HEALTHY HOMES INITIATIVE OUTCOMES EVALUATION SERVICE: INITIAL ANALYSIS OF HEALTH OUTCOMES

Motu Note #37

Nevil Pierse, Maddie White, Lynn Riggs

Motu Economic and Public Policy Research

nevil.pierse@otago.ac.nz, maddie.white@otago.ac.nz, lynn.riggs@motu.org.nz

SUMMARY HAIKU

Poor quality homes
cause injuries and illness
worth millions each year.

INTRODUCTION TO THE HHI OUTCOMES EVALUATION

The purpose of the Healthy Homes Initiative (HHI) Outcomes Evaluation is to determine whether the HHIs have improved health and social outcomes for families who have taken part, and whether the programme offers value for money.

The evaluation is co-funded by the Ministry of Health, Housing New Zealand (HNZ) and the Ministry of Housing and Urban Development (MHUD). The findings from this evaluation will inform and enable cross agency efficiencies in the HHI process to support health, social and wellbeing outcomes.

This is a staged evaluation, with this report including an overview of health outcomes and indicative savings to the health sector in the first year after HHI referral and receiving interventions. The next phase will use a bigger sample size of referrals to HHI providers, additional methodologies that will use controls to allow benefits across each of the four target populations to be captured, and longer follow-up periods. More detailed data from providers on specific interventions that have been received by each intervention will also allow the evaluation to include an investigation of the relative impacts of different interventions. Bringing this data into the IDI will ensure the evaluation can consider a wider range of health, wellbeing, and social outcomes that the multifaceted approach of the HHIs is designed to support.

A process evaluation of the HHIs was completed in May 2018. Overall, the evaluation found that the HHIs are exceeding or meeting expectations in all key areas and a number of opportunities across agencies were identified to strengthen the model's effectiveness.

BACKGROUND TO THE HHIS

The aim of the HHIs is to increase the number of children living in warm, dry and healthy homes and to reduce avoidable hospitalisations and ill health due to housing-related conditions.

The HHIs were established between December 2013 and March 2015 and cover 11 District Health Boards (DHBs) with high incidence of rheumatic fever (including Auckland, Waitematā, Counties Manukau, Northland, Waikato, Hutt Valley, Capital & Coast, Lakes, Bay of Plenty, Hawke's Bay and Tairāwhiti). Initially, the HHIs targeted low-income families with children at risk of rheumatic fever who were living in crowded households. The breadth of the programme was expanded in 2016 to focus more broadly on warm, dry and healthy housing for low-income families with 0 to 5 year-old children and pregnant women. The expanded eligibility criteria include: 0-5 year olds hospitalised with a specified housing-related indicator condition; families with children aged 0-5 years old with at least two of the social investment risk-factors; or pregnant women and newborn babies.

The HHI providers identify eligible families, undertake a housing assessment and then work across agencies to facilitate access to a range of interventions to create warmer, drier, healthier homes. These interventions can include: insulation,

The evaluation is co-funded by the Ministry of Health, Housing New Zealand and the Ministry of Housing and Urban Development. The results and opinions expressed in this study are the work of the authors.

curtains, heating sources, minor repairs and private/community/social housing relocation. They also provide information to families about practices to help keep a house warm and dry, and to reduce risks associated with household crowding.

Since the inception of the HHIs, the Ministry has worked closely with key government agencies, such as Housing New Zealand (HNZ), the Ministry of Social Development (MSD), the Energy Efficiency and Conservation Authority (EECA), the Ministry of Business, Innovation and Employment (MBIE) and the Ministry of Housing and Urban Development (MHUD), to improve and streamline processes (or to develop new ones) for families most in need. As at 30 December 2018, 15,330 referrals have been made to the HHIs and over 40,000 interventions have been provided, to families.

METHODOLOGY

Data sources: Referral data

HHIs provided data to the evaluation team for HHI referrals to their service that met the criteria outlined in Table 1.

Table 1: Referral criteria.

Include whānau if:
• You have the NHI of referred client and/or the NHI of others in the household.
• You know the earliest and latest date(s) of the intervention(s) being received. If this isn't available, you have the date of the housing assessment or the date that the referral was sent to you.
• You are confident this whānau has moved through the HHI process (including interventions) in a way that you're happy with, and this whānau has successfully received at least one intervention.
• The whānau received interventions at any point during 2015 and 2017.

The HHI providers supplied the NHIs (of both the primary client and household members, where available), earliest date of earliest intervention and the date of latest intervention. Additional information requested was the tenure of the property assessed and whether the referral met the rheumatic fever or 0-5 eligibility criteria.

The earliest intervention date was explained to providers as the earliest date that any intervention was delivered to a whānau. The date of housing assessment was usually supplied for this as assessors normally provide the household with key messages for healthy homes behaviour and/or a mould kit at this time. The latest date of intervention was explained as the date after which there was no substantial engagement with the whānau in terms of delivering any further interventions. Many providers continue to keep all clients on their books in an attempt to get needed interventions no matter the time delay. However, for this analysis we assumed that the latest date provided for each referral represented the end of substantial HHI engagement of a whānau for a given referral.

