SF-36 health survey, Indoor Environment and Housing Renovation

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Abstract The focus of the study was the effect of the renovation of the housing within the study area . The study population were all privately owned households within the Riverside Renewal Area in Cardiff, Wales, that had been planned for renovation within the period of the study. Subjects were all occupants of households recruited to the study, with detailed SF-36 data being collected on household members.

The objective was to recruit and monitor a cohort of households every winter approximately a year before renovation was due as the control group, and then monitor them again prior to renovation as the pre-renovation group, and finally a minimum of six months following renovation as the post-renovation group. The SF-36 enables people to describe their health status from their own perspective. The SF-36 was used to compare the health status of the different residents pre-renovation and post-renovation. The SF-36 questionnaire was divided into a series of health and wellbeing categories and the answers were plotted on a 100-point scale. High scores were associated with good health, and low scores with poor health.

The indoor environment analysis was centred on the change in 7 parameters. Paired data was available for 37 households for pre-renovation and post-renovation environmental monitoring. The analysis of the paired t-test data determined that there was a significant change in 5 of the 8 SF-36 parameters post renovation. Correlations were drawn between environmental data variables including temperature and humidity with measures of indoor air pollutants and dampness. Paired sample t-tests were conducted for pre-renovation and post- renovation variables, and a significant improvement in both the indoor environment and householder health was determined.

The benefits derived from setting up a multi-disciplinary project team drawn upon from different backgrounds, was from the outset a significant value to the implementation and outcome of such a health gain study. Evaluation of the data that was collected has lead to the conclusion that enrolment of a larger group of paired pre- and post renovation households would have been highly beneficial. The lack of published data within this field means that the small number of houses on which data is available from the Riverside study represents one of the principal datasets of this kind currently available.

Key-words: SF36, Indoor parameters, Health, Renewal area

1 Introduction

There is a scarcity of studies within the field of the potential health gains that may result from investment in housing [1][2][3] Current literature on housing and health suggests that housing improvements, may lead to improvements in self-reported physical and mental health with a decrease in symptoms and use of health services[4][5][6][7]. However, many of these observations are based on anecdote, or on small -scale observation studies.

Experimental studies of the health impacts of housing would provide the strongest evidence of a relationship between housing improvement and health gains. However, few studies have attempted to do this, possibly due to methodological difficulties and political obstacles. This lack of current research points to a specific area which should be examined further and integrated with future housing renovation projects at the policy and planning stage. Preferably, a holistic, multidisciplinary approach combining quantitative and qualitative methods would be advantageous.

1.1 Renewal areas

Renewal Areas are government-funded schemes aimed at renovating and revitalising deprived inner city areas. The aim of these schemes is to do more than just repair the fabric of a building; they encompass both social and environmental improvements of an area. Renewal areas are determined by application to the Secretary of State under the Local Government and Housing Act 1989[8]

1.2 South Riverside area

The south Riverside area of Cardiff was declared a Renewal Area in October 1991 following a House Condition Survey carried out by Cardiff City Council in 1989. The area consisted of 2314 dwellings and two commercial centres and is situated within a mile of Cardiff city centre.

Within this part of Riverside, 87% of people lived in private sector accommodation, 92% of homes were unfit, and 40% of households were in receipt of one or more state benefits (figures from 1991 census).[9]

The aim of the housing renewal was to have all the housing in the area structurally sound, double-glazed, central heating installed and with optimum insulation. Indoor facilities were to be upgraded to include a safe supply of hot water, a serviceable inside bathroom with toilet, basin, and shower/bath; a serviceable kitchen with cooker, fridge, cupboard space and sink; mains/battery operated interlinked smoke alarms both upstairs and down, effective locks on outside doors, and a good state of internal decoration.

The extent of renovation undertaken on individual houses varied depending on the state of the building, and in some cases how much money the owner was prepared to spend due to the means tested nature of the grants. The means tested grant facilities were available to ensure that most people could have any necessary work carried out.

Some properties were practically rebuilt with new roofs, floors and staircases, strengthening of external walls and damp proof courses, re-wiring, installation of central heating and double glazing, an indoor bathroom and replacement kitchen. Local area renovation that was non property specific was also undertaken, this included installing traffic calming measures, resurfacing pavements and the replacement of boundary walls and railings at the front of properties.

It has been recognised that the substantial housing renovation, and the environmental improvements that have been undertaken have changed the area cosmetically but it may also affect the character of the community. As the housing quality has improved, it has become a more desirable neighbourhood drawing new people to the area. This has resulted in house prices and rental costs rising, and the possibility of initial residents of the houses being priced out of the area. This may have resulted in them living in poor quality housing somewhere else but comparable to the pre-renovation housing within the riverside area.

