Health Impacts of the Healthy Housing Programme on Housing New Zealand Tenants: 2004-2008

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1.   Executive Summary

Introduction

This project aims to assess the health impacts of the Housing New Zealand Healthy Housing Programme (HHP) using the established Social Housing Outcomes Worth (SHOW) Study. The HHP is one of three major Housing New Zealand programmes concerned with improving living conditions for Housing New Zealand households and communities (the others being housing modernisation and community renewal).

The HHP began modifying significant numbers of Housing New Zealand properties in Auckland and Northland in 2003 and was extended to Wellington in 2008. This report examines outcomes for houses modified in Auckland and Northland in the 2004-2008 period (ie households who completed the HHP over that period).

Methods

This study is based on data collected by Housing New Zealand as part of its routine business operations. Information on housing applicants was recorded on a Needs Assessment (NA) record form. Most housing tenants self-completed an annual Income Related Rent (IRR) application form at least once a year. The Housing New Zealand data were forwarded to the New Zealand Ministry of Health (MoH) for matching to their national health index number (NHI). The data were then anonymised (including encrypting the NHI) and passed to researchers at the University of Otago, Wellington for analysis. Researchers linked cases to their hospitalisation records using the encrypted NHI.

The analysis was based entirely on principal diagnosis of the hospital admission (coded using International Statistical Classification of Diseases and Related Health Problems Version 10, ICD.10). The standard filter, which was applied to most hospitalalisations, excluded private hospital cases, overseas visitors, hospital transfers, hospital waiting list cases, day cases, and readmissions within a month. Hospitalisations were considered in several categories, starting with Total acute and arranged admissions, then in categories which we consider provide plausible indicators for measuring the health effects of housing conditions, notably: Potentially Avoidable Hospitalisations (PAH), Housing Related Potentially Avoidable Hospitalisations (HR-PAH), Close-contact infectious diseases, Circulatory and respiratory diseases, Mental health conditions, and Home injuries.

This analysis has distinguished three main populations of Housing New Zealand Tenants:

- HHP tenants − 3,470 households who received the HHP. This group is further divided into Pre-HHP and Post-HHP periods.

- Optout-HHP tenants − 1,246 households selected for the HHP who chose not to receive it. This group appears to be quite different to the HHP tenants so is excluded from the major analyses presented here.

- Non-HHP tenants − 26,909 Housing New Zealand households in Auckland and Northand not selected for the HHP (excluding some tenants that were non-classifiable, as described in the methods).

This report updates the last report, *Health Impacts of the Healthy Housing Programme on Housing New Zealand Tenants: 2004-2007*. The main changes are:

- This analysis extends the effective recruitment period by a year, so the population now included Housing New Zealand tenant households who completed the HHP during January 2004 to December 2008 in Auckland and Northland (corresponding to the Northland DHB, Auckland DHB and Counties Manukau DHB areas).

- Non-HHP tenants, used as a comparison group, are restricted to tenant households in Northland DHB, Auckland DHB and Counties Manukau DHB areas, instead of the entire Auckland and Northern regions in the RENTAL database. This is to improve their comparability to the HHP population.

- We have identified a closed-cohort of HHP tenants (7,477) who were exposed to at least one year Pre-HHP and one year Post-HHP to provide a more valid indication of the effect of the HHP. We have also selected from Non-HHP tenants (27,903) by sampling to make two comparable groups (Pre-Non-HHP and Post-Non-HHP). Hospitalisations rates and risks between Pre-HHP/Pre-Non-HHP tenants and Post-HHP/Post-Non-HHP tenants were compared. Multivariate modelling was used to investigate these rate ratios among closed-cohort HHP and Non-HHP tenants to estimate the independent effect of the HHP, after adjusting for important covariates (notably age group, ethnicity).

Results

For children, participation in the HHP was associated with a statistically significant fall in the total number of acute and arranged hospitalisations of 27% (95%CI -43% to -6%) in the year following completion of the HHP interventions. The effect of the HHP appeared more marked for the most intensive intervention, Crowding reduction, which was associated with the largest reduction of 61% (95%CI -79% to -26%) in acute and arranged admissions.

The HHP was also effective at reducing hospitalisations in the total participant population, but significant declines were only seen for the Ventilation only sub-group where acute and arranged hospitalisations declined by 20% (95%CI -33% to -4%). Participation in the overall HHP was associated with a change of -8% (95%CI -19% to +4%) in Total acute and arranged admissions, but this decline was not statistically significant.

Discussion

This evaluation of the HHP provides robust evidence that the programme is effective at reducing the risk of acute hospitalisation in children less than 20 years of age and these reductions are substantial. Findings of this evaluation are consistent with those from the recently published evaluation by Jackson et al.[21] They also found a significant reduction in acute hospitalisations for younger participants in the HHP (a 23% reduction for those aged 5-34 years). This current evaluation used different data sources, methods and time periods to that carried out be Jackson et al, so it is reassuring that it has shown broadly similar findings.

An important finding was that hospitalisation rates in the tenant population overall (ie the Non-HHP population) have been rising markedly during the observation period. Hospitalisations increasing by 24% from 2005 to 2009. This increase was one of the reasons for using a control population (Non-HHP tenants) in the analysis. However, the rising hospitalisation trend also has important health implications as it implies an increasingly vulnerable tenant population in general, making the need for the HHP even greater.

The results of the closed-cohort analysis reported both hospitalisation rates (based on the frequency of hospitalisation over the observation period and allowing multiple admissions for the same individual for the same condition) and hospitalisation risk, (which only counts the first time an individual is admitted during the observation period of one year). The univariate analyses showed that hospitalisation rates, and RRs were very similar for both rate and risk measures suggesting that results are not unduly influenced by a small number of patients with extremely high hospitalisation rates.

This Present study has several limitations, the most important of which are described below.

- Systematic differences between intervention and comparison groups - This cohort analysis is not a controlled trial where a careful randomisation process decides those receiving the HHP or not receiving it. Instead, the allocation is deliberately non-random with the HHP provided to the more deprived neighbourhoods. However, the fact that individual households are allocated to the HHP on the basis of neighbourhood, rather than individual circumstances, does reduce this selection bias. A further consideration is that about a third of those allocated to the HHP choose not to participate (the Optout-HHP group). This later group is likely to have systematic differences from those who chose to have the HHP.

- Difficulty in studying effects on young children – The nature of the intervention means that very few participants will be infants (<1 years of age) during both the Pre-HHP and Post-HHP periods that would allow assessment of the effect of the HHP on this age group. The closed-cohort analysis effectively excludes infants as it requires participants to have been living in a Pre-HHP household for at least one year. By not including this age group, we may be underestimating the impact of the HHP.

- Generalisability of findings - The Housing New Zealand social housing population is not representative of the total NZ population. The social allocation formula used by Housing New Zealand specifically selects tenants with low income and high need. The population has a relatively high proportion of children, Māori and Pacific People, and sole-parent households relative to the wider NZ population. After adjusting for age and ethnicity, it still has significantly higher rates of hospitalisation for most conditions. Even among this population, the HHP was deliberately focussed towards more deprived suburbs. Consequently, there may be limits on generalising the effects of the HHP on this highly vulnerable population to the total NZ population.

The closed-cohort multivariate analysis used here has overcome most of the limitations of the previous evaluation of the HHP. There is, however, further work that could be carried out to improve the usefulness and rigour of this evaluation:

- It would also be possible to specifically investigate the potential impact of the HHP on recorded levels of household crowding and active and passive smoke exposure.

- This study could be continued for one or more years into the future to increase its study power. This extension would be useful as it would allow us to assess whether the beneficial effects of the HHP continued for longer periods that the one-year focus of the current closed-cohort analysis. It could also provide greater statistical power to examine the effects of specific intervention sub-groups (eg crowding reduction) and population groups (eg specific age-groups). Such an extension would allow inclusion of additional households in other regions (notably Wellington).

- It would be useful to know more about the Optout-HHP group, in particular their reasons for opting out. Reasons for these households opting out could usefully be explored by in-depth qualitative interviews, as their non-participation complicates Housing New Zealand's strategy to improve their housing stock and means that these, and subsequent households occupying this stock, will continue to suffer from the effects of cold, damp housing.

2.   Introduction

Aims of this report - This project aims to assess the health impacts of the Housing New Zealand Healthy Housing Programme (HHP) using the established SHOW Study. This aim includes:

- Developing a system to distinguish participants in the HHP from other tenants in RENTEL. All completed HHP and Optout-HHP households during 2004-2008 were in Auckland and Northland, mainly located in the Northland, Auckland and Countries Manukau DHB areas. The analyses in this report therefore focus on HHP, Optout-HHP, and Non-HHP tenants in Auckland and Northland, who are located in these three DHB areas.

- Investigating HHP impact on health status by measuring the hospitalisation experience during July 2003-December 2009 for a set of housing sensitive health outcomes.

- Comparing the hospitalisation experience of participants in the HHP (Post-HHP) using suitable comparison populations, notably:
  - The same tenants (households) before joint assessment (Pre-HHP).

  - Other Housing New Zealand tenants, notably those who are selected to participate in the HHP but choose not to (Optout-HHP) where numbers allow such comparisons. Also with other Housing New Zealand tenants who are not living in the areas (Non-HHP).

- Comparing the hospitalisation experience of participants in the HHP (Post-HHP) who receive different interventions.

- Examining the hospitalisation experience of Optout-HHP tenants, including comparing their hospitalisations Post-Optout with their Pre-Optout time (with a 4 month delay to increase their comparability with the HHP tenants).

Background - The HHP is one of three major Housing New Zealand programmes concerned with improving living conditions for their tenants and communities (the others being housing modernisation and community renewal).

The three objectives of the HHP were described by the former Housing New Zealand CEO Michael Lennon as being, " to reduce state housing overcrowding, reduce the risk of meningococcal disease and other infectious disease, and conduct independent and external evaluation of the pilot scheme prior to any rollout implementation."[1](p.71).

The HHP had an initial pilot from January 2001 to June 2002 with the main programme starting in 2003. Bullen and colleagues described the original impetus of the HHP as coming from a policy drive to improve the well-being of Housing New Zealand tenants by addressing the housing circumstances of families at high risk of infectious disease, experiencing high levels of deprivation, and living in areas with high concentrations of low-income, and largely public, housing.[2] They used a 'success case' methodology that was based on qualitative interviews of 30 selected households and all available HHP providers. The authors concluded that the health goals of the initial HHP had been strengthened by its 'evolution' into a more holistic approach to promoting household well-being. Important principles of the HHP included a

commitment to intersectoral thinking; acknowledgement by providers of the importance of culture to well-being; and acceptance that the benefits transcend material dimensions.[2]

Figure 1. Main steps in Healthy Housing Programme

Source: Counties Manukau District Health Board
http://www.cmdhb.org.nz/funded-services/intersectoral/healthyhousing.htm
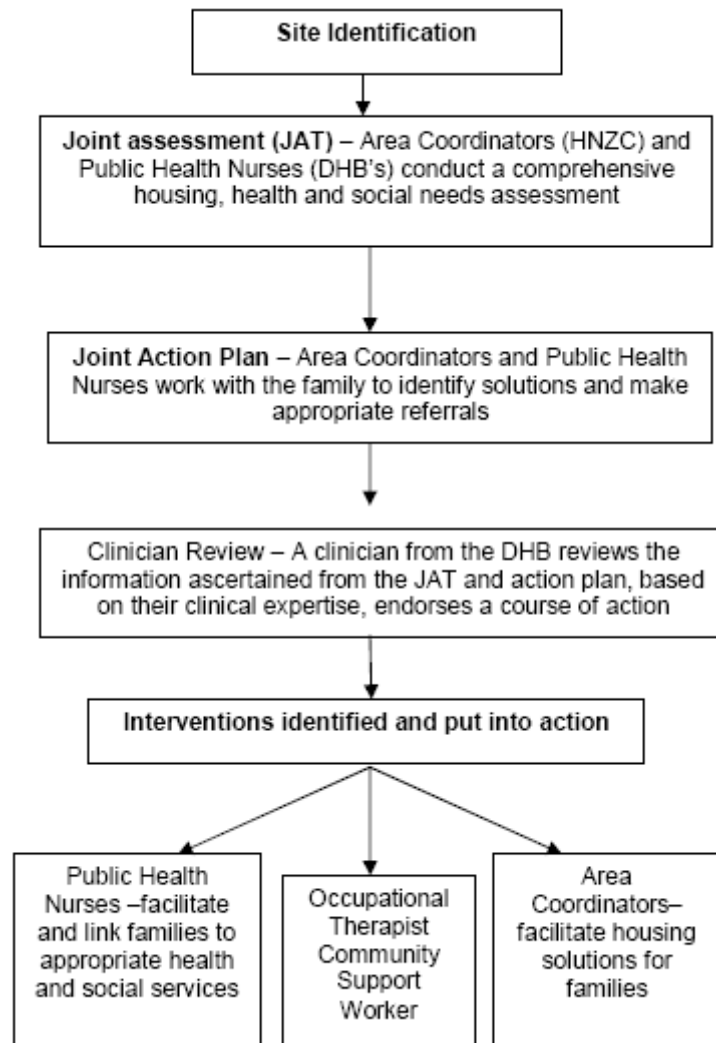
Key operational features of the HHP are shown in Figure 1, and include the following:

- Participation is based on health need assessed at the community level, in this case using Census area units (CAU), rather than at the level of individual households. This selection is based on four datasets: Census data on household crowding; Meningococcal disease rates from local public health service; Hospital discharges for potentially avoidable hospitalisations (PAH); and small area socio-economic deprivation based on NZ Dep score.

- All households in selected CAU, that are living in properties owned by Housing New Zealand, are invited to participate.

- A central feature of the HHP is an assessment to determine the level of crowding, health risk, and housing, health and social service needs. This assessment uses a Joint Assessment Tool (JAT). It is carried out by housing staff (an Area Coordinator from Housing New Zealand) and health staff (a Public Health Nurse from the local District Health Board) in conjunction with the participating household.[2]

- The Joint Assessment results in an action plan that includes both housing and health components. The plan is developed by the Area Coordinator and Public Health Nurse, and agreed to by the family. Both the housing and health parts are customised to the needs of the household.

- The Public Health Nurse and associated DHB staff coordinate the health component which often involves referral to health and social service agencies.

