	A4	F	45-54	Semi-detached house	2	pre	Online
B	B1	F	45-54	Mid Terrace house	3	post	Face-to-face
	B2	F	65+	Mid Terrace house	3	post	Face-to-face
	B3	M	65+	Flat	1	post	Face-to-face
	B4	M	65+	Flat	1	post	Face-to-face
	B5	M	65+	Flat	2	post	Face-to-face
	B6	F	65+	Mid Terrace house	3	post	Online

4.2 RAND Analysis and Data Interpretation

The RAND scoring system [26] was used for the interpretation of occupant health and well-being results from the pilot study. Currently, the RAND system is considered as the most widely used survey instrument for gauging health related QoL (HRQoL) [27]. RAND provides a useful matrix for interpreting each of the eight concepts, and also to weigh individual occupants in comparison to each other. RAND has two steps. First, numeral values are recoded according to the scoring key. All items are scored

from 0 to 100, with a higher score indicating a healthier state. Scores represent the percentage of the total possible score achieved. Second, the eight scale scores are calculated by averaging the items within the same scale [ibid]. Therefore, scale scores represent the average of the answers provided for all questions in the scale. For the data analysis, qualitative content analysis was applied for summaries of the interview data, combined with RAND analysis to evaluate the relationship between indoor environment, fuel poverty, energy use habits, and occupant health and well-being.

Due to the small number of participants completing the pilot surveys, the data was analysed using descriptive statistics and the results were interpreted on an individual basis. However, there are some differences in overall trends from the SF-36 results.

Fig. 1 and Fig. 2 below illustrate the comparisons of SF-36 subscale scores of occupants pre-retrofit (Site A) and post-retrofit (Site B).

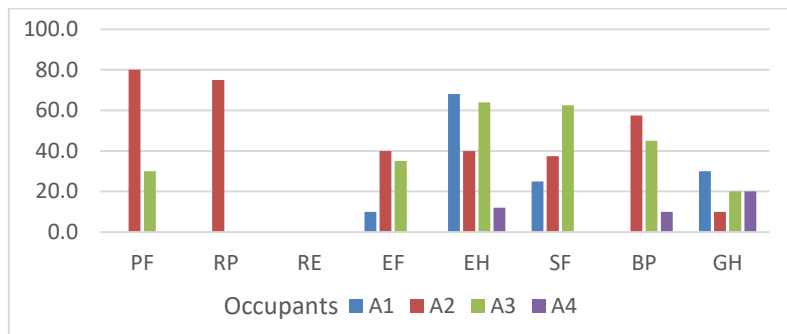


Fig. 1. Comparisons of SF-36 subscale scores of four occupants in Site A. PF = Physical Functioning, RP = Role Limitations due to physical health, RE = Role Limitations due to emotional problems, EF = Physical energy and fatigue, EH = Emotional health and well-being, SF = Social Functioning, BP = Bodily Pain, GH = General Health.

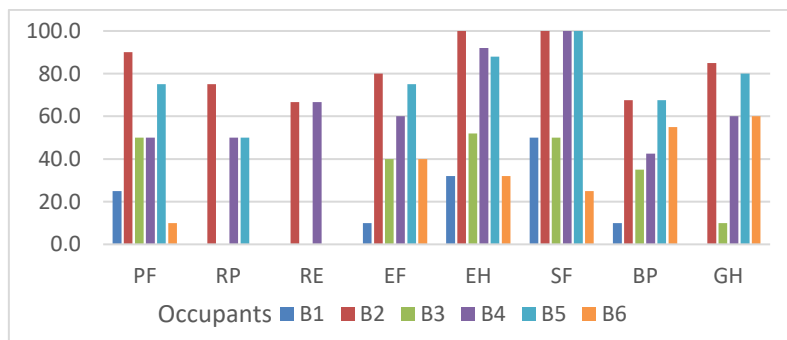


Fig. 2. Comparisons of SF-36 subscale scores of six occupants in Site B. PF = Physical Functioning, RP = Role Limitations due to physical health, RE = Role Limitations due to emotional problems, EF = Physical energy and fatigue, EH = Emotional health and well-being, SF = Social Functioning, BP = Bodily Pain, GH = General Health.

As can be seen from Fig. 1 and 2 above, the subscale scores of the post-retrofit occupants are generally higher than the pre-retrofit occupants at a group level. Meanwhile, on questions related to energy use, comfort and fuel poverty, post-retrofit Site B respondents generally responded more positively and scored higher on comfort satisfaction than pre-retrofit Site A respondents.