2. Methods

The initial study design utilised a quasi-experimental technique which aimed to evaluate indoor environmental parameters both pre-renovation and post-renovation, as well as obtaining simultaneous data from un-renovated 'control' homes.

The objective was to recruit and monitor a cohort of households every winter approximately a year before renovation was due as the control group, and then monitor them again prior to renovation as the pre-renovation group, and finally a minimum of six months following renovation as the post-renovation group.

The design enabled a progressive programme of data collection following the council renovation schedule of work. Comparisons were made between pre-renovation and post-renovation observations in the same houses. The design of the study enabled comparisons to be made between pre-renovation and post-renovation households, with un-renovated households used as controls over the same period of time. This methodology controlled for the differing confounding effects of weather conditions over consecutive winter periods e.g. unusual weather conditions, influenza epidemics, etc.

All measurements were made during the winter months October to March inclusive, when the greatest changes were expected to occur and ideally over the same two-week period as on previous occasions

Prior to winter time monitoring, an explanatory letter, information leaflet, consent form, screening questionnaire, and reply-paid envelope were hand delivered to all homes due for renovation over the subsequent 18 months.

Table 1. Number of households by year of the study

	Winter 95-96	**Winter 96-97**	**Winter 97-98**	**Winter 98-99**	**Winter 99-00**	**Winter 00-01**	**Total**
Control >=1 year pre-renovation	39	32	26	9	3	-	109
Pre-renovation just before renovation	1	43	25	34	29	9	141
Post-renovation =< 6/12 after renovation	-	-	1	12	8	16	37
Total	40	75	52	55	40	25	287

The SF-36 was designed for use in clinical practice and research, health policy evaluations, and general population surveys. The SF-36 included one multi-item scale that assessed eight health concepts: [10]. The SF-36 included one multi-item scale that assessed eight health concepts:
1) Limitations in physical activities because of health problems
2) Limitations in social activities because of physical or emotional problems
3) Limitations in usual role activities because of physical health problems
4) Bodily pain
5) General mental health (psychological distress and well-being)
6) Limitations in usual role activities because of emotional problems
7) Vitality (energy and fatigue)
8) General health perceptions

The SF-36 was developed for self-administration by persons 14 years and older, or for completion by a trained interviewer in person or by telephone. These properties made the SF-36 an ideal tool for the identification of the eight health concepts and their monitoring over the study period. The SF-36 has been extensively validated in other studies and used as a benchmark for the trial and validation of innovative health measurement tools. [11][12][13][14]

All adults (16 years and over) resident in the household were asked to complete an SF-36 Health Status questionnaire from which the following scores were derived; physical function (PF) score, emotional role (RE) score, general health (GH) score which reflected overall physical and mental health.

The following environmental measurements were carried out by the environmental scientist at all households recruited to the study: Air temperature and relative humidity within the living room was measured continuously for seven consecutive days using a thermohygrograph. [15] Instantaneous air temperature and relative humidity on the first day, and seventh day using a whirling hygrometer. [16]Dampness measured in walls at predetermined sites using a Protimeter. [17]

Concentrations of CO, NO_2 and HCHO measured over 8 hours using small gas monitoring badges that changed colour after filters reached specified concentrations. (Detection limits were 1.0ppm for CO, 0.125ppm for NO_2 and 0.05ppm for HCHO). [18][91][20] Residents were supplied with coloured pictures and asked to record the times at which the colour changes were observed. $PM_{2.5}$ concentrations were measured over eight hours using a Casella particulate sampler. [21]

2.1 Identification of subjects

Subjects were identified by using the electoral register which provided names and addresses within the target area. The council provided additional information relating to addresses within the Riverside Renewal Area and details of houses that had been scheduled for renovation work. The combined use of two sets of address data enabled all houses in the selected area to be contacted, for prospective participation within the study Residents were contacted by post and asked if they would have liked to participate, the replies were classed as the following; Yes, No, No Reply. In the case of No Reply a second postal request was sent out, with the identical classes of reply as the first. In the case of the second no reply, a visit was made to the houses to ask if they were willing to participate in the study. Residents were assured of confidentiality by using a House Hold Number (HHNum), which was a unique identifier for a house which enabled the data to be coded. The houses were visited and data was collected for each of the predetermined control, pre-renovation and post-renovation periods

2. 2 Recruitment difficulties

There were a number of problems with both the initial recruitment of subjects and with the recruitment of the same subjects on subsequent years of the project. The problems were related primarily to the demography (Study of the size, structure, dispersal, and development of human populations) of an urban area undergoing renovation.

The problems were typical of the recruitment of subjects within an urban setting; there was a mobile population of students and middle working class people. These residents would move to the area for short periods of time whilst renting a property and would then leave the area before the following year of the study.