- Housing New Zealand carries out any remedial or other housing work, which may include one or more of the following: Ventilation improvements to the house, (which are almost universal); Insulation (if the house was uninsulated); Heating improvements; Design improvements (including modernisation and disability modifications); and Crowding reduction (by housing extensions, transfers and new applications).

- There is consultation with house occupants throughout the process. They are free to opt-out of the HHP at any point.

Initial evaluation of the HHP, which focused on reducing crowding, found that participation in the programme was associated with a significant decline in hospitalisation for a pre-determined set of "housing-related" potentially avoidable hospitalisations (HR-PAH) conditions. [3]

Our current evaluation builds on the established Social Housing Outcomes Worth (SHOW) Study which links Housing New Zealand's housing applicants and tenants to their hospitalisation records via an encrypted National Health Index number and allows us to assess the health impact of participation in the HHP. It looks exclusively at the original main outcome that the HHP was designed to address - an improvement in health leading to a reduction in hospitalisation rates in the tenants.

3.   Methods

The HHP data were linked to the established SHOW study. This study collected detailed information on Housing New Zealand housing applicants and tenants, and linked them to their hospitalisation records using their encrypted NHI numbers. The method is described below, and included obtaining Tenancy data and HHP data from Housing New Zealand, using these data to distinguish HHP tenants and Non-HHP tenants, constructing the cohort, linking them to hospitalisation records, and analysis of this combined dataset.

Assessment of housing exposures and covariates - The SHOW study was built on Housing New Zealand's routine administrative procedures, which involve obtaining and storing detailed records on all applicants and existing tenants. Information on housing applicants is collected via a Needs Assessment (NA) semi-structured

interview completed at the time of application for social housing. Information on housing tenants comes from a self-completed Income-Related Rent (IRR) form that is filled out by almost all tenant households each year or more often if their circumstances change (92.3% of tenancies were claiming an IRR in December 2009). These administrative processes allowed collection of demographic variables (age, sex, ethnicity), some housing environment information (crowding based on number of people and number of bedrooms) and confounders (household income). A voluntary smoking question was added to the IRR form for completion by adult household members. Dates recorded on NA forms and IRR forms were used to identify person time that Housing New Zealand clients contributed as applicants and tenants, and to construct the cohort. The main methods used for construction of the cohort have been described in Previous reports on this cohort [4-5].

Distinguish HHP tenants and Non-HHP tenants – HHP data contained information on joint assessment, intervention types and dates for households and properties that completed or did not complete the HHP. Using these data, and linking them to the SHOW cohort, we could divide Housing New Zealand tenants into three cohorts and an excluded group.

- HHP Tenants – Tenants who had a joint assessment and completed the HHP during 2004-2008. Their person time splits into two person-time categories:
    - Pre-HHP tenants - During their time before joint assessment they were classified as Pre-HHP.
    - Post-HHP tenants - During their time staying in completed HHP properties they were classified as Post-HHP.
- Optout-HHP tenants – Tenants considered eligible for the HHP but who declined to participate and were recorded as "Optout" in HHP database.
- Non-HHP tenants - Tenants in the region of interest (Auckland and Northland in 2004-2008) who didn't take part in HHP and didn't live in HHP properties. The RENTEL databases records census area unit codes of Housing New Zealand properties. HHP tenants were in Northland, Auckland and Counties Manukau DHBs. In order to choose Non-HHP tenants who are more comparable to HHP tenants, Non-HHP tenants were those who lived in these three DHB areas.
- Excluded - Tenants in Auckland and Northland in 2004-2008 who were difficult to classify (eg didn't take part in HHP but lived in HHP properties as Non-HHP tenants).

Distinguishing a closed-cohort of HHP and Non-HHP tenants – The above cohorts followed the household's status of HHP instead of individuals, with individual tenants allowed to join or leave the cohort. This design is called an 'open cohort'.

A more robust approach is to restrict the cohort to those tenants who were followed for a specified period before and after the intervention, and exclude those who left the cohort during this observation period. This design is called a 'closed-cohort'. For this study we identified closed-cohorts of both HHP tenants and Non-HHP tenants and split them into two person-time categories:

- Closed-cohort HHP – Tenants in open cohort HHP who spent one year or longer during both Pre-HHP and Post-HHP. If tenants spent less than one year during Pre-HHP or Post-HHP, they were excluded from this closed-cohort.

- Closed-cohort Non-HHP – This cohort consisted of tenants in the open-cohort Non-HHP who spent a minimum of 2 years 4 months as Non-HHP tenants during the period January 2003 to December 2009 (this length of time was chosen to match the HHP cohort who were followed for one year Pre-HHP, a median of 4 months during the HHP, and one year Post-HHP). To allow comparison with the HHP group it was necessary to split their person time into before (Pre-Non-HHP) and after (Post-Non-HHP) periods for classifying hospitalisations rates, corresponding to the periods before and after the Joint Assessment for the HHP group. An artificial mid-point needed to be allocated to each of the Non-HHP households, which was allocated as follows: (i) if the household had only four years or less tenancy over the study period, the mid-point was defined to be the mid-point of this period of tenancy; (ii) all other households were randomly allocated a mid-point such that there was still at least a year of tenancy prior and subsequent to this mid-point during the period January 2003 to December 2009. Weights were then allocated to the Non-HHP households so that their distribution of mid-points once weighted matched the distribution of Joint Assessment dates of the HHP group per quarter.

Health outcomes - The health outcomes build on a Previous component of the project which has defined a set of Housing Sensitive Health Outcomes [6] including the following categories:
- Total acute and arranged hospital admissions
- Total potentially avoidable hospitalisations (PAH)
- Housing-related potentially avoidable hospitalisations (HR-PAH)
- Close contact infectious diseases
- Circulatory and respiratory disease hospitalisations
- Mental health hospitalisations
- Home injury hospitalisations
- Non-home injury hospitalisations
- Excess winter hospitalisations (circulatory and respiratory)

Distinguishing intervention sub-groups – As already discussed, participants in the HHP can be divided into the following sub-groups for further analysis:
- Total, receiving Joint Assessment and usually ventilation
- Ventilation only
- Insulation
- Heating
- Design improvement (including modernisation and disability modification)
- Crowding reductions (including addition of bedroom, transfers and new applications)

Incident hospitalisations - Hospitalisation data were filtered in the same way as Previously to exclude health events that had little or no relationship to the research questions being investigated. The standard filter selected publicly funded, NZ resident, acute, overnight hospitalisations and excluded non-treatment events and

admissions related to Pregnancy and the perinatal period. This was the same approach as used in Previous SHOW Study analyses (though there was no need to filter out non-NZ residents).[4-5]

The results of the closed-cohort analysis reported both rates and risk. Hospitalisation rates are based on the frequency of hospitalisation over the observation period and allow multiple admissions for the same individual for the same condition. The univariate results have also reported on hospitalisation risk, which only counts the first time an individual is admitted during the observation period (in this case one year). We looked at this additional measure of hospitalisation to see whether our results might be unduly influenced by a small number of patients with extremely high hospitalisation rates.

Analysis methods – The analyses reported in this paper describe health outcomes using standard methods for calculating crude and adjusted rates, rate ratios and confidence intervals.[7] Hospitalisation rates are expressed as cases per 1,000 population per year (for grouped diseases) or 100,000 population per year (for specified diseases). Most rates have been age-standardised (using 9 age bands from 0-4, 5-9, then 10-year age bands up to 70+) and age-ethnicity standardised to the age-ethnicity structure of the total cohort population as at 2006 (using Māori, Pacific, European/Other). In closed-cohort analysis, the tenants spent same time (one year) during Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP, hospitalisation risks that tenants were admitted to hospitals under the health outcomes during observed periods are reported too.

Small numbers - Because some of the intervention sub-groups contain small numbers of households, and some health outcomes are fairly uncommon, it is not appropriate to calculate age and ethnicity-adjusted rates. Stable age-standardised and age-ethnicity standardised rate generally requires 5+ cases in all cells. This analysis uses 9 age bands and 3 ethnic groups so requires 27 cells for calculating age-ethnicity standardised rates. Consequently, rates will become unstable when there are fewer than 135 hospitalised cases (3*9 age-ethnic cells with an average of 5 cases in each). In these situations, rates are shown in *italics* in this report. If numbers are considerably smaller then they are not reported at all. We have set these numbers as 1+ cases per cell, giving a minimum requirement of 27 hospitalised cases where we are covering all age groups. If numbers are less than this, then no age-ethnicity standardised rates are reported since some cells will have no cases.

Estimation of relative rate ratios using multivariate Poisson regression - As described below, the intervention group (HHP) was compared to the control group (Non-HHP) by randomly assigning a date to the Non-HHP households so that the hospitalisation rates before and after the intervention for the HHP group could be compared to before and after rates for the Non-HHP group. This provided an estimate of the way that rates may have changed for the intervention group if no intervention were applied to their housing, thereby controlling for aspects such as changing hospitalisation rates over the period studied. If a given hospitalisation rate for the HHP group before the intervention is denoted by Hb and the rate after by Ha, with the corresponding rates for the Non-HHP group designated by Nb and Na, then an

estimate of the change in hospitalisation rates attributable to the intervention is provided by the relative rate ratio: (Ha/Hb)/(Na/Nb) (equation 1).

As there may be differences in the proportions of tenants by age, gender and ethnic characteristics, which could confound estimates of change in rates, these were controlled for in a multivariate Poisson model that took into account the clustering of individuals by the household and by whether hospitalisations occurred before or after the intervention date (which was randomly allocated in the case of the Non-HHP group). The method of generalised estimating equations (GEEs) used extends generalised linear models (GLMs) to accommodate clustered or correlated data.[8] The SAS procedure[9] GENMOD with a REPEATED statement specifying the household was used to estimate the relative rate ratios in Equation 1. As the clustering had more than one level, the highest level was the one specified, in this case the household. The model was fitted with main effects age group, sex, ethnicity, whether HHP or Non-HHP ("group"), whether before or after the intervention date ("period"), and an interaction term group*period. The exponentiated estimated coefficient of this last term provided the estimate of the relative rate ratio. As it was expected that some of the housing improvements would be particularly important for the health of young people, separate models were fitted for all tenants aged less than 20.

4. HHP and Non-HHP tenants

This section explores HHP data from Housing New Zealand and links it to RENTEL databases. Three cohort population (HHP tenants, Optout-HHP tenants, and Non-HHP tenants) are constructed for later analysis of the health impact of the HHP. This section then presents the demographic and socio-economic characteristics for these cohorts at a cross-section date.

4.1. HHP, Optout-HHP and Non-HHP tenants

4.1.1. Households in HHP

The HHP data from Housing New Zealand recorded HHP intervention information, such as tenant households, lease and property reference, HHP Joint Assessment date, intervention types, codes and dates, and completion. The households were asked to join the HHP, and then had joint assessment if they agreed. The region reference (comp_ref) and tenant household reference (tnnt_ref) were used to identify the household.

Most of the households had only one joint assessment and completed HHP (termed a completed "stage" in the Housing New Zealand records). However, a small proportion (3 percent) of tenant households (under the same household reference - comp_ref and tnnt_ref) had multiple lease reference numbers and property reference numbers, which could have arisen through moving between Housing New Zealand houses. These changes also caused multiple joint assessments or HHP complete stages for a household. After consultation with Housing New Zealand, we used the following conventions for managing these households:

- All multiple joint assessments or complete stages for a household were combined as one.
- If a household had multiple "Complete" stages, the final stage was recorded as Complete with all interventions included. The first joint assessment date was recorded as the "Joint assessment date", and the last stage complete date was recorded as the "Complete date".
- If a household had multiple "Optout" stages, the final stage was recorded as "Optout", and the last Optout date was recorded as the final "Optout date".
- If a household had multiple stages of "Optout" and "Complete"
  o If "Optout" was earlier than or the same as the "Complete" date, then the final stage was recorded as "Complete", and its "Joint assessment date" and "Complete date" were recorded.
  o If "Optout" was later than "Complete", then the household was excluded.

This analysis was restricted to households that completed their HHP during 2004-2008 and linked them to their hospitalisations from July 2003 to December 2009. It also required them to have completed their Joint Assessment after July 2003. This requirement was because the analysis required at least some observation time of their hospitalisations before Joint Assessment and a year after HHP. Optout-HHP household just needed to have made this decision during July 2003 to December 2008 period, corresponding to the Joint Assessment period for the HHP Households. The HHP and Optout-HHP households breakdown by joint assessment / Optout years, and regions are shown in Table 4.1.

Table 4.1 Households completed HHP in 2004-2008 according to year of Joint Assessment or Optout, Auckland and Northland regions

Years	HHP Households (by Joint Assessment year)			Optout-HHP Households (by Optout year)		
	Auckland	Northland	Total	Auckland	Northland	Total
2003 (July-December)	170	53	223	46	8	54
2004	626	150	776	278	42	320
2005	643	108	751	258	44	302
2006	661	182	843	248	49	297
2007	734	192	926	220	59	279
2008	274	0	274	223	0	223
Total Jul 2003-Dec 2008	3,108	685	3,793	1,273	202	1,475

4.1.2. Interventions received by HHP tenants

The interventions received by HHP tenants are shown in Table 4.2.

This table shows numbers of "Completed" interventions as well as those that have been "Cancelled" (declined by Housing New Zealand or customers), and those

classified as "Other" ("Waiting for transfer", "Design stage" and "Region responsibility"). The subsequent analysis is based on those classified as "Completed".

Table 4.2 Intervention codes for HHP households with final complete stage, Auckland and Northland, 2004-2008

Intervention code	Detail	Completed	Cancelled	Other*	Total
BULT	Built	1	2	0	3
DISM	Disability Mods	60	100	0	160
EXTN	Extension	84	40	0	124
HAP	Household Action Plan	0	0	34	34
HDRY	Heat and Dry System	0	2	0	2
HTNG	Heating	255	2	0	257
INSUL	Insulation	2,310	1,200	0	3,510
MODN	Modernisation	165	75	0	240
MPS	Moved Private Sector	28	14	19	61
NEW	New Application	163	115	73	351
NOR	Remedy Notice	16	10	38	64
PURC	Purchase	19	2	0	21
REDV	Redevelopment	10	3	0	13
TRN	Transfer (Tenants transferring to another property)	199	380	470	1,049
VENT	Ventilation	3,772	34	0	3,806
Total interventions during period		7,082	1,979	634	9,695
Total households having intervention during period		3,793	1,635	615	3,793

*Other includes "Waiting for transfer", "Design stage" and "Region responsibility"

As noted in the methods section, this analysis has grouped these interventions into a Total category and five intervention sub-groups (Table 4.3). Essentially all households received ventilation following their joint assessment and agreement to participate in the HHP. After that, insulation was the only intervention that was reasonably common in the programme.