By the end of January 2018, all information had been supplied by providers in eight of the nine regions to an independent statistician. This ensured the study statisticians did not see any unencrypted NHIs, in accordance with the granted HDEC ethics.[1] The data was checked for validity of NHIs and made more complete where possible in direct consultation with providers.

1 Ethics was obtained by Nevil Pierse for this study from HDEC (ref 15/STH/138/AM02).

Data sources: National collections data on health outcomes

All NHIs were then encrypted by the New Zealand Health Information Systems (NZHIS) and matched with the National Minimum Dataset (NMDS) of publicly funded hospital discharges and Pharmaceutical Collection of all community pharmaceutical dispensings The hospitalisations and pharmaceutical dispensings data covered the period 2012 to 2018. Records were restricted to all those valid NHIs received from providers as either the primary client or as a household member.

Data sources: Programme cost data

The indicative programme cost data (based on the Funding Model Review completed in 2018[2]) of $1205 per family was provided by the Ministry of Health, and this has been used to inform the analysis of costs and benefits. It is important to note that this does not include the costs associated with provision of some of the interventions. These costs are more often met through donations of funds or time, or other programmes.

Sample description

In total, 4,093 referrals were received by HHI providers with a primary client identified in each case. A number of referrals also had at least one associated household member's NHI; these other household members were not included in the sample for this evaluation of health gains because this level of data collection was relatively uncommon.

Referrals were then selected where the primary client referred could be linked to health records, had dates provided for both the beginning and end of their HHI referral engagement (i.e. receiving interventions), had a full year before and after intervention start and end dates to evaluate health records across, and were within a suitable age range.

For this analysis, the data was therefore specifically restricted to:

1. Referrals whose interventions had been finished by the end of 2017 (i.e. intervention end date no later than 31st December 2017).
    - This was in order to allow for a full year post-intervention to be observed with available health data, which was available for records only up until 31st December 2018.
2. Referrals where the primary client referred was aged between 2 and 15 years old at the time of the earliest intervention.
    - This was in order to exclude birth and early-life related hospitalisations in those aged 0-1 in the year before HHI intervention.

The flowchart below demonstrates how the evaluation sample of 1,608 referrals was selected from this group.

Figure 1: Evaluation sample

Methods: Event definitions

Hospitalisation: Each line entry in the hospitalisation database is taken as an individual hospitalisation. This means that transfers between hospitals (or occasionally, wards) as well as discharge and same-day readmission as separate hospitalisations have been counted separately. These events are rare.

- The cost weights were used to estimate the cost of hospitalisations and the length of stay to estimate the number of nights spent in hospital.

GP visit: Records from the Pharmaceutical Collection were used as a proxy for GP visits. A visit to a family doctor for a child is assumed to have occurred with each unique day a non-repeat dispensing is recorded. Hence, each child is limited to one GP visit per day.

- The cost of a GP visit to the Government was estimated using from the Treasury CBAx Tool.

2 The cost data were provided under the condition that they only be used for the cost-benefit evaluation, and they are kept in a restricted access folder at Motu.

Pharmceutical dispensing: Pharmaceutical items dispensed is a count of the number of dispensings (type of item) from a script filled at community pharmacists. This includes repeat prescriptions.

- The average cost of a prescription was estimated using the average 2017 cost of a pharmaceutical prescription for housing-related conditions for all children in New Zealand less than 15 years. The provided pharmaceutical data did not include prescription cost information, so we use an unpublished estimate from Lucy Telfar-Barnard.

There are four types of hospitalisation events that are discussed in the remainder of this document.

- Hospitalisation: all-cause hospitalisations, for any condition. The total number of hospitalisations averted is used for the final estimates of hospitalisations prevented that can be attributed to the HHIs.
- Housing-sensitive hospitalisation (HSH): these are also referred to as the 'indicator' conditions in the eligibility criteria for two out of the four target groups for HHI referrals.
- Potentially attributable to the home environment (PAHHE) hospitalisation: This is a broader range of conditions identified as being related to the home environment.

Events that are PAHHE but that are not considered HSH have been used in the process of estimating selection bias for the analysis of hospitalisations averted in the year post-intervention across all referrals that can reasonably be attributed to the HHIs.