There were initial difficulties with recruitment of subjects with a language other than English as a first language; project information was made available in the most popular languages for the area. This information was made available via a tick boxed question in the specified language on the initial project information sent to households.

Initial recruitment was fraught with commitment problems due to the requirement of a number of visits over 3 separate years. The arrival of new residents to a house also resulted in a lack of interest in the project, as they had not seen the property in a poor condition or been part of the initial recruitment and information program. The initial recruitment of subjects was a time consuming process which required two postal requests and a minimum of one visit to gain approval for initial inclusion within the study.

There was an additional problem with missed or cancelled appointments, and this was found to be a major waste of resources, the most effective remediation was to contact the resident by telephone before visiting. The collection of the data for each winter period was also time consuming as 3 visits were required for each household to collect the environmental data over the period of a week.

There was a perception that due to council involvement information may have been passed onto government welfare providers; consequently some people were unwilling to participate. In certain instances these concerns regarding confidentiality were believed not to be a legitimate concern, especially after explanation of the house hold numbering system. There were numerous reasons for the lack of enthusiasm for participation due to information being collected on the people that are living in a dwelling.

The confidentiality of data that was collected was ensured, as data that was collected for the project was only used for that purpose. Data that was collected was coded and was not made widely available within the public domain; additionally data was not passed on to council welfare providers.

The renovation of the housing within the riverside renewal area was a pre planned project that was widely publicised within the area. An advantage of this was that residents were willing to co-operate with the riverside project as they were aware of the issue of poor quality housing. Subsequently, there was a willingness within the community to participate pre-renovation. This willingness to participate was not present post-renovation as they had nothing to gain from assisting the project, whilst pre-renovation residents could show the poor condition of the property.

The schedule for renovation altered to suit the political environment within the funding organisations. This led to problems with advance planning of which households to monitor on specific dates, and the subsequent problems relating to authorisation from the householders. This particular issue was only partially overcome by working closely with the council and by expedient response by the project team to changes within the housing renovation program.

3. Results and analysis

3. 1 Recruitment data

For the household study, data was available on 287 households comprising of 887 occupants. Data from 109 households were available for control purposes, from 141 households pre-renovation and from 37 households post-renovation. Due to the nature of the study, data was collected from some households on a number of occasions.

Data collected was available for use as controls and at pre-renovation and a limited number of households for post-renovation stages. The number of households recruited varied for different years of the study; this depended on the level of renovation that had been conducted at each particular winter period, the willingness of participants and the planned data collection. The number of households for each group and the corresponding winter period are shown in table 1.

Table 2.Initia analysis for humidity and temperature.

Parameter	Pre-renovation		Post-renovation	
	n	Mean	n	Mean
7 day minimum humidity	36	53.5	35	49.5
7 day maximum humidity	36	77.6	35	72.0
7 day humidity range	36	24.1	35	23.6
7 day temperature minimum	36	15.0	35	16.1
7 day temperature maximum	36	23.1	35	22.7
7 day temperature range	36	8.1	35	7.3

Table 3.Initial analysis for damp.

Parameter	Pre-renovation		Post-renovation	
	n	Mean	n	Mean
Living room dampness internal wall	37	11.7	37	10.5
Living room dampness external wall	37	14.2	37	13.1
Kitchen dampness internal wall	36	11.0	36	9.9
Kitchen dampness external wall	36	19.5	36	12.0
Bedroom dampness internal wall	36	10.5	37	9.6
Bedroom dampness external wall	36	14.5	36	12.2

Table 4.Initial analysis for air pollution.

Parameter	Pre-renovation		Post-renovation	
	n	Mean	n	Mean
$PM_{2.5}$ concentration μgm^{-3}	34	328.4	36	322.3
Carbon monoxide concentration (ppm)	17	3.2	3	1.4
Formaldehyde concentration (ppm)	1	0.3	1	0.1
Nitrogen dioxide concentration (ppm)	1	0.5	0	-

The data collected was paired for both pre- and post renovation data sets, and 37 cases were found. There were 141 cases of pre renovation data, although only 37 of these were matched with post renovation data. Moreover, all the post renovation data was matched for pre renovation data enabling the most complete analysis of the post-renovation data that was collected. The number of samples (n = 37) available for this study compared favourably with other analyses, within this field of research.

There were 17 cases of carbon monoxide pre-renovation and 3 cases post-renovation., the method of monitoring had a minimum detectable limit of 1ppm.[22] There was only one case of formaldehyde detected both pre- renovation and one case post-renovation although the cases were not matched, the method of monitoring had a minimum detectable limit of 0.05ppm.[23]

There was only one case of nitrogen dioxide pre-renovation and there were no cases recorded post-renovation, the method of monitoring had a minimum detectable limit of 0.125ppm. [24] The number of cases for each environmental parameter varied from a single observation to a complete set of 37 observations, the spread of date and the measure of the central tendency of the data was calculated for both pre-renovation (table 5.) and post renovation (table 6).