This analysis shows that ventilation was the only intervention offered on its own to significant numbers of tenants (Table 4.3). Almost all of the others were offered interventions in combination with ventilation, and sometimes with other interventions. Based on this analysis, the following intervention groups are proposed for more detailed analysis:

- Total

- Ventilation (on its own)

- Insulation (with or without other interventions)

- Heating (with or without other interventions)

- Design improvement (with or without other interventions)

- Crowding reduction (with or without other interventions)

Table 4.3 Intervention groups showing numbers of households receiving intervention in total and exclusively (ie where that is the sole intervention), Auckland and Northland, 2004-2008

Intervention group for analysis	Details	Number Total households	Number Households where sole intervention
Total	Joint Assessment	3,793	3,793
Ventilation	Ventilation	3,740	1,174
Insulation	Insulation	2,299	7
Heating	Heating	255	0
Design improvement	Modernisation and disability modification	224	5
Crowding reduction	Transfers and new applications, and Extension, purchase, redevelopment, build	391	35
Excluded	Moved to private sector, Remedy notice	41	2

Table 4.4 shows that the less common interventions of heating, design improvement, and crowding reduction were also usually combined with insulation (as well as ventilation).

Table 4.4 Intervention sub-groups showing total numbers of households receiving combinations of interventions (including two or more), Auckland and Northland, 2004-2008

	Ventilat-ion	Insulation	Heating	Design improve-ment	Crowding reduction	Excluded
Ventilation	3,740	2,289	253	218	355	39
Insulation	2,289	2,299	164	169	219	25
Heating	253	164	255	0	9	4
Design improvement	218	169	0	224	15	4
Crowding reduction	355	219	9	15	391	7

4.1.3. Open cohort HHP, Optout-HHP and Non-HHP tenant

HHP, Optout-HHP, and Non-HHP tenant open cohorts were constructed by linking households in the HHP to households recorded in the SHOW study. The household linkage uses the region reference (comp_ref) and tenant household reference (tnnt_ref). Non-HHP tenants were used as one of the comparison groups. HHP and Optout-HHP tenants in Northland and Auckland were located in the Northland, Auckland and Countries Manukau DHB areas. Consequently, Non-HHP tenants were restricted to these DHB areas also. After linking, more households and individuals were excluded (as shown in Table 4.5.):

1) HHP, Optout and Non-HHP tenants living outside the DHBs included in the study.

2) Households in HHP, but not in SHOW databases. These households might not have applied for an IRR.

3) Households and their individuals that were in uncertain HHP stage, in both HHP and Optout stages.

4) Households and their individuals that completed HHP or Optout HHP before 2004.

5) Households and their individuals that had joint assessment before July 2003, whether HHP or Optout-HHP.

6) Households and their individuals that completed HHP or Optout HHP after 2008 (ie 2009). Note that they can be included in future analyses of the impact of the HHP.

7) Households and their individuals that were not in the HHP but later moved to HHP completed properties.

8) Households and individuals whose records as Housing New Zealand tenants were not continuous through July 2003 to December 2009. For example, a tenant during May 2004-June 2005 and February 2007-December 2008, but no information during July 2005- January 2007.

9) Individuals who shifted between HHP, Optout-HHP or Non-HHP households during the observation period.

10) Individuals who died during July 2003-2009 as it is hard to estimate accurate person time for these people. Deaths were recorded in the NZ mortality database 2003-2006 and those hospital discharge data (for those dying in hospital) in 2007-2009.

There were about 210,205 individuals identified as Housing New Zealand tenants during the hospitalisation observation period July 2003-December 2009 in Auckland and Northland. Among these tenants, 5.3 percent joined HHP, 1.9 percent were Optout-HHP, 41.5 percent were Non-HHP and 51.3 percent were excluded, mostly because they lived outside the research areas included in the study. The largest groups excluded from the Non-HHP tenants were those whose tenant records with HNZC were not continuous, who moved into HHP household after the intervention had taken place, or who had complex histories of moving between properties.

Table 4.5   Numbers of tenant households and individuals in Auckland and Northland, July 2003-Dec 2009, according to HHP category

HHP category	Number of households	Percent	Number of individuals	Percent
Included:				
HHP in Northland, Auckland and Manukau DHB area				
HHP tenants	3,470	5.3	13,969	6.6
Optout-HHP tenants	1,246	1.9	4,067	1.9
Non-HHP tenants*	26,909	41.5	83,452	39.7
Excluded				
1. HHP outside Northland, Auckland & Manukau DHB area				
HHP tenants	4	0.0	16	0.0
Optout-HHP tenants	1	0.0	14	0.0
Non-HHP tenants*	21,608	33.3	66,398	31.6
2. HHP only (no data in SHOW)				
Completed HHP	28	0.0	-	-
Optout-HHP	27	0.0	-	-
3. Uncertain HHP stage	72	0.1	485	0.2
4. Finished HHP before 2004				
Completed HHP	342	0.5	1,518	0.7
Optout-HHP	52	0.1	143	0.1
5. Joint assessment HHP before July 2003				
Completed HHP	251	0.4	1,495	0.7
Optout-HHP	1	0.0	8	0.0
6. Had HHP after 2009				
Completed HHP	768	1.2	3,078	1.5
Optout-HHP	181	0.3	661	0.3
7. Moved to intervened properties	3,381	5.2	9,267	4.4
8. Tenant records in Housing New Zealand not continuous				
HHP tenants	291		967	0.5
Optout-HHP tenants	148		348	0.2
Non-HHP tenants	6,104		15,009	7.1
9. Uncertain individual status			5,779	2.7
10. Died during 2003-2009				
HHP tenants	-		227	0.1
Optout-HHP tenants	-		70	0.0
Non-HHP tenants	-	-	3,234	1.5
Total				
Total July 2003-Dec 2009	64,884	100.0	210,205	100.0

- Not applicable

SHOW data records dynamic movement of households and tenant individuals among Housing New Zealand houses during the observation periods. It uses a set of research assumptions described in Previous reports (and listed in appendix 7.1). The person time that tenants contributed as HHP tenants, Optout-HHP tenants and Non-HHP tenants are calculated as:

- **HHP tenants:**
  - Pre-HHP: started from the beginning of observation (1 July 2003) or the date that the tenant households first moved into a Housing New Zealand house if later than 1 July 2003, to the date of joint assessment. Does not include those tenants who decided to Optout.
  - Post-HHP: started from the date completed HHP stage, to the end of the observation period (31 December 2009), or the date the tenants moved out of the Housing New Zealand houses (if earlier than 31 December 2009). If tenants joined HHP households after the HHP had been completed, their person time started from the date they moved into the HHP households.
  - During HHP: between the date of joint assessment and complete last HHP stage.

- **Optout-HHP tenants**:
  - Pre-Optout-HHP: started from the beginning of the observation (1 July 2003) or the date that the tenant households first moved into a Housing New Zealand house if later than 1 July 2003, to the date of opt-out HHP.
  - Post-Optout-HHP: started 4 months after opting out of the HHP (close to the median duration of HHP intervention), to the end of the observation period (31 December 2009), or the date the tenants moved out of the Housing New Zealand houses (if earlier than 31 December 2009). If tenants joined Post-Optout-HHP households later, their person times started from the date they moved into the Opt-out-HHP household.

- **Non-HHP tenants**: started at the beginning of the observation period (1 July 2003) or the date of moved into Housing New Zealand (if later than 1 July 2003), to the end of the observation period (31 December 2009), or the date the tenants moved out of the Housing New Zealand houses (if earlier than 31 December 2009).

Table 4.6 shows the person times that individuals contributed to the different HHP populations and states during the period from 1 July 2003 to 31 December 2009. There were about 83,452 tenants classified as Non-HHP. The large size of this population and associated person time during the observation period means that health measurements (hospitalisations) in this comparison population are relatively stable. There were about 13,969 tenants in HHP, though not all spent time in all three HHP states (Pre-HHP, During HHP and Post-HHP). They spent slightly more time Post-HHP than Pre-HHP. There were 4,401 Optout-HHP tenants. As with HHP tenants, not all of them spent time in Pre-Optout-HHP and Post-Optout-HHP.

Table 4.6 Person time of HHP, Optout-HHP and Non-HHP tenants during July 2003-December 2009, Northland and Auckland

Person Time	Number	Median (day)	Mean (day)	Person years
HHP tenants				
Pre-HHP	11,939	686	751.3	24,557.6
During-HHP	11,858	133	187.9	6,100.0
Post-HHP	12,915	931	1,000.4	35,373.2
Optout-HHP, after Optout				
Pre Optout-HHP	3,873	800	853.4	9,049.0
Post Optout-HHP	3,877	842	930.8	9,879.7
Non-HHP tenants	83,452	1,476	1,451.8	331,701.6

The distribution of the intervention start time by month, and comparison groups is shown in Table 4.7 and Figure 4.1. This analysis suggests the distribution of intervention start times (Post-HHP) and opt-out start times (Optout-HHP) was fairly even during the year. However, the majority of Pre-HHP and Non-HHP effectively began on 1 July 2003 when the study observation period started.

Table 4.7 Intervention start time by month for Pre-HHP, Post-HHP, Optout-HHP and Non-HHP tenants during July 2003-December 2009, Auckland and Northland

Start Months	Pre-HHP		Post-HHP		Optout-HHP		Non-HHP*	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
January	160	5.8	759	5.9	323	7.9	4,250	6.3
February	193	7.0	986	7.6	302	7.4	5,431	8.0
March	223	8.1	1,058	8.2	346	8.5	6,528	9.6
April	293	10.6	948	7.3	267	6.6	5,459	8.1
May	216	7.8	785	6.1	382	9.4	6,235	9.2
June	238	8.6	1,041	8.1	371	9.1	5,645	8.3
July	276	10.0	1,096	8.5	388	9.5	3,419	5.0
August	293	10.6	1,092	8.5	316	7.8	6,785	10.0
September	185	6.7	1,285	10.0	536	13.2	6,585	9.7
October	204	7.4	1,351	10.5	385	9.5	6,149	9.1
November	238	8.6	1,125	8.7	266	6.5	5,872	8.7
December	245	8.9	1,389	10.8	194	4.8	5,415	8.0
Existing tenants#	8,265		0		0		41,575	

Existing tenants were tenants who lived in Housing New Zealand houses when observation started in 1 July 2003, 73% of total Pre-HHP and 52% of total Non-HHP tenants

Figure 4.1 Intervention start time by month for Pre-HHP, Post-HHP, Optout-HHP and Non-HHP tenants during July 2003-December 2009
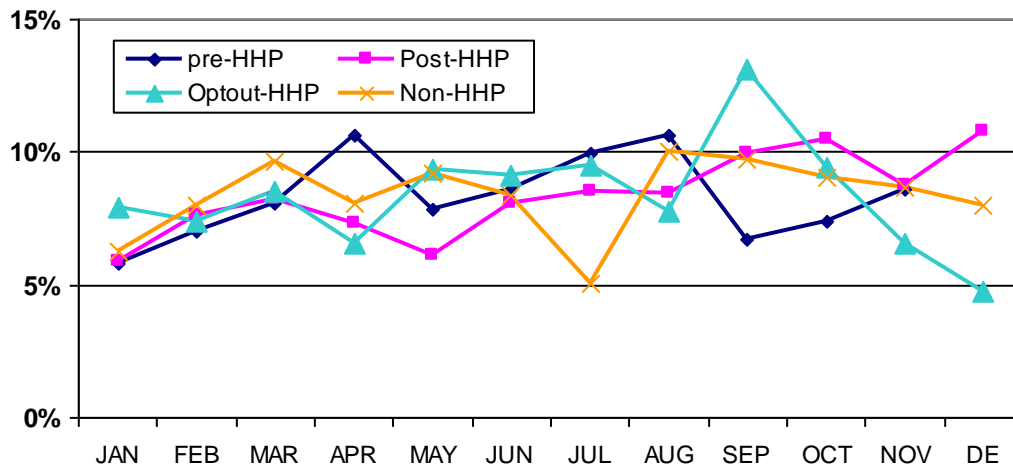
Most interventions in the HHP were ventilation and insulation. The sub group of interventions that included heating, design improvement and crowding reduction were small and unevenly through DHB areas and ethnic groups. Table 4.8 shows the number of people (rather than person time for simplicity) who received the interventions. The largest population receiving the Heating intervention were Māori living in Northland. Design improvement and Crowding reduction were largely in Auckland and Manukau DHB areas and received by Māori and Pacific households. Consequently, it is not appropriate to calculate age-ethnicity standardised hospitalisation rates and rate ratios for these 3 sub-group interventions. Instead, hospitalisations rates for those receiving the Heating intervention will be restricted to Māori and for assessing the Design improvement and Crowding reduction interventions the analysis will be restricted to Māori and Pacific People.

Table 4.8 Intervention sub-groups showing total numbers of people receiving interventions by DHB area and ethnic groups, Auckland and Northland, 2004-2008

Intervention sub-group	Northland DHB	Auckland DHB	Manukau DHB	Māori	Pacific People	European /Other
Ventilation All	2,218	2,890	8,651	4,154	8,262	1,343
Ventilation only	667	761	2,579	1,196	2,423	388
Insulation	1,265	2,044	5,396	2,530	5,286	889
Heating	797	13	10	669	28	123
Design improvement	0	111	782	216	599	78
Crowding reduction	93	200	1,380	371	1,224	78

4.2. Demographic and socio-economic characteristics

This section describes demographic and socio-economic characteristics of the three HHP cohorts at cross-section. The cross section dates are defined as the date of completed HHP for HHP tenants, the Optout date for Optout-HHP tenants, and 31 December 2008 for Non-HHP tenants.