Methods: Unit of analysis

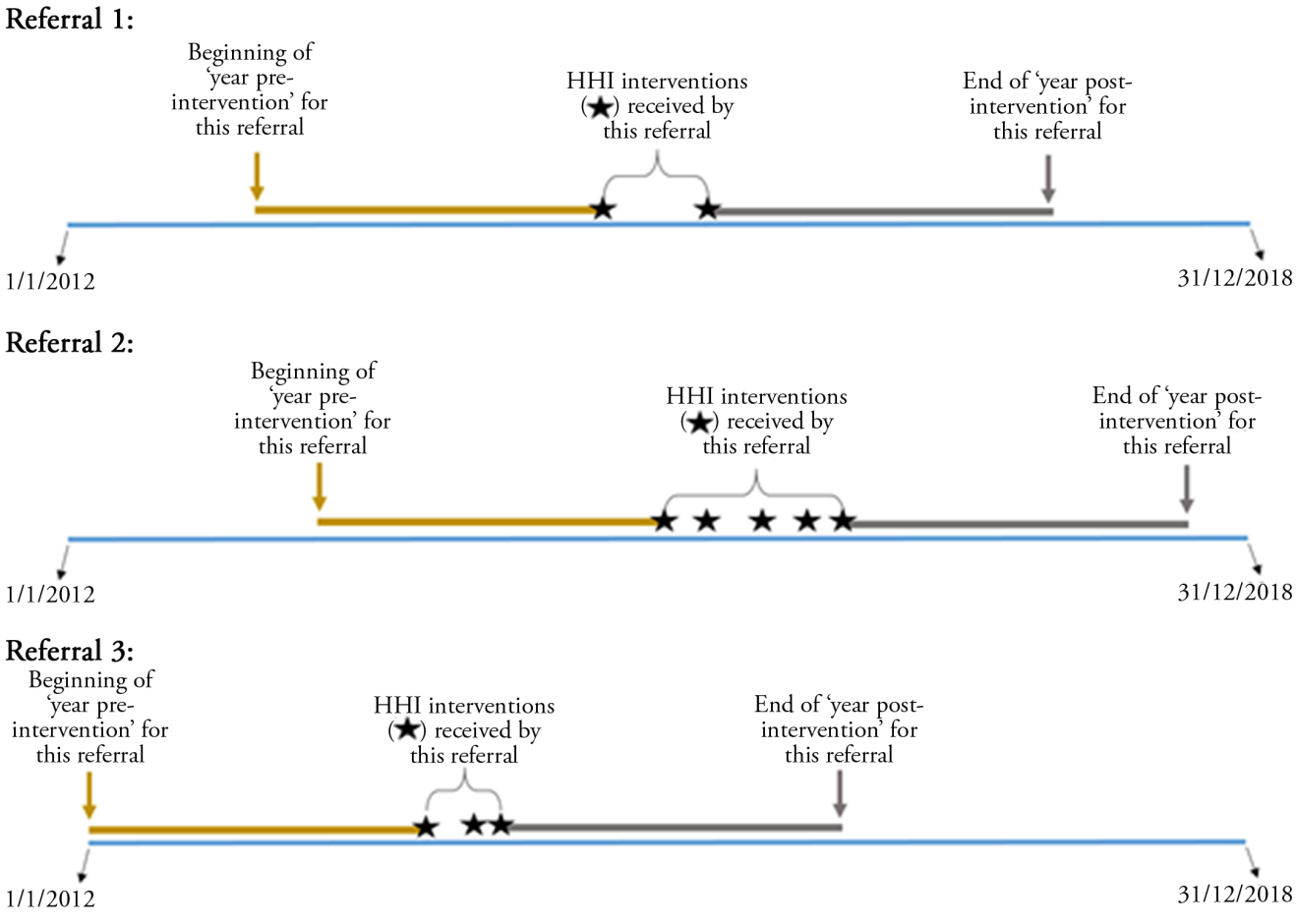
The unit of analysis is the HHI referral. Most children were referred to an HHI provider only once. However, in rare cases (generally when the family moved), there would have been multiple HHI referrals for the same child. All referrals were included and counted as separate units in the analysis in these cases because of the different timeframes relevant for each referral. These timeframes, or 'observation periods' are explained further below.

For each referral, the time between that referral's earliest intervention date and latest intervention date was considered the intervention period, or 'intervention'. On average across all 1,608 HHI referrals in the evaluation sample population, the latest intervention was 0.4 years (or almost 5 months) after the earliest intervention.

Methods: Analytical approach

For each referral, we therefore had data from two periods either side of when the whānau of that referred child were engaged with an HHI provider to receive interventions to improve their home environment. This is pre-post data and is treated accordingly: the number of events happening in the year either side of this 'intervention' period were used to obtain counts of both 'pre-intervention' and 'post-intervention' health events on a referral-by-referral basis.

Figure 2: Example of analytical approach for three hypothetical HHI referrals over time period of available health outcomes data (2012-2018).



The 'pre-intervention' period was considered as the year immediately before each referral's 'intervention start' date. The 'post-intervention' period was the year immediately after the latest intervention date provided for each referral. Figure 2 details these observation periods to obtain the necessary pre-/post-intervention counts for three hypothetical HHI referrals that we might expect in the evaluation sample population of 1,608.

For each analysis of the three health events (hospitalisations, GP visits and pharmaceutical dispensings) the difference between the number of events happening in the post-intervention period with regards to the pre-intervention period was found on a referral-by-referral basis. Any events that happened for the referred child between the earliest and latest intervention dates of their referral (i.e. within the 'intervention' period of the HHI referral) were excluded.