3.2 Pearson's correlations for humidity and temperature

The Pearson's correlations that were undertaken identified a number of significant correlations. Pre-renovation minimum humidity was found to correlate with maximum humidity (r: 0.65, p<0.0001), a similar correlation occurred with post-renovation data (r: 0.49, p=0.0027). The humidity range had a strong correlation with the temperature range both pre and post-renovation (r: 0.57, p=0.0003) (r: 0.47, p=0.0047).

There was found to be an inverse correlation between minimum humidity and maximum temperature both pre-renovation (r:-0.51, p=0.0015) and post-renovation (r: -0.41, p=0.0132). Maximum humidity and humidity range positively correlated for pre-renovation (r: 0.52, p=0.0011) and post-renovation (r: 0.35, p=0.0410). The correlation between maximum humidity and minimum temperature both pre-renovation (r: -0.46, p=0.0044) and post renovation (r:-0.44, p=0.0083) were very similar and of an inverse nature, this meant that houses that had a high minimum temperature had a low maximum humidity.

There was found to be a negative correlation There was a correlation between internal dampness of the living room and external dampness of the bedroom, both pre-renovation (r:0.52, p=0.0013) and post-renovation (r:0.39, p=0.0199). Living room external data correlated with bedroom internal data both pre-renovation (r:0.54, p=0.0007) and post-renovation (r:0.42, p=0.0089), although there was a weaker correlation for living room external data and bedroom external data pre-renovation (r:0.32, p=0.0549) and no correlation post renovation (r:0.02, p=0.9199).

3.3 Pearson's correlations for temperature and dampness

There was a strong negative correlation of minimum temperature and dampness in the exterior bedroom wall pre-renovation (r:-054, p=0.0009), this negative correlation still existed post-renovation although it was far weaker and less significant (r:-0.27, p=0.1187).

3.4 Pearson's correlations for room dampness

The average WME% values were compared for all internal and external measurement locations for the 3 rooms. The strongest correlation was found for dampness within the internal bedroom wall and the external bedroom wall, the r statistic was very similar for both pre-renovation (r: 0.64, p<0.0001) and post-renovation (r:0.61, p<0.0001) with a very high significance.

Correlations were also found for internal and external dampness within the living room, with the pre-renovation correlation being stronger and more significant (r:0.58, p=0.0002) than the post renovation correlation (r:0.27, p=0.1058). Similar correlations were determined for the kitchen dampness data between internal and external walls, with a strong pre-renovation correlation (r:0.47, p=0.0035) and post-renovation no significant correlation (r:0.007, p=0.6793).

There were other correlations found between different rooms for average WME%, but as with the internal and external room comparisons the correlations were weaker and less significant post renovation. The strongest of these correlations was internal dampness in the living room with internal dampness in the bedroom, which had a pre-renovation correlation that was visually identifiable on an x-y plot (r:0.56, p=0.0004) and had a less significant post renovation correlation (r:0.38, p=0.0198). There was a correlation between internal dampness of the living room and external dampness of the bedroom, both pre-renovation (r:0.52, p=0.0013) and post-renovation (r:0.39, p=0.0199). Living room external data correlated with bedroom internal data both pre-renovation (r:0.54, p=0.0007) and post-renovation (r:0.42, p=0.0089), although there was a weaker correlation for living room external data and bedroom external data pre-renovation (r:0.32, p=0.0549) and no correlation post renovation (r:0.02, p=0.9199).

3.5 Pearson's correlations dampness and gaseous

The only significant correlation that was identified was for kitchen internal dampness and carbon monoxide concentration pre-renovation (r:0.52, p=0.0373), this correlation was not present post renovation (r:-0.99, p=0.1014) or significant due to the p value and sample size

Table 5. Pre-renovation environmental parameters.