Age and sex - Table 4.9 shows age and sex distributions for HHP tenants, Optout-HHP tenants and Non-HHP tenants at cross sections. HHP tenants were younger than Non-HHP tenants. The median age of HHP tenants was 18 years old, 2 years younger than the median ages of Optout-HHP at 20 years old and 3 years less than Non-HHP tenants. Sex distributions are similar for HHP, Optout-HHP and Non-HHP tenants, about 55 percent of females and 45 percent of males

Table 4.9 Age and sex distribution for HHP, Optout-HHP and Non-HHP tenants at cross section, Auckland and Northland

Age and Sex	HHP tenants		Optout-HHP tenants		Non-HHP tenants	
	Number	Percent	Number	Percent	Number	Percent
Mean age (years)	25.4	-	27.8	-	28.7	-
Median age (years)	18	-	20	-	21	-
0-4 years	1,412	12.4	301	8.8	5,951	10.8
5-17 years	4,228	37.1	1,206	35.3	18,002	32.7
18-64 years	5,104	44.8	1,718	50.3	26,432	48.0
65+ years	645	5.7	188	5.5	4,707	8.5
Female	6,224	54.7	1,858	54.4	30,213	54.8
Male	5,165	45.4	1,555	45.6	24,879	45.2
Total Number	11,389	100.0	3,413	100.0	55,092	100.0

Ethnicity - Ethnicity distributions among HHP, Optout-HHP and Non-HHP tenants were different. Pacific People were a higher proportion in HHP tenants (65.2 percent, using total responses, which allows tenants to be counted more than once if they report multiple ethnicities), compared with Optout-HHP tenants (54.6 percent), and Non-HHP tenants (52.3 percent). Māori (29.4 percent) were a lower proportion compared with Optout-HHP tenants (37.5 percent) and Non-HHP tenants (30.1 percent). Fewer Asian, European/Other and Not stated tenants were in HHP tenants than in Optout-HHP tenants and Non-HHP tenants.

Table 4.10 Distribution of ethnicity for HHP, Optout-HHP and Non-HHP tenants at cross section, Auckland and Northland

Ethnic groups	HHP tenants		Optout-HHP tenants		Non-HHP tenants	
	Prioritised ethnicity (%)	Total ethnicity (%)	Prioritised ethnicity (%)	Total ethnicity (%)	Prioritised ethnicity (%)	Total ethnicity (%)
Māori	29.4	29.4	37.5	37.5	30.1	30.1
Pacific	62.0	65.2	50.8	54.6	48.3	52.3
Asian	2.1	2.4	2.1	2.5	5.1	5.8
European and Other	4.4	9.7	7.8	12.3	15.0	21.4
Not stated	2.1	2.1	1.9	1.9	1.6	1.6
Total	100.0	108.8	100.0	108.6	100.0	111.1

Household income - The sum of income field (from Needs Assessment and IRR records) measures total weekly household income that is relevant to the calculation of the income-related rent. Jensen equivalised income weights are used to adjust for household size and composition (adults and children)[10]. The household income is adjusted by dividing the weekly income by the appropriate weight for the number of adults and children in a household. Household weekly income among HHP, Optout-HHP and Non-HHP tenants were similar (Table 4.11). The median equivalised income was $206.2 for HHP tenants, $225.5 for Optout-HHP tenants and $235.7 for Non-HHP tenants

Table 4.11: Household weekly income for HHP, Optout-HHP and Non-HHP tenants at cross section, Auckland and Northland

Income summary	HHP tenants		Optout-HHP tenants		Non-HHP tenants	
	Income ($)	Equivalised income ($)	Income ($)	Equivalised income ($)	Income ($)	Equivalised income ($)
Mean	373.5	239.9	377.4	264.0	392.5	277.9
90th percentile	628.7	397.0	621.0	436.7	663.0	457.4
Upper quintiles	455.2	292.5	463.4	318.9	486.8	346.6
Median	290.7	206.2	297.5	225.5	306.9	235.7
Lower quintiles	249.1	157.7	249.1	167.5	263.8	173.5
10th percentile	221.1	128.9	210.7	138.0	230.2	142.6

Household   structure   -

Table 4.12 Presents the household structure by households and individuals for HHP, Optout-HHP and Non-HHP tenants. These data show that a higher proportion of the HHP tenants were living as "Couple with children" (39.5 percent) compared with Optout-HHP tenants (31.7 percent) and Non-HHP tenants (34.8 percent). Adult only families were a smaller proportion (19.4 percent) of HHP tenants than Optout-HHP tenants (24.2 percent) and Non-HHP tenants (27.0 percent).

Table 4.12: **Household types for HHP, Optout-HHP and Non-HHP tenants at cross section, Auckland and Northland**

Household type	HHP tenants		Optout-HHP tenants		Non-HHP tenants	
	Household (%)	Individual (%)	Household (%)	Individual (%)	Household (%)	Individual (%)
Single with children (1+)	40.6	41.1	41.9	44.1	33.1	38.2
Couple with children (1+)	29.0	39.5	20.0	31.7	20.8	34.8
Adults without children (single, couple without children)	30.4	19.4	38.0	24.2	46.1	27.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Household tenancy duration - Previous research using the SHOW Study showed that hospitalisation rates of Housing New Zealand tenants were associated with tenancy durations. Tenants in their first year had the highest hospitalisations, with rates gradually decreasing and flattening after 3+ years tenancy. Table 4.13 shows household tenancy durations from their household lease start dates to their "cross section" dates.

Table 4.13 **Tenancy duration from beginning of leases start to cross section for HHP, Optout-HHP and non-HHP, Auckland and Northland**

Tenancy duration	HHP tenants		Optout-HHP tenants		Non-HHP tenants	
	Household (%)	Individual (%)	Household (%)	Individual (%)	Household (%)	Individual (%)
<1 year	11.1	11.6	10.8	10.3	11.1	10.2
1-3 years	27.2	26.9	28.5	29.6	28.5	27.5
4-6 years	20.7	21.5	20.3	20.9	18.0	18.3
7-9 years	10.3	10.4	8.5	9.0	13.4	14.2
10+ years	30.6	29.6	31.9	30.2	29.0	29.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

4.3. Housing exposures and conditions

Active smoking -

Table 4.14 shows active smoking Prevalence for HHP, Optout-HHP and Non-HHP tenants 18+ years. Active smoking rates for HHP adult tenants were 29.8 percent, which was slightly lower than   Optout-HHP adult tenants (32.5 percent) and higher than Non-HHP tenants (26.5 percent).

Table 4.14:   Active smoking for HHP, Optout-HHP and Non-HHP tenants (18+ years) at cross sections, Auckland and Northland

Population	HHP tenants	Optout-HHP tenants	Non-HHP tenants
Number of smokers	1,323	487	5,459
Number of tenants providing smoking information	4,433	1,499	20,629
Smokers (%)	29.8	32.5	26.5
Smoke response (%)	77.1	76.6	66.2

Passive smoking - Living in a household with smokers was a relatively common exposure (Table 4.15). As the smoking Prevalence of HHP tenants was slightly lower, the passive smoker proportion for HHP tenants was also slightly lower at 50.3 percent, than the Prevalence for Optout-HHP tenants (53.9 percent) and higher than Non-HHP tenants (48.3 percent).

Table 4.15:   Passive smoking for HHP, Optout-HHP and Non-HHP tenants at cross sections, Auckland and Northland

Population and year	HHP tenants	Optout-HHP tenants	Non-HHP tenants
Number of passive smokers	4,267	1,396	16,119
Number of tenants providing smoking information	8,489	2,591	33,381
passive smokers %	50.3	53.9	48.3

Household crowding - HHP tenants had higher levels of household crowding 50.2 percent for 1+ bedroom deficit and 19.7 percent for 2+ bedroom deficit) than that seen in Optout-HHP and Non-HHP tenants. It is not surprising that household crowding was higher in the HHP tenants – Census data on levels of household crowding was one of the criteria used for selecting CAU to participate in the HHP.

Table 4.16: Household crowding for HHP, Optout-HHP and Non-HHP tenants at cross sections, Auckland and Northland

Crowding level	HHP tenants		Optout-HHP tenants		Non-HHP tenants	
	Household (%)	Individual (%)	Household (%)	Individual (%)	Household (%)	Individual (%)
No deficit	60.7	49.8	69.6	59.5	70.8	54.8
1+ bedroom deficit	39.3	50.2	30.4	40.5	29.2	45.2
2+ bedroom deficit	13.9	19.7	9.3	13.4	10.0	18.2

4.4. Hospitalisations trends in Non-HHP tenants

Hospitalisation rates in the Non-HHP tenant population rose during the observation period, certainly from 2006 to 2009. **Error! Reference source not found.** shows that the age-ethnicity standardised Total acute and arranged hospital rates for Non-HHP tenants rose 24 percent in 2009 compared with 2004. Tenants in Auckland and Counties Manukau DHBs had consistent rising trends and those in the Northland DHB were stable except in 2008. The rising hospitalisation rates were mostly driven by increased rates in older people. There was no change for children under 17 years.

Figure 4.2 Acute and arranged hospitalisations trends, age-ethnicity standardised rates and rate ratios for non-HHP tenants, Auckland and Northland, January 2004-December 2009

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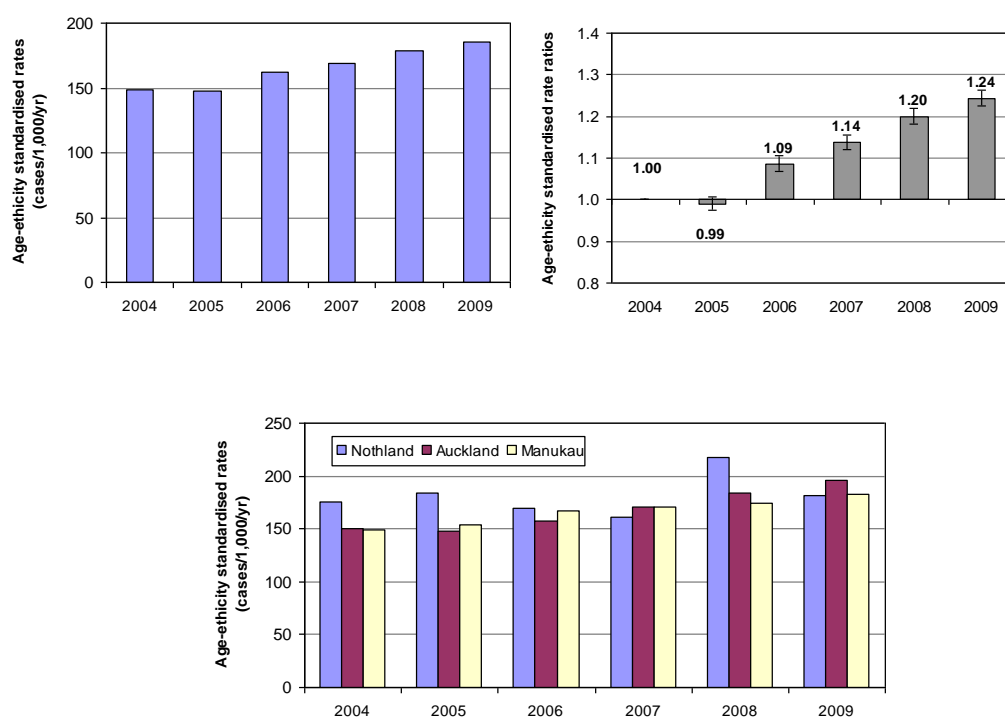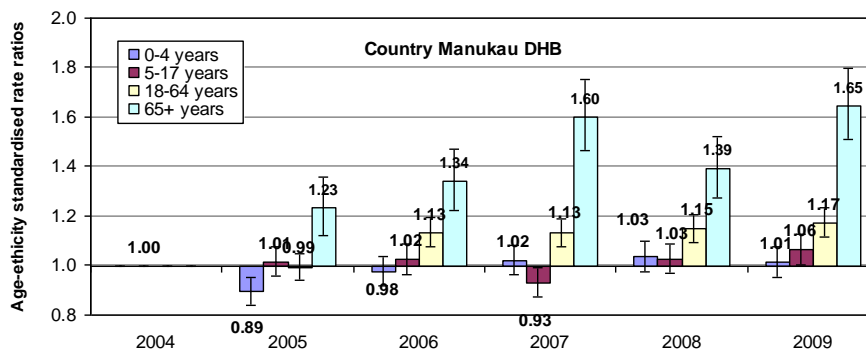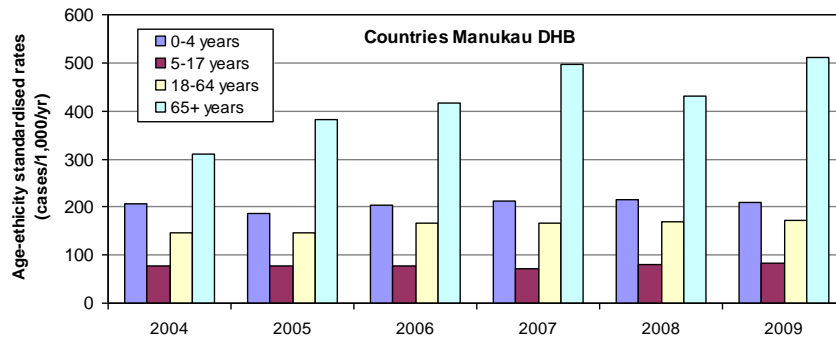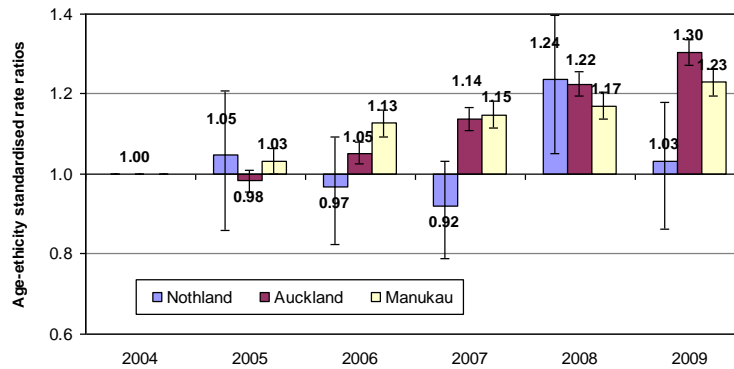
4.5. Closed-cohort HHP and Non-HHP tenants

The open cohort described above was established by following Housing New Zealand tenancy households from Pre-HHP to Post-HHP. The tenants in the HHP households were allowed to join or leave cohort at any time during study.