This comparison of the number of events that occurred for each referral in the 'year post-intervention' compared to the 'year pre-intervention' allowed for estimation of what reduction in the number of events (hospitalisations, GP visits, pharmaceutical dispensings) was attributable to the HHI programme. This was found first for all referrals in the evaluation sample population, and the estimated number of events averted per referral were then used to obtain estimates of health gains across the wider population of HHI referrals. These are referred to as 'averted' or 'prevented' events throughout the remainder of this document.

Adjustments for known effects that might led to overestimation of this difference (age effect, and selection bias in the 'pre-intervention' counts for hospitalisations) were adjusted where appropriate to obtain estimates of an health effect likely attributable to the HHI across each of the three key health outcomes: hospitalisations, GP visits, pharmaceutical dispensings. These adjustments are described below.

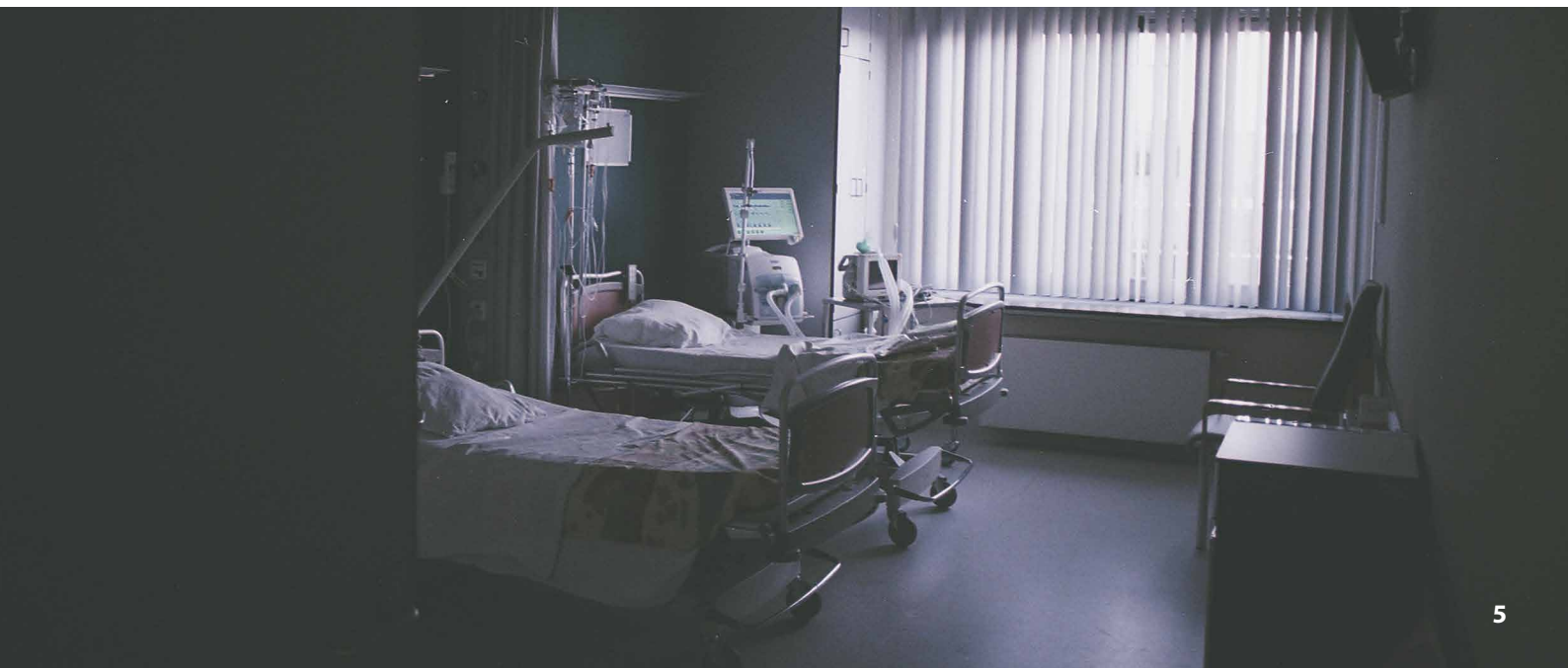
Corrective adjustments

To improve the reliability of estimates of any differences in the post-intervention periods compared to the pre-intervention periods attributable to the HHI, methods were established to control for known biases present in the before-after analyses of this kind. An explanation of these effects and rationale for addressing them are explained below.

Aside from the HHI programme effect, age effect, and the selection bias operating in the pre-intervention observed counts there are unlikely to be any other systematic effects in the before and after comparison for hospitalisations. Therefore, we can estimate a programme-attributable change in hospitalisations by adjusting the necessary pre-intervention/post-intervention counts for the estimated age and selection bias effects. For hospitalisations, each of these effects was adjusted for. For GP visits and pharmaceutical dispensings, the only corrective adjustment done was for the estimated age effect; it was assumed there was no selection bias operating across these events because they were not entry criteria into the HHI. This meant that any difference between the post-intervention and pre-intervention observation periods for these events was considered attributable to the HHI.

Age effect: each child in the evaluation sample population will be systematically older in the post-intervention period compared to their pre-intervention period. This aging is by one year plus the time difference between their earliest and latest intervention and it has the effect of naturally decreasing the number of hospitalisations that a child has, independent of any potential effect of the HHI.