Parameter pre-renovation	**n**	**Mean**	**Median**	**Mode**	**SD**	**SE**	**95% CI of Mean**
Minimum Humidity	36	53.5	55.0	40.0	10.0	1.7	50.1 to 56.9
Maximum Humidity	36	77.6	79.0	87.0	11.2	1.9	73.8 to 81.4
Humidity Range	36	24.1	22.5	17.0	8.9	1.5	21.1 to 27.1
Minimum Temperature	36	15.0	15.5	16.0	3.1	0.5	13.9 to 16.0
Maximum Temperature	36	23.1	23.0	22.0	3.3	0.6	22.0 to 24.2
Temperature Range	36	8.1	7.5	7.0	3.0	0.5	7.1 to 9.1
Dampness Living room Internal	37	11.7	10.3	8.6	5.7	0.9	9.8 to 13.6
Dampness Living room External	37	14.2	13.5	11.5	5.2	0.8	12.5 to 15.9
Dampness Kitchen Internal	36	11.0	11.0	13.6	4.6	0.8	9.5 to 12.6
Dampness Kitchen External	36	19.5	14.9	11.6	12.7	2.1	15.2 to 23.8
Dampness Bedroom Internal	36	10.5	10.9	9.6	3.3	0.6	9.3 to 11.6
Dampness Bedroom External	36	14.5	13.1	11.3	7.8	1.3	11.8 to 17.1
$PM_{2.5}$ Concentration	34	328.4	303.3	208.3	188.4	32.3	262.7 to 394.2
Carbon monoxide concentration	17	3.2	1.4	1.0	3.6	0.9	1.4 to 5.1
Formaldehyde concentration	1	-	-		-	-	- to -
Nitrogen Dioxide concentration	1	-	-		-	-	- to -

Table 6. Post-renovation environmental parameters.

Parameter post-renovation	n	Mean	Median	Mode	SD	SE	95% CI of Mean
Minimum Humidity	35	49.5	50.0	39.0	10.6	1.8	45.9 to 53.2
Maximum Humidity	35	72.0	73.0	74.0	10.9	1.8	68.3 to 75.8
Humidity Range	35	23.6	23.0	21.0	8.0	1.3	20.9 to 26.4
Minimum Temperature	35	16.1	16.5	17.5	2.9	0.5	15.1 to 17.1
Maximum Temperature	35	22.7	23.0	23.0	3.2	0.5	21.6 to 23.8
Temperature Range	35	7.3	7.0	5.0	3.1	0.5	6.2 to 8.4
Dampness Living room Internal	37	10.5	9.8	9.0	3.1	0.5	9.4 to 11.5
Dampness Living room External	37	13.1	12.3	10.5	4.2	0.7	11.7 to 14.5
Dampness Kitchen Internal	36	9.9	9.4	6.2	4.1	0.7	8.6 to 11.3
Dampness Kitchen External	36	12.0	11.8	12.3	4.3	0.7	10.6 to 13.5
Dampness Bedroom Internal	37	9.6	9.7	10.3	2.3	0.4	8.8 to 10.4
Dampness Bedroom External	36	12.2	10.7	10.3	6.0	1.0	10.2 to 14.2
PM2.5 Concentration	36	322.3	190.7	104.2	370.5	61.7	197.0 to 447.7
Carbon monoxide concentration	3	1.4	1.2	-	0.8	0.5	0.6 to 3.4
Formaldehyde concentration	1	-	-	-	-	-	- to -
Nitrogen Dioxide concentration	0	-	-	-	-	-	- to -

Table 7. Mean values calculated for SF-36 parameters

Parameter	Pre-renovation	Post-renovation
Physical functioning	66.9	65.1
Role – physical	62.7	65.8
Bodily pain	54.3	57.5
General health	56.4	56.5
Vitality	53.9	53.2
Social functioning	66.3	70.8
Role – emotional	61.5	71.9
Mental health	68.7	70.5

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3.6 Environmental t-test analysis

Paired sample t-tests were conducted for pre-renovation and post- renovation variables. The t statistic was compared with the 2-tailed p value, and if the t-statistic was greater than the critical value then H0 the null hypothesis was rejected. Consequently, HA was accepted thus there was a difference between the means of the two samples.
A paired t-test was applicable as the two means were dependent, as in the case of the same individual measured at two different times (pre-renovation and post-renovation pared cases). The use of the two-tailed test for significance implied that the change from pre-renovation to post-renovation could have been either an increase or a decrease. The only samples that were found not to be significantly different pre and post renovation were maximum temperature which

had a decrease of 0.4°C post renovation, and the $PM_{2.5}$ concentration which decreased by 16 μgm^3

3.7 Humidity

The minimum humidity post renovation decreased, from 53.5 %RH to 49.5 %RH (t:1.89, p=0.0675). The maximum humidity decreased post renovation by from 78 %RH to 72 %RH (t:2.64, p=0.0123). A decrease in humidity range was observed although this was by 0.8 %RH and had a weak significance (t:0.69, p=0.4943).

3.8 Temperature

The minimum temperature was found to increase post renovation by 1.1°C (t:2.15, p=0.0385), and temperature range decreased by 0.8°C (t:1.50,p=0.4134). No significant change was determined for the maximum temperature.