For closed-cohort HHP tenants, Pre-HHP period is defined one year before HHP Joint Assessment date and Post-HHP is one year after HHP completed date. Only HHP tenants, who spent both at one year or more during Pre-HHP and Post-HHP, were eligible in closed-cohort HHP tenants. If tenants spent less than one year during Pre-HHP or Post-HHP, they were enclosed.

An artificial mid-point needed to be allocated to each of the Non-HHP households, which were acting as controls for the HHP group, and hence needed to have a "before" and "after" period defined for classifying hospitalisations rates,

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corresponding to the periods before and after the Joint Assessment for the HHP group. Where an individual in the Non-HHP group was resident in the house for at least two years and four months during the period January 2003 to December 2009, an artificial mid-point was allocated as follows: (i) if the household had only four years or less tenancy over the study period, the mid-point was defined to be the mid-point of this period of tenancy; (ii) all other households were randomly allocated a mid-point such that there was still at least a year of tenancy prior and subsequent to this mid-point during the period January 2003 to December 2009. Weights were then allocated to the Non-HHP households so that their distribution of mid-points once weighted matched the distribution of Joint Assessment dates of the HHP group per quarter.

Table 4.17 shows the numbers of households and tenants in the closed-cohort HHP and Non-HHP groups, along with the weights calculated for the Non-HHP households to mimic the distribution across quarters of the Joint Assessment dates of the HHP group. Hospitalisation observation periods were from January 2003 to December 2009 so as to leave at least one year of Pre-HHP for the HHP households assessed at the start of the programme.

Table 4.17:   closed-cohort HHP and Non-HHP tenants and weights

Middle point	Households in Closed-cohort HHP	Tenants in Closed-cohort HHP	Households in Closed-cohort non HHP	Tenants in Closed-cohort non HHP	Weights for Non-HHP based on households
2004 quarter 1	13	32	179	436	0.07
2004 quarter 2	103	343	925	2300	0.11
2004 quarter 3	131	380	896	2187	0.15
2004 quarter 4	118	418	884	2153	0.13
2005 quarter 1	132	365	619	1471	0.21
2005 quarter 2	88	286	622	1397	0.14
2005 quarter 3	193	556	617	1468	0.31
2005 quarter 4	106	306	590	1326	0.18
2006 quarter 1	116	358	564	1366	0.21
2006 quarter 2	183	510	542	1235	0.34
2006 quarter 3	163	513	538	1304	0.30
2006 quarter 4	168	537	578	1364	0.29
2007 quarter 1	98	316	561	1316	0.17
2007 quarter 2	199	647	559	1267	0.36
2007 quarter 3	170	498	539	1260	0.32
2007 quarter 4	197	611	500	1165	0.39
2008 quarter 1	84	260	653	1556	0.13
2008 quarter 2	66	190	609	1413	0.11
2008 quarter 3	84	267	630	1555	0.13
2008 quarter 4	24	84	148	364	0.16
Total	2436	7477	11753	27903	

Table 4.18: Numbers of closed-cohort HHP and Non-HHP tenants with tenancy longer than 2 years and 4 months during January 2003 to December 2009 by age group and ethnicity

age group at mid-point of period	HHP					Non-HHP				
	Maori	Pacific	Other	Total	%	Maori	Pacific	Other	Total	%
<2 years	31	89	8	128	1.7%	44	86	16	146	0.5%
2-4 years	167	346	34	547	7.4%	428	752	161	1341	4.8%
5-9 years	344	693	54	1091	14.7%	1158	2198	470	3826	13.7%
10-19 years	569	1281	150	2000	26.9%	2049	3886	972	6907	24.8%
20-29 years	175	337	50	562	7.6%	555	1047	392	1994	7.1%
30-39 years	253	531	65	849	11.4%	976	1615	590	3181	11.4%
40-49 years	255	544	75	874	11.7%	1137	2088	899	4124	14.8%
50-59 years	186	349	76	611	8.2%	685	1317	849	2851	10.2%
60-69 years	95	265	105	465	6.2%	340	690	793	1823	6.5%
70+ years	47	174	93	314	4.2%	156	421	1132	1709	6.1%
Total	2122	4609	710	7441	100%	7528	14100	6274	27902	100%
ethnicity %	28.5%	61.9%	9.5%	100%		27.0%	50.5%	22.5%	100%	

Table 4.18 shows the numbers of closed-cohort HHP and Non-HHP tenants with tenancy longer than 2 years and 4 months over the period January 2003 to December 2009 by age group and ethnicity, together with the percentages of tenants by age and ethnicity in the two groups (HHP and Non-HHP). This shows that there was a much higher proportion of Pacific people in the HHP group, but similar proportions of Maori. There were also higher proportions of children aged less than 5 years in the HHP group.

5. Hospitalisations for closed-cohort HHP and Non-HHP tenants

This section analyses the hospitalisation rates and risks for the closed-cohort HHP and Non-HHP tenants. We compared hospitalisation rate ratios and risk ratios between Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP to show changes for the closed-cohort HHP and Non-HHP tenants. The logistic model is used to adjust multiple variables. The analyses are based on the same housing health sensitive health outcome:

- Total acute and arranged hospital admissions (filter 1-4)
- Total potentially avoidable hospitalisations (specific PAH filter)
- Housing-related potentially avoidable hospitalisations (specific PAH filter)
- Close contact infectious diseases (standard filter ie filter 1-6)
- Circulatory and respiratory disease hospitalisations (standard filter)
- Mental health hospitalisations (standard filter)
- Home injury hospitalisations (standard filter)
- Non-home injury hospitalisations, (standard filter)

5.1. Total acute & arranged, Avoidable and Housing related

5.1.1. Total acute and arranged hospital admissions

Scope of indicator: Uses International Statistical Classification of Diseases and Related Health Problems Version 10 (ICD.10) codes for total illness and injury admissions: A00-N99, R00-T98, Excludes Pregnancy, childbirth and puerperium (O00-O99), certain conditions originating in perinatal period (P00-P96), congenital malformations, deformities and chromosomal abnormalities (Q00-Q99), and factors influencing health status and contact with health services (Z00-Z99).

Rationale for indicator: Indicator of overall level of ill-health and injury in population as well as use of hospital services.

Exclusions: Excludes private hospital cases, overseas visitors, transfers, and waiting list admissions, i.e. the same as standard filter, except that day cases and readmissions within a month are retained.

Figure 5.1 shows age-ethnicity standardised rates and risks for total acute and arranged hospitalisations in the closed-cohort HHP/Non-HHP tenants during Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP periods. After age-ethnicity standardisation, the rates of total acute and arranged hospitalisations decreased significantly, by five percent, from Pre-HHP to Post-HHP for closed-cohort HHP tenants and increased insignificantly, by five percent, from Pre-Non-HHP to Post-Non-HHP. The risk ratios for the closed-cohort HHP/Non-HHP tenants had the same trends, but the changes were smaller and not significant.

Among closed-cohort HHP subgroups, the rates for tenants with Ventilation only reduced significantly, by 15 percent, during Post-HHP period compared with Pre-HHP. However, the rates for the tenants with Insulation increased 10 percent during Post-HHP.

Figure 5.1 Total acute and arranged hospitalisations, age-ethnicity standardised rates/risks and rate ratios/risk ratios for Post-HHP/Non-HHP compared with Pre-HHP/Non-HHP tenants in closed-cohort HHP/Non-HHP
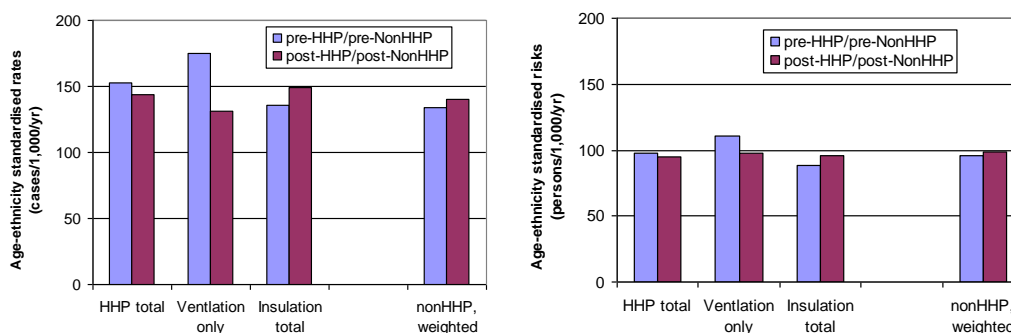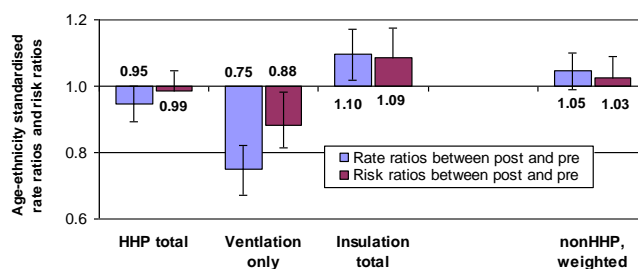
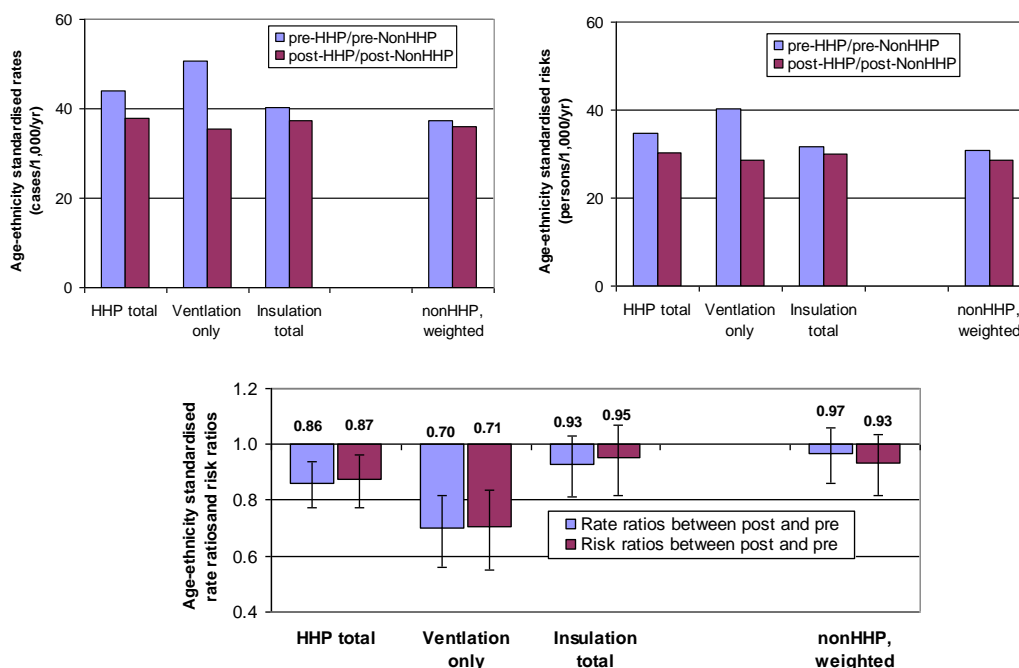## 5.1.2. Total potentially avoidable hospitalisations (PAH)

Scope of indicator: Uses a Ministry of Health (MoH) set of ICD.10 codes for conditions considered Potential Avoidable Hospitalisations (PAH). This approach has been used in NZ to identify avoidable mortality [11] and avoidable hospitalisations.[12] The list of such conditions has been extensively reviewed and revised to ICD.10 for use across NZ and Australia.[13]

Rationale for indicator: PAH include both Ambulatory Sensitive Hospitalisations (ASH) and Population Preventable Hospitalisations (PPH). ASH result from diseases sensitive to prophylactic or therapeutic interventions deliverable in a primary health care setting (e.g. vaccine-Preventable diseases, mammography for early breast cancer, effective glycaemic control in diabetics). They are considered a good indicator of access to primary health care health services. PPH are those resulting from diseases Preventable through population-based strategies (e.g. smoke-free laws, housing improvements, better road safety). PPH provide an indication of the extent that this population is being reached by public health programmes.

Error! Not a valid bookmark self-reference. shows age-ethnicity standardised rates and risks of total PAH hospitalisations in closed-cohort HHP/Non-HHP tenants during Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP. After age-ethnicity standardising, the rates of total PAH hospitalisations decreased significantly, by 14 percent, from Pre-HHP to Post-HHP for the closed-cohort HHP tenants and the risk decreased 13 percent. There were no insignificantly changes of PAH rate and risk for closed-cohort Non-HHP tenants.

Among closed-cohort HHP subgroups, the tenants with Ventilation only had a significant reduction in their PAH rate by about 25 percent and PAH risk by about 12 percent during Post-HHP period compared with Pre-HHP. The tenants with Insulation did not show a significant reduction in PAH rate and risk.

Figure 5.2 Total PAH hospitalisations, age-ethnicity standardised rates/risks and rate ratios/risk ratios for Post-HHP/Non-HHP compared with Pre-HHP/Non-HHP tenants in closed-cohort HHP/Non-HHP

Rate/risk for tenants Ventilation only based on small number

5.1.3. Housing-related potentially avoidable hospitalisations

Scope of indicator: Uses a set of ICD.10 codes for conditions considered to be related to housing conditions and therefore potential avoidable.

Rationale for indicator: This is a subset of PAH that includes conditions considered sensitive to housing conditions (HR-PAH). A Previous component of the Present project defined a set of Housing Sensitive Health Outcomes (which include HR-PAH but also defined some additional indicators)[6] building on work by Gary Jackson et al.[3] It therefore has the potential to provide a single indicator of the health impact of housing conditions.

Figure 5.3 shows age-ethnicity standardised rates and risks of HR-PAH hospitalisations in closed-cohort HHP/Non-HHP tenants during Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP. After age-ethnicity standardising, the rates of HR-PAH hospitalisations decreased significantly, by 20 percent, from Pre-HHP to Post-HHP for the closed-cohort HHP tenants and the risk decreased 18 percent. There were no insignificantly changes of HR-PAH rate and risk for closed-cohort Non-HHP tenants.

Among closed-cohort HHP subgroups, the tenants with Ventilation only had a significant reduction in their HR-PAH rate by about 26 percent and HR-PAH risk by about 34 percent during the Post-HHP period compared with Pre-HHP. The tenants with Insulation had a significant reduction in their HR-PAH rate by about 23 percent

and HR-PAH risk by about 17 percent during the Post-HHP period compared with Pre-HHP.