At an individual level, from the face-to-face interview data, Occupant A3 indicated they have two electric convector heaters as supplementary space heating and does not ventilate often in winter. A3's comfort satisfaction score is two for room temperature and three for RH, where the SF-36 result shows that A3 has lower subscale scores in RP, RE and GH. Occupant B3 also has lower subscale scores in RP, RE and GH, and comfort satisfaction scores across room temperature and humidity are three and two, respectively. B3 reported damp walls in the bedroom, condensation and mould in the bathroom and bedroom. Although different people's perception of temperature and RH is subjective, this finding may link poor housing temperature and RH to negative impacts on occupants' physical health.

Nearly all households surveyed were in fuel poverty [24]. The data from A4 and B6 are both collected through the online questionnaire. Their subscale scores in RE, EH and SF were lower than other occupants. For the energy use questions, they both responded by indicating they only activated the space heating when feeling cold and deactivate when leaving their homes. They also sacrificed other living options to save on heating bills. This finding may suggest that fuel poverty affects the mental health and general health of occupants to a certain extent.

For the occupants of the pre-retrofit Site A, only the dwelling occupied by A4 was installed with a smart meter. Most occupants did not understand how smart meters operate and thought it would consume more electricity than a conventional meter. In the post-retrofit Site B, all the residents who participated in the QoL survey had installed smart meters and indicated they can view and manage the energy use through it, which has also changed how they live in their homes to use less energy.

Occupants also expressed concerns about the retrofit work, for example Resident A3 pointed out that his furniture might be damaged if moved to accommodate the retrofit being undertaken. From the pilot study of occupant engagement, the online questionnaire had a lower response rate, and produced less information than the face-to-face interviews.

5 Discussion

The occupant engagement process provided an opportunity to discuss how occupants could benefit from the retrofitted home such as eradicating fuel poverty by considerably reducing energy use, improving occupant's comfort and QoL. Furthermore, occupant participation in the entire retrofit process will result in a better outcome after the retrofitted home is in use, thus improving the overall occupant QoL.

Occupant engagement is a complex and challenging process with many uncertainties. Even though the RSL's had had sent out information letters introducing the authors, the research project and the dates when face to face interviews would take place

some occupants were surprised that they would be expected to have a physical face to face interview. The legacy of the Covid19 pandemic when social gatherings were prohibited could be one reason for the lack of occupant engagement. So, for the next steps in occupant engagement the authors and RSL's will also include other data collection and occupant engagement strategies, such as community meetings and welcoming occupants to empty properties that have their retrofit work completed prior to occupied dwellings as a form of 'living lab'. For the latter occupants would be invited to spend some time in the retrofitted dwellings to experience at first hand the retrofit improvements, with increased comfort and reduced energy use.

The occupant who withdrew did so as they did not want any disturbance to her living pattern during the retrofit works. So, relocating occupants to alternative accommodation during the retrofit work is under consideration.

By combining the RAND analysis of the SF-36 results with the interpretation of the face-to-face interview data, researchers will be able to understand the relationship between the physical and mental health of occupants and the internal environment of the housing as well as whether the retrofit affect occupant thermal comfort, energy use, and health and well-being.

A post-retrofit survey will be conducted upon completion of the retrofit work. In addition, environmental conditions will be monitored on site before, during and after the interview. By doing this, the environmental condition data including temperature, relative humidity, ventilation, lighting, air quality and solar radiation, etc. will be collected and compared with the interview results in order to evaluate the actual performance of buildings and their component parts, and whether they meet the predicted expectations.

6 Acknowledgements

The research has been supported by the Welsh Government funded Optimised Retrofit (one) programme, managed by Pobl Housing Association and Sero Life. Thanks, are also given to the staff from Pobl and Valleys to Coast RSL's that manage and owns the 40 dwelling case studies, and to the occupants that engaged with the research team.

7 Conclusion

This paper has discussed the context of the Optimised Retrofit project and the pilot study of the SF36 questionnaire and plan for the next stage. The gaps in knowledge, the process and the challenges of the occupant engagement have been discussed. The pilot study from two RSLs pre-retrofit and post-retrofit as well as the development of hybrid SF36 questionnaire and how the data were analysed through RAND analysis were presented. Through the pilot study, it can be concluded that the method from pilot study can be used to understand the link between the physical and mental health of occupants and the internal environment of the housing, and whether the retrofit has positive impacts on occupant thermal comfort, energy use, and health and well-being.