3.9 Dampness

The dampness within the living room internal wall decreased by 1.3 %WME (t:1.58, p=0.1234), the decrease also occurred within the external wall by 1.1 %WME (t:1.42, p=0.1651).

The dampness within the kitchen internal wall decreased by 1.3 %WME post renovation (t:1.37, p=0.1803), an far larger decrease was observed within the external wall of 7.8 %WME (t:3.65, p=0.0009).

A similar pattern was found for the internal and external walls of the bedroom. The internal wall was found to have a decrease of 0.9 %WME (t: 1.4, p=0.1707) and the external wall had a decrease of 2.6 %WME (t:3.13, p=0.0035)

3.10 Gaseous Analysis

Carbon monoxide was found to decrease post renovation by 1.7 ppm (t: 0.82, p=0.4996) although the post renovation cases were small (n=3) and consequently the significance of this result was debateable. What may have been more significant was the decrease of 14 cases post renovation, as pre-renovation there were 17 cases.

3.11 SF-36 analysis

The data collected was matched for both pre-renovation and post-renovation data sets, and 37 cases were found. The 37 household cases were matched with the respective occupants that SF-36 questionnaire data had been collected on.

Data was available for baseline comparison in the form of the control data, although useful for multivariable analysis it was believed that the complexity of the analysis was outside the realms of this research. Subsequently, the analysis of the data was concentrated upon the pre-renovation and post-renovation data that had been collected for subjects within the households which had been used for the household data analysis. The data that was collected using the SF-36 questionnaire was collected by the research nurse working for the riverside project.

The initial analysis of the data calculated the mean of each parameter that had been collected using the SF-36 questionnaire, shown in table 7

Subsequent analysis calculated the measure of central tendency of the data and the data spread for both pre-renovation (table 8.) and post-renovation (table 9.).

3.12 SF-36 paired t-test

The only samples that were found not to be significantly different pre and post renovation were physical function, vitality, role emotional.

The analysis of the paired t-test data determined that there was a change in 5 of the 8 SF-36 parameters post-renovation, although these changes had a very weak significance due primarily to the small sample size. The effect of the small sample size was investigated as was the weak power of the study.

The role–physical score increased from 61 to 67 (t:0.79, p=0.4352), as did body pain which increased from 54 to 58 (t:0.75, 0.4564). The SF-36 score for general health increased from 56 pre-renovation to 59 post renovation (t:0.98, p=0.3350), social functioning increased from 67 pre-renovation to 72 post-renovation (t:1.20, p=0.2385). The SF-36 score for mental health pre-renovation was 69 and had increased post renovation to 71 (t:0.76, p=0.4553). These results have shown that post-renovation the people perceive their own health to have improved in the 5 categories described, and there is no significant change in the other 3 categories. These results were noteworthy as no worsening of health was perceived by the residents post renovation and only health.

4.0 Conclusions

Research was conducted as described within the measurement protocol to fulfil the project objectives and subsequently the aim of the research. Correlations were drawn between environmental data variables including temperature and humidity with measures of indoor air pollutants and dampness, there were significant findings with scope for further research.

The following are the major findings for each parameter studied. Minimum humidity (p=0.07), maximum humidity (p<0.05) decreased significantly post renovation. Minimum temperature was found to increase significantly post-renovation by 1.1°C ($p<0.05$). Dampness decreased within the interior, internal and external walls of the kitchen, living room and a bedroom post-renovation. Significant reductions were in the external wall of the kitchen which decreased by 7.8 WME units ($p<0.05$) and the external wall of the bedroom which decreased by 2.6 WME units ($p<0.05$) Carbon monoxide was found to decrease post-renovation to 3 cases from 17 cases pre-renovation.

Formaldehyde was not found to be a significant indoor pollutant primarily due to the low sensitivity of the monitoring technique. Nitrogen dioxide was found not to be a significant indoor pollutant due to the low sensitivity of the monitoring technique.PM2.5 was found not to be significantly different post renovation. SF-36 results were significantly weak, although they did show that post-renovation, people perceive their own health to have improved in role–physical, body pain, general health, social functioning and for mental health. There were is no significant change in the other 3 categories.

There is an absence of extensive literature that assesses the effectiveness of specific housing improvements on the indoor environment. Basic methods are used to determine the success of investment within housing, such as the satisfaction of residents. [25] The weakness in this field of research necessitates further large scale studies in relation to the change of the indoor environment following housing renovation.