The size of this effect was estimated from a linear model by regressing age at the start of each observation period (year pre-intervention, year post-intervention) and whether this observation period was pre/post against the number of hospitalisations observed in the period. This was done for each of the health outcome analyses (hospitalisations, GP visits, and pharmaceutical dispensings).



Selection bias: One of the eligibility criteria for two out of the four HHI target groups[3] is hospitalisation because of an HSH indicator condition. In the year before the intervention start period for a given referral, we therefore expect the evaluation sample population as a whole to have an elevated level of HSH (and therefore hospitalisations, more generally) compared to what we would expect in the underlying population of children of interest. This has the effect of making any decreases in the number of hospitalisations happening in the post-intervention periods for these referrals in the evaluation sample population look more pronounced than what can actually be reasonably attributed to the effect of the HHI. It is important to adjust for this effect so as to not overestimate the potential effect of the HHI in preventing hospitalisations.

In order to estimate the amount of selection bias pre/post comparisons of hospitalisations, a staged analysis was done that found pre/post estimates across different types of hospitalisation events. The effect of the HHI was first estimated in preventing hospitalisations that were PAHHE hospitalisations but not also HSH. Selection bias was not considered to be operating in this group of hospitalisations in any substantial way because although they are housing-related conditions, PAHHE hospitalisations are not indicator conditions for any of the HHI eligibility criteria. Any effect then observed in the analysis of HSH-only hospitalisations that was in excess of the HHI effect estimated initially was therefore believed to be due entirely to selection bias. This estimation of bias in pre-intervention counts of HSH was finally used to adjust the observed count of pre-intervention hospitalisations (see Tables 3-5).

Estimating uncertainty

In order to measure how uncertain our estimates were, we used a repeated sampling method (bootstrap sampling).

RESULTS: HEALTH OUTCOMES

Our evaluation sample population was young with over 40% of the children aged 2 to 5. They were more likely to be Māori (55.2%) or Pacific (36.6%) than the general population. Nearly half of the households lived in Housing New Zealand (HNZ) homes and 38% lived in private rentals; owner-occupied housing amongst these referrals was relatively rare (8%). Table 2 summarises these results.

The earliest intervention date was in January 2014, and the latest intervention date for referrals in the sample was December 2017. The median date of latest intervention was October 2016.

3 For the 0-5 hospitalisations criteria (Group 1), eligibility is dependent on a 0-5 year old having been hospitalised with a housing-related condition. For the rheumatic fever criteria (Group 4), overnight hospitalisation with an indicator condition is one of the referral pathways in addition to evidence of crowding and other children in the household.

Table 2: Characteristics of evaluation sample population.

Variable	Count	Relative percentage (%)
Age		
Age at earliest intervention 2 to 5 years	656	40.8
Age at earliest intervention 6 to 14 years	952	59.2
Ethnicity		
Māori	888	55.2
Pacific	588	36.6
Non-Māori, non-Pacific	132	8.2
Gender		
Male	901	56.0
Female	707	44.0
Tenure		
Owner occupied	135	10
HNZ	763	47.5
Private market rental	610	37.9
Temporary/Other	100	4.7

Hospitalisations

The HHI programme is expected to make the biggest difference in diseases that are PAHHE. For the subset of these conditions that are not also HSH, there should be no selection bias operating. In Table 3, the age-adjusted ratio of pre-intervention/post-intervention hospitalisations is found for only this group of conditions. This ratio of 1.48 is used in the calculation of selection bias (Table 4) to adjust the observed pre-intervention count of all-cause hospitalisations for bias (Table 5).

Table 3: Estimating the effect of the HHIs on hospitalisations that are on the PAHHE list but not on the HSH list.

Population	1608
Hospitalisation in 12 months before intervention (PAHHE not HSH)	212
Hospitalisation in 12 months after intervention (PAHHE not HSH)	130
Difference (Before-after) in hospitalisations, not adjusted for age	82
Difference (Before-after) in hospitalisations as a rate, not adjusted for age	-0.051
Adjusting for age	
Average change in hospitalisations (PAHHE not HSH) per year age	-0.009
Average difference in age between start of observation periods	1.40
Rate difference due to age	-0.013
# of decreased hospitalisations due to age	20.22
'Before' hospitalisation count estimate, adjusted for age	191.78
Difference (Before–After) adjusted for age	61.78
Ratio of age adjusted before-after hospitalisations	1.48
Summary of effect attributable to HHI	
Prevented hospitalisations in sample (PAHHE not HSH)	61.78
Rate of prevented hospitalisations per referral (PAHHE not HSH)	0.038
Prevented hospitalisations in population (PAHHE not HSH)	582.54

Children hospitalised with HSH diseases were a key target group for the HHI and made up the majority of referrals. In Table 4, we calculate how many excess HSH we had in the study population relative to the PAHHE not HSH group. These 228.96 hospitalisations are our estimate of the selection bias. This has been used to adjust calculations of the effect attributable to the programme across all hospitalisations in Table 5 to obtain the final estimate of reduction in hospitalisations in pre-post period attributable to the HHIs.