References

1. Welsh Government. Optimised RetroFit Programme. <https://gov.wales/optimised-retrofit-programme> (2021), last accessed 2022/06/10.
2. Sero Life. The Future – Optimised Retrofit. <https://www.optimised-retrofit.wales/> (2020), last accessed 2022/06/10.
3. Atkinson, J. Littlewood, J. R. Geens, A. J. Karani, G. Relieving fuel poverty in Wales with external wall insulation. *Journal of Engineering Sustainability*. Vol. 170 Issue 2, April 2017, pp. 93-101. <https://doi.org/10.1680/jensu.15.00064> (2016).
4. Jahic, D. Littlewood, J. R. Karani, G. Atkinson, J. Bolton, D. Evaluating occupant wellbeing in retrofitted dwellings with the short form 36 questionnaire. Chapter 35. In: SEB18, Smart Innovation, Systems and Technologies, Springer. Vol. 131. https://link.springer.com/chapter/10.1007/978-3-030-04293-6_35 (2019).
5. IPCC. IPCC Sixth Assessment Report – Impacts, Adaptation and Vulnerability. <https://www.ipcc.ch/report/ar6/wg2/> (2022).
6. UK Government. UK enshrines new target in law to slash emissions by 78% by 2035. <https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035>, last accessed 2022/02/02.
7. Welsh Government. Net Zero Wales. <https://gov.wales/net-zero-wales> (2021).
8. United Nations Environment Programme. 2021 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Global Alliance for Buildings and Construction (2021).
9. ONS. UK local authority carbon dioxide emissions estimates 2019. Department for Business, Energy & Industrial Strategy, p.1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/996056/2005-19-local-authority-co2-emissions-statistical-release.pdf. London (2021).
10. National Statistics. Dwelling Stock Estimates for Wales, 2019-2020. <https://statswales.gov.wales/Catalogue/Housing/Dwelling-Stock-Estimates/dwellingstockestimatespercentages-by-year-tenure>. last accessed 2022/02/02.
11. Littlewood, J. R., Karani, G., Atkinson, J., Bolton, D., Geens, A. J., & Jahic, D. Introduction to a Wales project for evaluating residential retrofit measures and impacts on energy

performance, occupant fuel poverty, health and thermal comfort. *Energy Procedia*, 134, 835-844 (2017).

12. British Foreign Policy Group. COVID-19 Timeline. <https://bfpgrp.co.uk/2020/04/covid-19-timeline/>, last accessed 2022/06/10

13. ONS, 2020 UK greenhouse gas emissions, provisional figures. Department for Business, Energy & Industrial Strategy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972583/2020_Provisional_emissions_statistics_report.pdf. London (2021).

14. Jones, P., Li, X., Perisoglou, E., & Patterson, J. Five energy retrofit houses in South Wales. *Energy and Buildings*, 154, 335-342 (2017).

15. Welsh Government. Written Statement: The Optimised Retrofit Programme 2020-21. In: <https://gov.wales/written-statement-optimised-retrofit-programme-2020-21>, last accessed 2022/02/04.

16. Brown, D., Jaccarini, C., Kumar, C., & Madge, C. Financing Wales' Housing Decarbonisation. <https://neweconomics.org/uploads/files/Financing-Wales-Housing-Decarbonisation.pdf> (2021).

17. Littlewood, J. R. Smallwood, I. In-construction tests show rapid smoke spread across dwellings. *Journal of Engineering Sustainability*. Volume 170 Issue 2, March 2017, pp. 102-112. Link: Themed issue on sustainability in energy and buildings – part 2. <https://doi.org/10.1680/jensu.15.00063> (2017).

18. Littlewood, J. R. Alam, M. Goodhew, S. A new methodology for the selective measurement of building performance and safety. *Energy Procedia*, March. Vol. 111. pp. 338-346. <https://www.sciencedirect.com/science/article/pii/S1876610217302254> (2017).

19. Rand Health: 36-Item Short Form Survey Instrument (SF-36). https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form.html (1969).

20. Ware Jr, John E., and Cathy Donald Sherbourne. "The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection." *Medical care*: 473-483 (1992).

21. Hays, R.D., & Shapiro, M.F. "An Overview of Generic Health-Related Quality of Life Measures for HIV Research," *Quality of Life Research*. 1:91-97, (1992).

22. Pobl Group. Welcome to Pobl. <https://www.poblgroup.co.uk/>, last accessed 2022/06/10.

23. Valleys to Coast. Welcome to Valleys to Coast. <https://www.valleystocoast.wales/>, last accessed 2022/06/10.

24. Age Cymru. Public Policy Statement - Fuel poverty. <https://www.ageuk.org.uk/globalassets/age-cymru/documents/policy/public-policy-statements/fuel-poverty-policy-statement---october-2017.pdf> (2017).

25. Qualtrics XM. <https://www.qualtrics.com/uk/experience-management/>, last accessed 2022/04/28.

26. 36-Item Short Form Survey (SF-36) Scoring Instructions. https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form/scoring.html (1969). Last accessed 2022/06/10.

27. Ron, D Hays & Leo, S Morales. The RAND-36 measure of health-related quality of life, *Annals of Medicine*, 33:5, 350-357, DOI: 10.3109/07853890109002089 (2001).