The environmental variables that have been discussed within this work have been shown to be associated with poor health. [26] [27] [28] It is evident that intervention to remove contact with these specific variables would be beneficial initially the individual and consequently the community as a whole.[29] Current research does not however show direct evidence for specific changes within the indoor environment, resulting identifiable health gains. The mechanisms through which specific aspects of housing affect health are extremely complicated, but they do exist. [30]

Evaluation of the data that was collected has lead to the conclusion that enrolment of a larger group of paired pre- and post-renovation households would have been highly beneficial. The lack of published data within this field means that the small number of houses on which data is available from the Riverside study represents one of the principal datasets of this kind currently available.

The undertaking of studies such as this are the most difficult to conduct utilising scientific methodology, as careful judgement is required regarding appropriate study design to minimise the influences of chance, bias and confounding. There is little good research evidence on the potential health gains that may result from investment in housing. Existing literature on housing and health suggests that improvements in self-reported physical and mental health, as well as reductions in symptoms and use of health services, may result from housing improvement.

It is this type of evidence that is likely to be most valuable to policy makers and housing providers, although it is the area where little research has been conducted. Large scale studies that investigate the wider social framework of housing improvements and their comparative efficiency and cost effectiveness are currently required. The improvements in the indoor environment and associated health gains that have been outlined within this research should be utilised as a foundation for similar studies. Further analysis and interpretation of data that has been collected as part of Riverside study is required, as there is a wealth of data that is available for potential analysis, interpretation and dissemination to the wider scientific community.

Ideally, an evaluation of housing renovation such as this should have been planned as an integral component of the policy initiative, which funded the housing renovation. The lack of integration has shown the substantial void that exists between academic research work in the field of housing and health and those involved in public policy decision making, which is lead by the current political agenda.

Table 8 SF-36 pre-renovation data.

SF-36 parameter pre-renovation	n	Mean	Median	Mode	SD	SE	95% CI of Mean
Physical functioning	36	67	68	100	25.2	4.2	58.3 to 75.4
Role – physical	34	63	61	100	35.2	6.0	50.4 to 75.0
Bodily pain	37	54	58	41	23.9	3.9	46.3 to 62.3
General health	34	56	52	30	20.2	3.5	49.4 to 63.5
Vitality	35	54	55	65	18.6	3.1	47.6 to 60.3
Social functioning	35	66	69	75	24.7	4.2	57.9 to 74.8
Role – emotional	34	62	67	100	34.5	5.9	49.5 to 73.6
Mental health	35	69	72	74	14.9	2.5	63.5 to 73.8

Table 9 SF-36 post-renovation data.

SF-36 Parameter post-renovation	n	Mean	Median	Mode	SD	SE	95% CI of Mean
Physical functioning	33	65	68	100	28.4	4.9	55.0 to 75.1
Role – physical	32	66	71	100	37.4	6.6	52.3 to 79.3
Bodily pain	33	57	57	74	22.8	4.0	49.4 to 65.6
General health	32	57	62	72	19.2	3.4	49.6 to 63.5
Vitality	33	53	55	55	16.8	2.9	47.2 to 59.1
Social functioning	33	71	69	63	19.5	3.4	63.9 to 77.7
Role – emotional	31	72	84	100	35.3	6.3	58.9 to 84.8
Mental health	33	70	72	76	15.0	2.6	65.1 to 75.8

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6. *References*

[1] Lotto, R. Assessment methods to improve urban regeneration quality, In Environmental Problems and Development, 2008, eds. Popescu *et al.* , WSEAS publication pp 163-168

[2] Jacobs, D.E., Wilson, J., Dixon, S.L., Smith, J. and Evens, A. The Relationship of Housing and Population Health: A 30-Year Retrospective Analysis *Environ Health Perspect.* 2009 April; 117(4): 597–604.

[3] Ioja, C., Patroescu M., Niculita, L. , Pavelescu, G., Nita, M. and Ioja Assessment methods to improve urban regeneration quality, A., In Environmental Problems and Development, 2008, eds. Popescu *et al.* WSEAS publication pp 163-168

[4] Polcin, D.L. A Model for Sober Housing during Outpatient Treatmen*t J Psychoactive Drugs*, *2009* June; 41(2): 153–161.

[5] Schwarcz, S.K., Hsu,L.C., Vittinghoff,E., Vu,A., Bamberger,J.D., and Katz, M.H. Impact of housing on the survival of persons with AIDS, *BMC Public Health*. 2009; 9: 220. Published online 2009

[6] Bailie R. , Stevens, M., McDonald, E., Brewster, D., and Guthridge, S. Exploring cross-sectional associations between common childhood illness, housing and social conditions in remote Australian Aboriginal communities *BMC Public Health*. 2010; 10: 147

[7] Petticrew, M., Kearns, A., Mason, P., and Hoy, C. The SHARP study: a quantitative and qualitative evaluation of the short-term outcomes of housing and neighbourhood renewal *BMC Public Health* 2009, **9**:415

[8] HMSO, *Local Government and Housing Act 1989 (c. 42)* HMSO and the Queen's printer for Scotland, 1989 ISBN 0105442895.