Table 4: Estimating the bias in HSH

Population	1608
Hospitalisation in 12 months before intervention (HSH)	385
Hospitalisation in 12 months after latest intervention (HSH)	91
Difference (Before-after) in hospitalisations, not adjusted for age	294
Difference (Before-after) as a rate, not adjusted for age	-0.18
Adjusting for age	
Average change in hospitalisations (HSH) per year age	-0.01
Average difference in age between start of observation periods	1.40
Rate difference due to age	-0.013
# of decreased hospitalisations due to age	21.36
Ratio of age adjusted before-after hospitalisations (from PAHHE not HSH)	1.48
'Before' hospitalisation count estimate, adjusted for age and selection bias	134.68
Adjusting for selection bias	
Implied selection bias	228.96
Summary of effect attributable to HHI	
Prevented hospitalisations in sample (HSH)	43.68
Rate of prevented hospitalisations per referral (HSH)	0.027
Prevented hospitalisations in population (HSH)	413.91

We use the effect of age and the selection bias calculated above (228.96) to adjust the observed before number of hospitalisations and calculate the average difference in the year following the intervention across all referrals. This allows us to estimate the number of prevented hospitalisations the programme in the 12 months following the intervention in the sample (160.78) and hence in the wider population (1533).

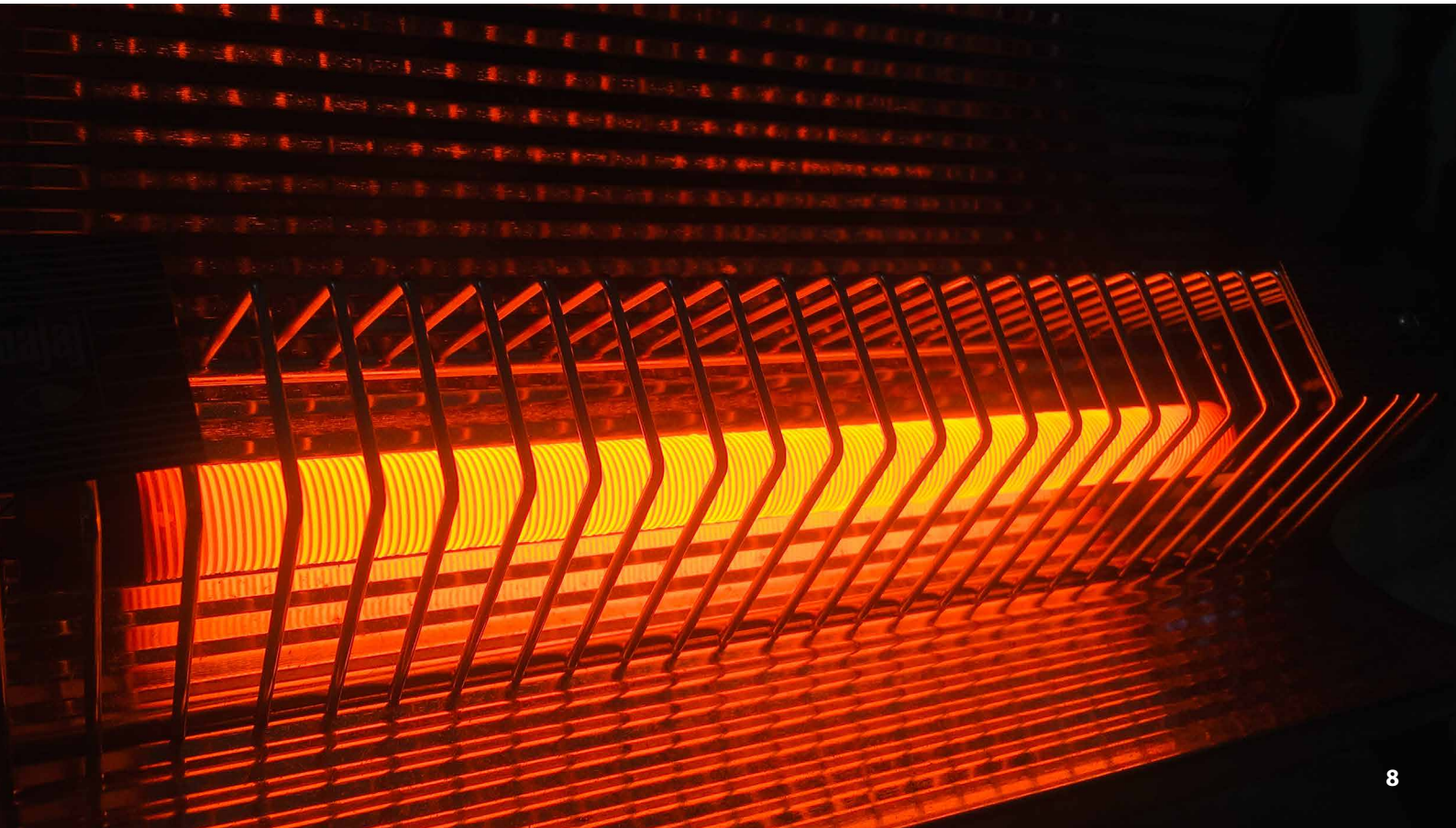


Table 5: Estimating the effect of the HHI on all cause hospitalisations

Population	1608
Hospitalisation in 12 months before intervention	1137
Hospitalisation in 12 months after intervention	640
Difference (Before-after), not adjusted for age	497
Adjusting for age	
Average change in hospitalisations per year age	-0.048
Average difference in age between start of observation periods	1.40
Rate difference due to age	-0.067
Hospitalisation in 12 months before intervention	1137
# of decreased hospitalisations due to age	107.26
Adjusting for selection bias	
Selection bias	228.96
Hospitalisations in 12 months before intervention , adjusted for age and selection bias	800.78