Figure 5.3 HR-PAH hospitalisations, age-ethnicity standardised rates/risks and rate ratios/risk ratios for Post-HHP/Non-HHP compared with Pre-HHP/Non-HHP tenants in closed-cohort HHP/Non-HHP
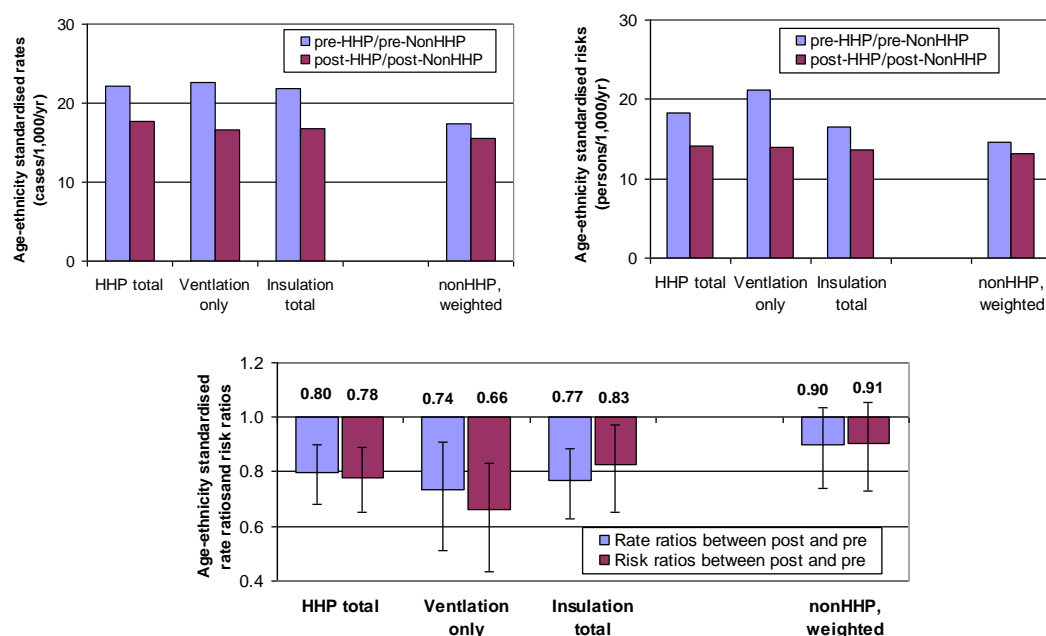
*Rate/risk for tenants Ventilation only based on small number

5.2.   *Hospitalisation rates and risks – specified diseases*

Close-contact infectious diseases

Scope of indicator: Uses a set of ICD.10 codes for Close-Contact Infectious diseases. This indicator is restricted to the infections themselves rather than their late effects.

Rationale for indicator: This approach was based on a set of ICD.9 codes initially developed by the US Centers for Disease Control and Prevention for identifying (and recoding) diseases with an infectious aetiology.[14] This approach has been applied in the US to distinguish infectious disease deaths[14] and hospitalisations.[15-16] This coding scheme has also been used in NZ to describe the burden of disease attributed to infection.[17] We further refined this ICD list by identifying a subset of *close-contact infectious diseases*. These are those where (i) humans are the only or the most important source, (ii) where transmission is by direct physical contact, respiratory transmission, or faecal-oral spread, and (iii) illness is an acute rather than chronic effect of infection. They therefore provide an indicator of the potential effects of household crowding and poor access to washing facilities

Circulatory and respiratory diseases

Scope of indicator: Uses ICD.10 codes for circulatory and respiratory diseases: I00-I99, J00-99

Rationale for indicator: These conditions are related to exposure to indoor cold, damp and mould.

Exclusions: Hospitalisations for housing applicants and tenants are filtered using the standard filter (excludes private hospital cases, overseas visitors, transfers, waiting list cases, day cases, and readmissions within a month).

Mental and behavioural disorders

Scope of indicator: Uses ICD.10 codes for mental and behavioural disorders: F00-F99.

Rationale for indicator: These conditions are considered potentially related to housing conditions.

Exclusions: Hospitalisations for housing applicants and tenants are filtered using the standard filter (excludes private hospital cases, overseas visitors, transfers, waiting list cases, day cases, and readmissions within a month).

Injuries

Scope of indicator: Uses ICD.10 codes for home injury hospitalisations (S00-T99). Occurrence at home identified by additional code (4th digital is 0 in ICD.10 v1, or Y920 in ICD.10 V2&3).

Rationale for indicator: These conditions are considered related to physical hazards in the home.

Exclusions: Hospitalisations for housing applicants and tenants are filtered using the standard filter (excludes private hospital cases, overseas visitors, transfers, waiting list cases, day cases, and readmissions within a month).

Figure 5.4 shows age-ethnicity standardised rates and risks of CCID hospitalisations in the closed-cohort HHP/Non-HHP tenants during Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP periods. The rates of CCID hospitalisations decreased significantly, by 12 percent, from Pre-HHP to Post-HHP for the closed-cohort HHP tenants whereas risk showed a non-significant decline of 11 percent. There was no change for closed-cohort Non-HHP tenants across Pre and Post periods.

Figure 5.5 shows age-ethnicity standardised rates and risks of Circulatory and respiratory disease hospitalisations in the closed-cohort HHP/Non-HHP tenants during Pre-HHP/Pre-Non-HHP and Post-HHP/Post-Non-HHP. The rates of Circulatory and respiratory disease hospitalisations decreased significantly, by 25 percent, from Pre-HHP to Post-HHP for the closed-cohort HHP tenants and the risk showed a significant 19 percent reduction. The rates and risk for closed-cohort Non-HHP tenants showed non-significant increases of 10 percent and 3 percent across Pre and Post periods.

Figure 5.6 show crude rates and risks of Mental health hospitalisations, Home injuries and Other place injuries for the closed-cohort HHP tenants and Non-HHP tenants. The cases numbers were too small to report age-ethnicity standardised rates or risks. All appeared to show declines in rates and risk for the Post-HHP period compared with Pre-HHP period for the closed-cohort HHP tenants. By contrast, rates increased for Non-HHP tenants in the Post compared with Pre periods.

Figure 5.4 CCID hospitalisations, age-ethnicity standardised rates/risks and rate ratios/risk ratios for Post-HHP/Non-HHP compared with Pre-HHP/Non-HHP tenants in closed-cohort HHP/Non-HHP
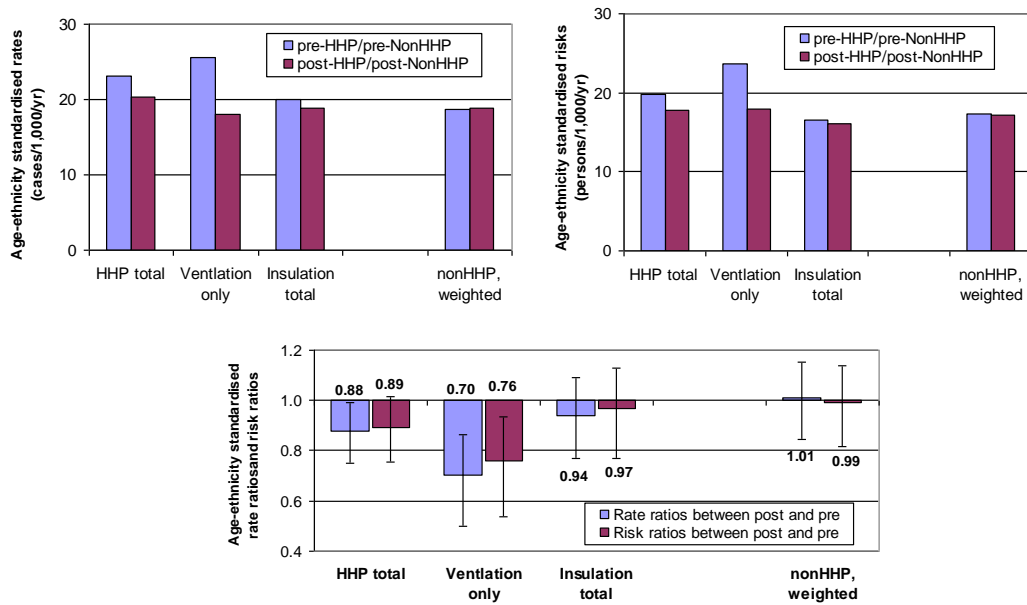
Rate/risk for tenants Ventilation only based on small number

Figure 5.5 Circulatory and respiratory disease hospitalisations, age-ethnicity standardised rates/risks and rate ratios/risk ratios for Post-HHP/Non-HHP compared with Pre-HHP/Non-HHP tenants in closed-cohort HHP/Non-HHP

40
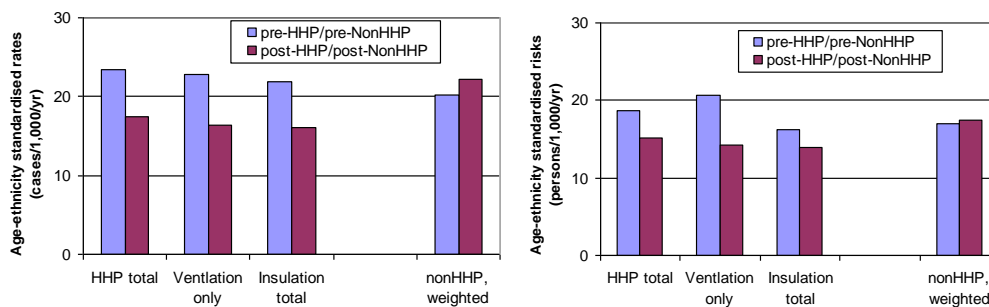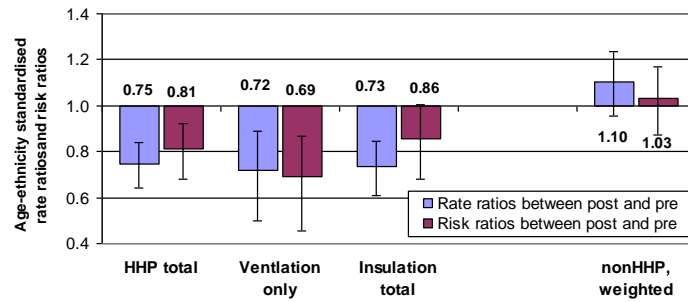
Rate/risk for tenants Ventilation only based on small number

Figure 5.6 Mental health, Home injury and Other injury hospitalisations, crude rates/risks and rate ratios/risk ratios for Post-HHP/Non-HHP compared with Pre-HHP/Non-HHP tenants in closed-cohort HHP/Non-HHP
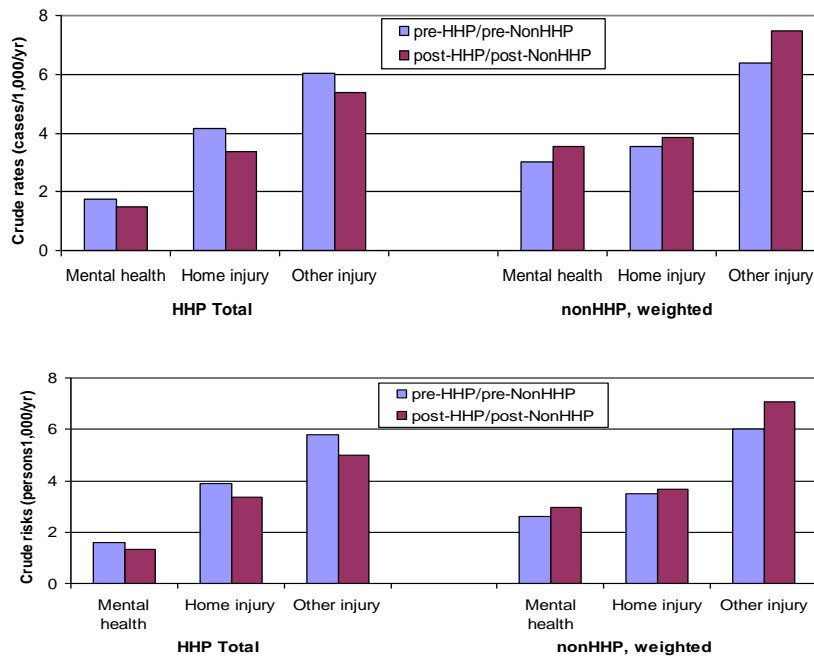
5.3.   *Results of the multivariate analysis*

The change in hospitalisation rates associated with the housing improvements controlling for age group, sex and ethnicity were estimated using Poisson regression with generalised estimating equations to account for the clustering of the observations, as described above. The estimated rates for the year after the remediations compared to the year previous, and controlling for any changes in rates occurring in the control (the Non-HHP) group are shown in Table 5.1, The changes that were statistically significantly different from 1 (i.e., those for which the 95% confidence interval (95%C|I) did not overlap 1) are marked with an asterisk (*). An estimate of 0.75, for example, indicates that the rate following the housing improvements was reduced by 25% relative to the rate before the improvement, controlling for changes in rates occurring in the control group. Although most of the estimated changes show reductions in rates, there is considerable statistical

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uncertainty about the precise degree of change. The asterisked values indicate those changes that we can be more certain are real and not just a consequence of random variation. Where a dash (-) occupies a cell, the data were insufficient to allow the model to produce viable estimates.

These estimates show that for all age groups combined, the regression model fitted to the data estimated that the intervention "Ventilation only" was associated with a statistically significant fall in the total number of acute and arranged hospitalisations of 20% (95%CI -33% to -4%). Participation in the HHP was associated with a fall of 8% (95%CI -19% to +4%) in Total acute and arranged admissions, but this was not statistically significant. Most of the intervention sub-groups were associated with a trend towards reduced hospitalisation rates, the exception being design improvements.

For children under 20 years of age (Table 5.), participation in the Total HHP was associated with a statistically significant fall in the total number of acute and arranged hospitalisations of 27% (95%CI -43% to -6%). All of the interventions sub-groups were associated with reductions in acute and arranged hospitalisations of 20% or more, but these reductions were only significant for "Crowding reduction" which was associated with the largest reduction of 61% (95%CI -79% to -26%) and "Ventilation only" which was associated with a fall of 33% (95%CI -52% to -6%). When looking at specific outcome categories, the most consistent and statistically significant declines were seen for Circulatory and respiratory admissions which fell by 79% (95%CI -95% to -16%) in the "Crowding reduction" sub-group and 53% (95%CI -77.6% to -0.1%) for the HHP in total. Although close contact infectious diseases changed by -69% (95% CI -91% to +1%) in the crowding reduction sub-group, this decline was not statistically significant.