[9] HMSO. 1991 Census Key Statistics for Cardiff and Wales – Household data. Office for National Statistics (ONS). HMSO and the Queen's printer for Scotland.
[10] War JJ, Sherbourne CD The MOS 36-item short-form health survey (SF-36).I. Conceptual framework and item selection. Medical Care; 30; 473-483
[11] Hoopman,R., Terwee,C.B., Devillé, W., Knol,D.L. and Aaronson, N.K. Evaluation of the psychometric properties of the SF-36 health survey for use among Turkish and Moroccan ethnic minority populations in the Netherlands, *Qual Life Res*. 2009 August; 18(6): 753–764.
[12]. Garratt A, Ruta D, Abdalla M, Buckingham J, Russell I. Short form 36 (SF36) health survey questionnaire: an outcome measure suitable for routine use within the NHS? 1993,*British Medical Journal* 306:1440-4.
[13] Holly E . Syddall,H.E. Martin, H.J., Harwood, R.H., Cooper, C. and Sayer, A.A. The SF-36: a simple, effective measure of mobility-disability for epidemiological studies *J Nutr Health Aging*. 2009 January; 13(1): 57–62
[14] Wang,R., Cheng W., Yanfang Z., Xiaoyan Y., Xiuqiang M., Meijing W., Wenbin L., Zheng G., June Z., and Jia H. Health related quality of life measured by SF-36: a population-based study in Shanghai, China, *BMC Public Health. 2008; 8: 292*.
[15]. Casella CEL, Kempston, Beds. www.casellacel.com, *Model: M109002 Thermohygrograph Deluxe*
[16]. Casella CEL, Kempston, Beds. www.casellacel.com, *Model: 3156/82 Whirling Hygrometer*
[17] PROTIMETER PLC, Meter House, Fieldhouse Lane, Marlow, Bucks, SL7 1LW. Model: mini 111
[18]. Shawcity Ltd, Pioneer Road, Faringdon, Oxfordshire, SN7 7BU
Model: Carbon monoxide SafeAir Badges, Carbon Monoxide detection limit 1.0ppm
[19] Shawcity Ltd, Faringdon, Oxfordshire, Model: SafeAir Nitrogen Dioxide Badges, Nitrogen Dioxide detection limit 0.125ppm
[20]. Shawcity Ltd, Faringdon, Oxfordshire, Model: SafeAir Formaldehyde Badges, Formaldehyde detection limit 0.05ppm
[21]Casella CEL, Kempston, Beds. www.casellacel.com Model: AFC123 personal air sampling pump / filter paper AA .
[22]. Carbon Monoxide Threshold level: 7ppm, Minimum detectable limit (8hrs):1ppm. SafeAir System. (1996), Operating instructions for SafeAir badges. K&M_Environmental Inc, Virginia Beach.
[23] Formaldehyde Threshold level: 0.4ppm, Minimum detectable limit (8hrs):0.05ppm. SafeAir System. (1996), Operating instructions for SafeAir badges. K&M Environmental Inc, Virginia Beach.
[24]. Nitrogen Dioxide Threshold level: 1ppm, Minimum detectable limit (8hrs):0.125ppm. SafeAir System. (1996), Operating instructions for SafeAir badges. K&M Environmental Inc, Virginia Beach.
[25]. Galster, G. Evaluating indicators for housing policy: Residential satisfaction vs marginal improvement priorities. *Social Indicators Research*. 1985,16:415-448
[26]Zhang, J and Smith, KR Household Air Pollution from Coal and Biomass Fuels in China: Measurements, Health Impacts, and Interventions *Environ Health Perspect*. 2007,June; 115(6): 848–855
[27] Zhao Z, Zhang Z, Wang Z , Ferm M, Liang Y, and Norbäck D Asthmatic Symptoms among Pupils in Relation to Winter Indoor and Outdoor Air Pollution in Schools in Taiyuan, China *Environ Health Perspect*. 2008 January; 116(1): 90–97
[28]Indo Y, Miyazaki T, Hikita Y. Sampling methods and residential factors affecting formaldehyde concentration in indoor air. Tohoku *J Exp Med.* Dec; 2001,195(4):227-36
[29] Ahman M, Lundin A, Musabasic V, Soderman E. Health after intervention in a school with moisture problems. *Indoor Air*. 2000,Mar;10(1):57-62.
[30] Wu F, Jacobs D, Mitchell C , Miller D, and Karol MH Improving Indoor Environmental Quality for Public Health: Impediments and Policy Recommendations *Environ Health Perspect.2007,* June; 115(6): 953–957

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