Hospitalisation in 12 months after intervention	640
Summary of effect attributable to HHI	
Prevented hospitalisations in sample	160.78
Rate of prevented hospitalisations per referral	0.100 (0.00498, 0.184)
Prevented hospitalisations in population	1533 (76, 2820)

GP Visits

Table 6 estimates the number of GP visits avoided in the 12 months following the intervention in the sample (990.17) and the total number in the wider population of HHI referrals when extrapolated out (9443.28).

Table 6: GP Visits

Sample Population	1608
GP Visits in 12 months before intervention	7097
GP Visits in 12 months after intervention	5407
Difference (Before-after), not adjusted for age	1690
Adjusting for age	
Average change in GP visits per year age	-0.31
Average difference in age between start of observation periods	1.40
Rate difference due to age	-0.43522
# of decreased GP visits due to age	699.83
Summary of effect attributable to HHI	
Prevented GP visits in sample	990.17
Rate of prevented GP visits per referral	0.616 (0.563, 0.668)
Prevented GP visits in population	9443.28 (8630, 10240)

Pharmaceutical dispensings

Table 7 estimates the number of pharmaceutical dispensings avoided in the 12 months following the intervention in the sample at 990.17. Extrapolated out to the wider population, the rate calculated amounts to 9443.28 pharmaceutical dispensings fewer in the post-period. There was a very large correction due to an age effect in this analysis.

Table 7: Pharmaceuticals dispensed

Sample Population	1608
Pharmaceuticals dispensed in 12 months before intervention	17750
Pharmaceuticals dispensed in 12 months after intervention	14807
Difference (Before-after), not adjusted for age	2943
Average change in dispensings per year age	-0.90
Average difference in age between start of observation period	1.40
Rate difference due to age	-1.26
Number of decreased dispensings due to age	2021.82
Summary of effect attributable to HHI	
Prevented dispensings in sample	921.17
Rate of prevented dispensings per referral	0.573 (0.354, 0.792)
Prevented dispensings in population	8784.09 (5426, 12141)