Table 5.1: All HHP residents: estimated rates of hospitalisation following the housing improvements specified compared to before the housing improvements, compared to the Non-HHP group, adjusted for age, sex and ethnicity.

	Close contact infectious diseases	Circ/resp	Housing-related PAH	All Preventable	Home Injury	Other injury	All acute & arranged
Crowding reduction	0.749	0.545	0.53	0.741	0.909	-	0.735
Insulation	0.835	0.773	0.763	0.981	0.547	0.734	1.008
Design improvement	1.012	1.197	1.244	1.293	0.909	-	1.162
Ventilation only	0.593*	0.745	0.786	0.88	1.459	-	0.801*
Heating	0.429	0.419*	0.239*	0.624	2.729	-	0.801
Total HHP	0.769	0.789	0.795	0.94	0.759	0.761	0.921

* Indicates that the confidence interval for the estimate did not overlap with 1

Table 5.2: HHP residents aged less than 20 years: estimated rates of hospitalisation following the housing improvements specified compared to before the housing improvements, compared to the Non-HHP group, adjusted for age, sex and ethnicity.

	Close contact infectious diseases	Circ/resp	Housing-related PAH	All Preventable	Home Injury	Other injury	All acute & arranged
Crowding reduction	0.306	0.213*	0.245*	0.515	-	-	0.392*
Insulation	0.662	0.479	0.775	0.847	0.337	0.622	0.795
Design improvement	0.186	0.388	0.94	0.589	-	-	0.636
Ventilation only	0.787	0.327*	0.705	1.003	0.944	-	0.672*
Heating	0.775	1.453	0.4	0.526	-	-	0.73
Total HHP	0.707	0.473*	0.754	0.868	0.473	0.484	0.734*

* Indicates that the confidence interval for the estimate did not overlap with 1

6.   Discussion

6.1.   Key findings

This evaluation of the HHP provides robust evidence that the programme is effective at reducing the risk of acute hospitalisation in children less than 20 years of age. Participation in the HHP was associated with a statistically significant fall in the total number of acute and arranged hospitalisations of 27% (95%CI -43% to -6%) in the year following completion of the HHP interventions. The effect of the HHP appeared more marked for the most intensive intervention component, Crowding reduction, which was associated with the largest decline of 61% (95%CI -79% to -26%) in acute and arranged admissions.

The HHP was also effective at reducing hospitalisations in the total participant population, but significant declines were only seen for the Ventilation only sub-group where acute and arranged hospitalisations declined by 20% (95%CI -33% to -4%). Participation in the overall HHP was associated with an 8% (95%CI -19% to +4%) decline in Total acute and arranged admissions, but this decline was not statistically significant.

Findings of this evaluation are consistent with those from the recently published evaluation by Jackson et al.[21] They also found a significant reduction in acute hospitalisations for younger participants in the HHP (for those aged 5-34 years they observed a 23% reduction, hazard ratio = 0.77, 95%CI 0.70-0.85).

This present evaluation adds several methodological refinements to the evaluation by Jackson et al:

- We introduce a comparison Non-HHP population which is sampled in a manner that effectively adjusts for changes in overall hospitalisation rates over time (ie period effects).

- While the number of HHP tenants in the closed-cohort (7,477) is slightly less than in the Jackson study, it derives added statistical power from using the comparison population of 27,903 Non-HHP tenants. This study is therefore able to look at the impact of specific intervention sub-groups within the HHP. This analysis is

important as some categories (such as crowding reduction) are relatively expensive.

- This analysis has added a wider set of housing related outcome categories to help assess the plausibility of the relationships being investigated.

An important observation was that hospitalisation rates in the tenant population overall (ie the Non-HHP population) have been rising markedly during the observation period. Hospitalisation rates increasing by 24% from 2005 to 2009. This finding was one of the reasons for using a control population (Non-HHP tenants). This rising trend also has important health implications as it implies an increasingly vulnerable tenant population in general, making the need for the HHP even more important.

The results of the closed-cohort analysis reported here have focussed on hospitalisation rates, which are based on the frequency of hospitalisations over the observation period and allow multiple admissions for the same individual for the same condition. The univariate results have also reported on hospitalisation risk, which only counts the first time an individual is admitted during the observation period (in this case one year). We looked at this additional measure of hospitalisation to see whether our results might be unduly influenced by a small number of patients with extremely high hospitalisation rates. The univariate analyses showed that hospitalisation rates, and RRs were very similar for both rate and risk measures.

6.2.   Conclusions and implications

The consistency of findings from this evaluation of the HHP with those from Jackson et al.[21] provide strong evidence that this programme is highly effective at reducing acute hospitalisations in children and young adults and these reductions are substantial. This present evaluation used different data sources, methods and time periods to those in the Jackson et al study, so it is reassuring that it has shown broadly similar findings.

There is also evidence that some specific components of the HHP may be able to achieve even greater reductions in hospitalisations, notably the more intensive crowding reduction sub-group.

A few of the findings of the evaluation are less consistent with existing research findings, so require further investigation. The insulation sub-group includes those who also receive ventilation, and sometimes other interventions as well. We might therefore expect this group to have better outcomes than the ventilation only group, but that was not generally the case. Receiving the insulation intervention was still associated with reduced hospitalisations, particularly for circulatory and respiratory admissions, but this decline did not reach statistical significance. The housing insulation community trial previous carried in NZ by *He Kainga Oranga* showed health improvements for housing occupants following insulation of their homes.[20] This positive impact included a trend towards reduced hospital admissions for respiratory conditions.

Findings from this evaluation will add to the small published evidence base on the health effects of housing improvements [18-19].

6.3. Limitations

This Present study has several limitations.

- Outcomes measured - Hospitalisations only measure a proportion of the health impact of housing conditions and housing improvements. By definition, they include the severe end of the disease spectrum. In addition, some types of hospitalisations are excluded, such as those containing most elective surgical cases, because they are likely to be strongly influenced by health service factors. There is also a need to focus on acute effects of housing exposures.

- Errors in assigning person time - Accurately assigning participants and their person-time to the study is prone to some error. Some of these errors reflect the limitations of using administrative data, which are collected for applicant and tenant management purposes. However, none of these limitations are likely to have been of sufficient importance to alter the major findings of this research. One group that is particularly difficult to accurately identify in the study are newborn children. They will spend several months living in a household before there is an opportunity to record them on the IRR form, which is typically completed once a year. Even then, they may be omitted from this form. This problem is being partly addressed by a correction process that will be applied to future analyses.

- Study design – This study uses an 'open cohort' approach which allows participants to enter and leave Pre-HHP and Post-HHP households (analogous to the 'tenancy duration approach' used for investigating the health effects of social housing). An alternative method would be a 'closed-cohort' approach restricted to a cohort of tenants who spent a specified amount of time in Pre-HHP and Post-HHP households (analogous to the 'comparative cohort' approach Previous used).

- Systematic differences between intervention and comparison groups - This cohort analysis is not a controlled trial where a careful randomisation process decides those receiving the HHP or not receiving it. Instead, the allocation is deliberately non-random with the HHP provided to the more deprived neighbourhoods. However, the fact that individual households are allocated to the HHP on the basis of neighbourhood, rather than individual circumstances, does reduce this selection bias. A further consideration is that about a third of those allocated to the HHP choose not to participate (the Optout-HHP group). This later group is likely to have systematic differences from those who chose to have the HHP.

- Cohort effects – We need to be cautious in conclusions we draw from observing changes in hospitalisation rates in tenants over time. There is considerable potential for 'cohort effects' caused by changes in the wider social, economic and health environment in NZ. Changes in employment levels, the cost of living, and other external factors could alter hospitalisation rates over time independent of the effects of housing conditions. The closed-cohort analysis should largely eliminate these effects as it includes a control population of Non-HHP tenants.

- Seasonal effects – These are another form of potential systematic difference between the intervention and comparison groups. This may arise where these groups have been exposed to differences in weather or temperatures because of the timing of recruitment or interventions. As shown in Table 4.7 and Figure 4.1 the distribution of intervention start times (Post-HHP) and Optout start times (Optout-HHP) was fairly even during the year. However, the majority of Pre-HHP

and Non-HHP effectively began on 1 July 2003 when the study observation period started. Again, the closed-cohort analysis should largely eliminate such effects as it follows HHP participants and the Non-HHP control group for a complete year before and after the intervention (or selection date in the case of the Non-HHP group).

- Age effects – Some of the differences seen in the comparative analyses may be caused by age effects. Households living as Housing New Zealand tenants inevitably age over time, with fewer infants and young children and a higher proportion of elderly. This aging of the cohort population is likely to particularly affect Pre-HHP and Post-HHP comparisons. These effects are largely adjusted using age-standardisation, but there may be some residual effect. Again, the closed- cohort analysis should largely eliminate such effects as they should apply equally to both the HHP participants and the Non-HHP control group. Age is also included as a co-variate in the multivariate model thus providing additional control for this effect.

- Difficulty in studying effects on young children – The nature of the intervention means that very few participants will be infants (<1 years of age) during both the Pre-HHP and Post-HHP periods that would allow assessment of the effect of the HHP on this age group. The closed-cohort analysis effectively excludes infants as it requires participants to have been living in a Pre-HHP household for at least one year. Young children are particularly vulnerable, as shown by their high rates of hospitalisation overall, and for specific diseases such as bronchiolitis which have their peak incidence in the first two years of life. By not including this age group, we may be underestimating the impact of the HHP. Probably the only way to assess the impact of the HHP on this age group is to use an open-cohort approach which allows newborn babies to be added to the Post-HHP population.

- Generalisability of findings - The Housing New Zealand social housing population is not representative of the total NZ population. The social allocation formula used by Housing New Zealand specifically selects tenants with low income and high need. The population has a relatively high proportion of children, Māori and Pacific People, and sole-parent households relative to the wider NZ population. After adjusting for age and ethnicity, it still has significantly higher rates of hospitalisation for most conditions. Even among this population, the HHP was deliberately focussed towards more deprived suburbs. Consequently, there may be limits on generalising the effects of the HHP on this highly vulnerable population to the total NZ population.

6.4. Further work

The use of the closed-cohort multivariate analysis used here has overcome most of the limitations of the previous evaluation of the HHP. There is, however, further work useful work that could be carried out to improve the usefulness and rigour of this evaluation:

- It would also be possible to specifically investigate the potential impact of the HHP on recorded levels of household crowding and active and passive smoke exposure.

- This study could be continued for one or more years into the future to increase its study power. This extension would be useful as it would allow us to assess whether the beneficial effects of the HHP continued for longer periods that the one-year focus of the current closed-cohort analysis. It could also provide greater statistical power to examine the effects of specific intervention sub-groups (eg crowding reduction) and population groups (eg age-groups). Such an extension would allow inclusion of additional households in other regions (notably Wellington).

- It would also be possible to conduct an Intention to Treat (ITT) analysis. This analysis could be done by adding in the Optout group to the analysis ie pooling those in the Post-HHP and Post-Optout-HHP and comparing them with the pooled Pre-HHP and Pre-Optout-HHP.

- It would be useful to know more about the Optout-HHP group, in particular their reasons for opting out. Reasons for these households opting out could usefully be explored by in-depth qualitative interviews, as their non-participation complicates Housing New Zealand's strategy to improve their housing stock and means that these, and subsequent households occupying this stock, will continue to suffer from the effects of cold, damp housing.

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7. Appendix

7.1. Rules for establishing cohort

In a relatively small proportion of households, individuals with the same reference number (Household reference number/NHI number) appeared in different applications or tenancies with overlapping time. The following rules and research assumptions were developed to remove overlapping time by assigning person time or in some cases excluding person time entirely.

- The person was recorded as a housing applicant, and then became a tenant, while still being recorded as an applicant. Time as a tenant retained, but time as an applicant removed while any overlap occurred.
- The person was recorded as a tenant, and then became a housing applicant, while still being recorded as a tenant. Time as a tenant retained, but time as an applicant removed while any overlap occurred.
- The person was included in two applications at the same time. Second application was assumed to supersede first, which was exited at the time the second application was made.
- A subset of these overlapping applications are those with the same start date. Because it was difficult to know which application to assign the person to, these subjects are **excluded**.
- The person was included in three or more applications at the same time. These subjects are **excluded** from the study because of the high level of uncertainty around which household to assign them to.
- The person was included in two tenancies at the same time. The second tenancy was assumed to supersede the first, which was exited at the time the second tenancy started.
- A subset of these overlapping tenancies are those with the same start and finish date. Because it was difficult to know which tenancy to assign the person to, these subjects are **excluded**.
- A further subset of these overlapping tenancies are those where one was included within the other i.e. the second one has a later start date and an earlier finish date than the other. Because it was difficult to know which tenancy to assign the person to, these subjects are **excluded**.
- The person was simultaneously included in three or more tenancies. These subjects are **excluded** from the study because of the high level of uncertainty around which household to assign them to.
- The person was simultaneously included in a mix of multiple applications and tenancies. These subjects are **excluded** from the study because of the high level of uncertainty around which household to assign them to.

Other research assumptions to be used in future analyses:
- In long-term data collection, some individuals disappeared in some IRR forms and then appeared again. If an individual missed only one IRR form, the person was assumed to be still in the household. If the person missed 2+ IRR forms, then the

person was assumed to leave the household during that period when they did not appear on an IRR.

- Adjusting for infants not recorded on the IRR. For children who are less than 5 years of age when they first appear in the Housing New Zealand database (IRR), if their household tenancy started before that date, and it had stable female adults (same number of female adults in households) since lease start time, then adjust the start time for these children in the Housing New Zealand household to their household lease start time or children's date of birth.

7.2. Hospitalisations rates for HHP, Optout-HHP and Non-HHP tenants

Table 7.1 Hospitalisation rates in Post-HHP tenants compared with Pre-HHP, Optout-HHP, and Non-HHP[4] tenants, according to outcomes, and intervention sub-groups, Auckland and Northland, July 2003-December 2008

Health outcome category, HHP population, and Intervention sub-group	Number of hosps.	Crude rate per 1,000	Age standard-ised rate per 1,000[1]	Age ethnicity standard-ised rate per 1,000[1]	Rate ratio[2]	CI (95%CI)	
Total acute and arranged hospitalisation							
Post-HHP							
Total	5,182	146.7	154.4	159.4			
vs. Pre-HHP					1.10	1.07	1.13
vs. Post Optout-HHP					1.05	1.01	1.09
vs. Non-HHP					0.97	0.95	0.99
Ventilation only	1,554	140.7	149.2	159.3			
vs. Pre-HHP					0.97	0.92	1.02
vs. Post Optout-HHP					1.05	1.00	1.10
vs. Non-HHP					0.97	0.94	1.00
Insulation total	3,089	147.9	153.3	157.1			
vs. Pre-HHP					1.16	1.12	1.20
vs. Post Optout-HHP					1.04	1.00	1.08
vs. Non-HHP					0.95	0.93	0.98
Heating total (Māori only)	269	160.9	170.6				
vs. Pre-HHP					0.97	0.88	1.08
Design improvement total (Māori & Pacific People)	391	179.0	175.3	139.1			
vs. Pre-HHP					0.95	0.86	1.05
Crowding reduction total (Māori and Pacific People)	601	136.3	161.2	*161.2*			
vs. Pre-HHP					0.92	0.85	1.01
Pre- HHP							
Total	3,379	137.7	143.2	145.4	1.00	-	-
Ventilation only	948	147.4	151.9	164.0	1.00	-	-
Insulation total	2,153	131.7	137.3	135.7	1.00	-	-
Heating total (Māori only)[3]	167	156.7	175.7		1.00	-	-
Design improvement total (Māori and Pacific People)[3]	234	162.6	162.0	146.9	1.00	-	-
Crowding reduction total (Māori and Pacific People)	337	141.4	143.6	174.6	1.00	-	-
Optout-HHP							
Post Optout-HHP	1,479	149.7	149.7	151.6	1.09	1.05	1.15
Pre Optout-HHP	1,204	133.1	139.2	138.5	1.00	-	-
Non-HHP[4]							
Total	53,809	162.2	161.2	164.8	1.00	-	-
Potentially avoidable hospitalisations (PAH age<75 years)							

Health outcome category, HHP population, and Intervention sub-group	Number of hosps.	Crude rate per 1,000	Age standard-ised rate per 1,000[1]	Age ethnicity standard-ised rate per 1,000[1]	Rate ratio[2]	CI (95%CI)	
Post-HHP							
Total	1,574	45.5	51.8	47.7			
vs. Pre-HHP					1.08	1.02	1.14
vs. Post Optout-HHP					1.12	1.04	1.19
vs. Non-HHP					1.00	0.96	1.03
Ventilation only	468	43.2	47.6	48.0			
vs. Pre-HHP					0.91	0.82	1.00
vs. Post Optout-HHP					1.12	1.03	1.23
vs. Non-HHP					1.00	0.94	1.07
Insulation total	924	45.2	51.3	44.8			
vs. Pre-HHP					1.11	1.04	1.19
vs. Post Optout-HHP					1.05	0.98	1.13
vs. Non-HHP					0.94	0.90	0.98
Heating total (Māori only)	98	59.4	82.7				
vs. Pre-HHP					1.27	1.04	1.56
Design improvement total (Māori & Pacific People)	83	39.0	45.2	34.4			
vs. Pre-HHP					1.18	0.93	1.50
Crowding reduction total (Māori and Pacific People)	108	24.7	32.3	27.3			
vs. Pre-HHP					0.80	0.67	0.95
Pre- HHP							
Total	677	28.0	27.6	25.4	1.00	-	-
Ventilation only	210	33.2	31.7	28.2	1.00	-	-
Insulation total	412	25.6	25.5	23.8	1.00	-	-
Heating total (Māori only)[3]	37	35.0	39.8		1.00	-	-
Design improvement total (Māori and Pacific People)[3]	37	26.2	26.1	29.1	1.00	-	-
Crowding reduction total (Māori and Pacific People)	90	38.1	32.6	34.1	1.00	-	-
Optout-HHP							
Post Optout-HHP	423	43.8	46.6	42.7	1.11	1.02	1.21
Pre Optout-HHP	348	39.1	41.9	38.6	1.00	-	-
Non-HHP[4]							
Total	14,435	44.9	47.7	47.7	1.00		
Housing-related potentially avoidable hospitalisations (HR-PAH age<75 years)							
Post-HHP							
Total	854	24.7	27.4	24.3			
vs. Pre-HHP					0.96	0.90	1.02
vs. Optout-HHP					1.00	0.92	1.08
vs. Non-HHP					0.95	0.91	1.00
Ventilation only	277	25.6	27.2	26.1			
vs. Pre-HHP					0.93	0.82	1.04
vs. Optout-HHP					1.07	0.97	1.19
vs. Non-HHP					1.02	0.95	1.10
Insulation total	458	22.4	24.8	20.8			
vs. Pre-HHP					0.87	0.80	0.95
vs. Optout-HHP					0.85	0.78	0.93

Health outcome category, HHP population, and Intervention sub-group	Number of hosps.	Crude rate per 1,000	Age standard-ised rate per 1,000[1]	Age ethnicity standard-ised rate per 1,000[1]	Rate ratio[2]	CI (95%CI)	
vs. Non-HHP					0.81	0.77	0.86
Heating total (Māori only)	41	24.8	39.5				
vs. Pre-HHP					0.99	0.74	1.34
Design improvement total (Māori & Pacific People)	83	39.0	45.2	34.4			
vs. Pre-HHP					1.18	0.93	1.50
Crowding reduction total (Māori and Pacific People)	108	24.7	32.3	27.3			
vs. Pre-HHP					0.80	0.67	0.95
Pre- HHP							
Total	677	28.0	27.6	25.4	1.00	-	-
Ventilation only	210	33.2	31.7	28.2	1.00	-	-
Insulation total	412	25.6	25.5	23.8	1.00	-	-
Heating total (Māori only)[3]	37	35.0	39.8		1.00	-	-
Design improvement total (Māori and Pacific People)[3]	37	26.2	26.1	29.1	1.00	-	-
Crowding reduction total (Māori and Pacific People)	90	38.1	32.6	34.1	1.00	-	-
Optout-HHP							
Post Optout-HHP	261	27.0	28.9	24.4	1.20	1.08	1.32
Pre Optout-HHP	196	22.0	23.7	20.4	1.00	-	-
Non-HHP[4]							
Total	8,032	25.0	25.7	25.5	1.00	-	-
Close contact infectious diseases							
Post-HHP							
Total	949	26.9	28.4	26.0			
vs. Pre-HHP					1.06	1.00	1.13
vs. Optout-HHP					1.06	0.98	1.15
vs. Non-HHP					1.01	0.97	1.06
Ventilation only	268	24.3	25.4	25.5			
vs. Pre-HHP					1.01	0.90	1.14
vs. Optout-HHP					1.04	0.94	1.15
vs. Non-HHP					0.99	0.92	1.07
Insulation Total	549	26.3	27.7	24.5			
vs. Pre-HHP					1.02	0.94	1.10
vs. Optout-HHP					1.00	0.92	1.09
vs. Non-HHP					0.95	0.90	1.01
Heating total (Māori only)	52	31.1	35.1				
vs. Pre-HHP					0.92	0.73	1.16
Design improvement total (Māori & Pacific People)	87	39.8	40.3	30.5			
vs. Pre-HHP					0.90	0.71	1.12
Crowding reduction total (Māori and Pacific People)	144	32.7	41.5	35.3			
vs. Pre-HHP					1.14	0.96	1.35
Pre- HHP							
Total	647	26.4	25.8	24.5	1.00	-	-
Ventilation only	172	26.8	25.9	25.3	1.00	-	-

Health outcome category, HHP population, and Intervention sub-group	Number of hosps.	Crude rate per 1,000	Age standardised rate per 1,000[1]	Age ethnicity standardised rate per 1,000[1]	Rate ratio[2]	CI (95%CI)	
Insulation total	420	25.7	25.3	24.0	1.00	-	-
Heating total (Māori only)[3]	37	34.7	38.3		1.00	-	-
Design improvement total (Māori and Pacific People)[3]	46	32.0	33.5	34.1	1.00	-	-
Crowding reduction total (Māori and Pacific People)	80	33.6	30.0	31.1	1.00	-	-
Optout-HHP							
Post Optout-HHP	268	27.1	28.7	24.5	1.13	1.03	1.25
Pre Optout-HHP	199	22.0	23.7	21.6	1.00	-	-
Non-HHP[4]							
Total	8,711	26.3	26.0	25.6	1.00	-	-
Circulatory and respiratory diseases							
Post-HHP							
Total	961	27.2	29.7	27.7			
vs. Pre-HHP					1.04	0.97	1.10
vs. Optout-HHP					1.00	0.92	1.08
vs. Non-HHP					0.97	0.93	1.01
Ventilation only	282	25.5	28.5	29.2			
vs. Pre-HHP					1.03	0.93	1.15
vs. Optout-HHP					1.05	0.95	1.16
vs. Non-HHP					1.03	0.95	1.10
Insulation Total	547	26.2	28.3	25.5			
vs. Pre-HHP					1.04	0.96	1.13
vs. Optout-HHP					0.92	0.84	1.00
vs. Non-HHP					0.90	0.85	0.95
Heating total (Māori only)	50	28.9	32.3				
vs. Pre-HHP					0.72	0.57	0.91
Design improvement total (Māori & Pacific People)	81	37.1	37.5	28.8			
vs. Pre-HHP					0.92	0.72	1.17
Crowding reduction total (Māori and Pacific People)	118	26.8	39.3	30.7			
vs. Pre-HHP					1.04	0.87	1.25
Pre- HHP							
Total	668	27.2	28.1	26.7	1.00	-	-
Ventilation only	203	31.6	31.7	28.2	1.00	-	-
Insulation total	402	24.6	25.3	24.4	1.00	-	-
Heating total (Māori only)[3]	36	33.8	44.6		1.00	-	-
Design improvement total (Māori and Pacific People)[3]	40	27.8	28.3	31.3	1.00	-	-
Crowding reduction total (Māori and Pacific People)	76	31.9	30.2	29.4	1.00	-	-
Optout-HHP							
Post Optout-HHP	292	29.6	30.2	27.7	1.11	1.01	1.23
Pre Optout-HHP	219	24.2	26.7	24.9	1.00		
Non-HHP[4]							
Total	9,666	29.1	28.8	28.4	1.00	-	-
Mental health							

Health outcome category, HHP population, and Intervention sub-group	Number of hosps.	Crude rate per 1,000	Age standard-ised rate per 1,000[1]	Age ethnicity standard-ised rate per 1,000[1]	Rate ratio[2]	CI (95%CI)	
conditions							
Post-HHP							
Total	64	1.8	1.9	3.4			
vs. Pre-HHP					0.71	0.58	0.87
vs. Optout-HHP					1.06	0.82	1.37
vs. Non-HHP					0.78	0.67	0.91
Pre- HHP							
Total	72	2.9	3.1	4.8	1.00	-	-
Optout-HHP							
Post Optout-HHP	31	3.1	3.1	3.2	1.15	0.85	1.54
Pre Optout-HHP	26	2.9	2.9	2.8	1.00		
Non-HHP[4]							
Total	1,251	3.8	3.8	4.4	1.00	-	-
Home injury							
Post-HHP							
Total	160	4.5	4.7	5.6			
vs. Pre-HHP					1.01	0.86	1.18
vs. Post Optout-HHP					1.05	0.81	1.35
vs. Non-HHP					1.05	0.95	1.17
Pre- HHP							
Total	106	4.3	4.3	5.5	1.00	-	-
Optout-HHP							
Post Optout-HHP	42	4.3	4.3	5.3	1.09	0.82	1.44
Pre Optout-HHP	45	5.0	5.1	4.9	1.00	-	-
Non-HHP[4]							
Total	1,646	5.0	4.9	5.5	1.00	-	-
Non-home injury							
Post-HHP							
Total	238	6.7	6.8	7.1			
vs. Pre-HHP					0.92	0.81	1.04
vs. Optout-HHP					1.26	1.07	1.49
vs. Non-HHP					0.96	0.88	1.05
Pre- HHP							
Total	169	6.9	7.1	7.8	1.00	-	-
Optout-HHP							
Post Optout-HHP	61	6.2	5.9	5.7	1.05	0.83	1.32
Pre Optout-HHP	39	4.3	4.5	5.4	1.00	-	-
Non-HHP[4]							
Total	2,397	7.2	7.2	7.4	1.00	-	-
Excess winter hospitalisation (circulatory and respiratory)							
Post-HHP (Total)							
Winter (June-September)	426	35.6	39.2	36.9	1.45	1.33	1.57
Other Months	545	23.3	25.4	25.5	1.00	-	-
Pre- HHP (Total)							
Winter (June-September)	299	34.6	35.2	33.2	1.39	1.26	1.52
Other Months	370	23.3	24.3	23.9	1.00	-	-
Post Optout-HHP							
Winter (June-September)	125	37.2	38.0	34.0	1.34	1.18	1.52
Other Months	171	26.2	26.8	25.4	1.00	-	-

Health outcome category, HHP population, and Intervention sub-group	Number of hosps.	Crude rate per 1,000	Age standard-ised rate per 1,000[1]	Age ethnicity standard-ised rate per 1,000[1]	Rate ratio[2]	CI (95%CI)	
Pre Optout-HHP							
Winter (June-September)	96	30.3	33.8	32.2	1.43	1.23	1.66
Other Months	122	20.8	22.9	22.6	1.00	-	-
Non-HHP[4]							
Winter (June-September)	4,489	39.2	38.7	38.4	1.59	1.56	1.63
Other Months	5,276	24.3	24.0	24.3	1.00	-	-

1 Age and age-ethnicity standardised to the distributions of the tenant population in 2006

2 Rate ratios calculated using Pre-HHP, Optout-HHP and Non-HHP rates as the reference values.

3 Note that most people in these intervention sub-groups received multiple interventions, including ventilation and insulation if not already insulated

4 Non-HHP tenants are from Auckland and Northland

* Small numbers of hospitalisations means low numbers in some age-ethnicity cells so only crude rates and rate ratios are Presented.