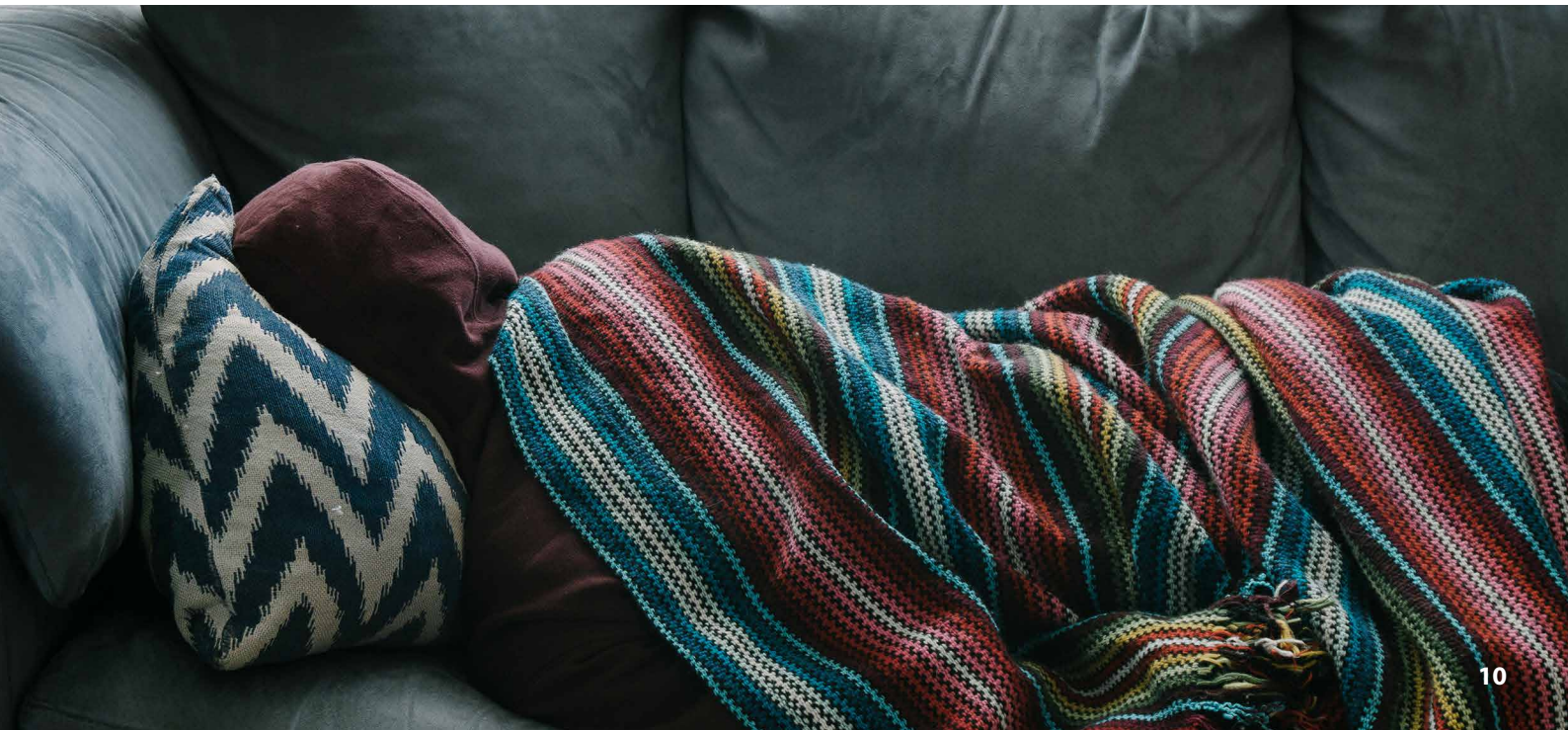
RESULTS: COSTS AND BENEFITS

Building on the results of the aforementioned analysis, we estimate the costs of implementing the programme as well as the value of the benefits from medical costs averted.

The programme costs for this initial analysis are primarily related to staffing costs (including overheads) for delivering the programme[4], with the lion's share of these costs funded by the Ministry of Health (MoH) but with some contributions by the District Health Boards. These costs are estimated at $1205 per family, and for the 15,330 families served by the programme through December 2018, the total programme costs would be $19,173,581.

These programme costs do not cover all the costs of programme. Specifically, the costs of providing some of the interventions (e.g., the cost of providing heaters or installing insulation) beyond these staffing costs is not included because there was insufficient information about the number of families that received each intervention or about the total value of all the interventions provided. Hence, it was not possible to calculate the costs associated with the provision of these interventions.

4 These costs are primarily related to the following four components: setting up systems, generating referrals, coordinating interventions, and generating the supply of interventions.



To estimate the value of the benefits of the program, the number of hospitalisations, GP visits, and pharmaceuticals prevented by the programme were used to calculate the associated costs averted by the program. After adjusting for age and selection bias, the program is estimated to have prevented 1,533 hospitalisations, 9,443 GP visits, and 8,784 pharmaceutical dispensings. Moreover, hospitalisations, on average, after the intervention were less costly and shorter in duration than those prior to the intervention. After adjusting for age and selection bias, the average hospitalisation post-intervention was 0.69 nights shorter (CI: 0.346-1.191) and $541 less costly (CI: 9.84-1,073) than hospitalisations in the year prior to the intervention, with these reductions considered to be attributable to the programme.

The associated health care costs averted by the programme are shown in Table 8. Using the average cost of a hospitalisation post-intervention, the 1,533 hospitalisations prevented would have cost approximately $6.3 million in the earliest year post-intervention, and hence, these costs were averted by the programme. Moreover, those hospitalisations that did occurr post-intervention for the referral child were less severe. This reduction in severity is estimated to avert costs of $3.3 million in the earliest year post-intervention. Using the cost per visit from Treasury's CBAx Tool of $80, the expected costs averted is $755,440 for the 9,443 GP visits prevented by the programme. For prescription dispensings, the costs averted are estimated using the average 2017 cost of a prescription for housing-related conditions for all children in New Zealand less than 15 years old.[5] The cost per prescription is estimated at $8.45, which amounts to costs averted of approximately $74,225 in the earliest year post-intervention.

Given that the costs of the program span multiple years, the costs averted by the program have been estimated beyond the earliest year post-intervention for comparability. Moreover, it is expected that the programme will continue to yield benefits for several years after the invention has been provided. It is assumed that the programme is as effective in future years (years 2 and 3 post-intervention) as it was in the earliest year post-intervention, though Appendix E provides alternative analyses using different assumptions about the continued effectiveness of the programme. The costs averted in years 2 and 3 post-intervention are discounted using a rate of 6 percent as recommended by Treasury[6] and are shown in Table 8.

5 Prescription cost information at the time of publication was not available, so the per prescription cost has been drawn from an unpublished estimate from Lucy Telfar-Barnard for this initial phase of the evaluation.
6 While the interventions occurred over many years, the totals for each year post-intervention have been aggregated. Hence, the total cost-savings for the earliest year post-intervention, second year post-intervention, etc.

Table 8: Health Care Costs Averted by the Healthy Homes Initiative

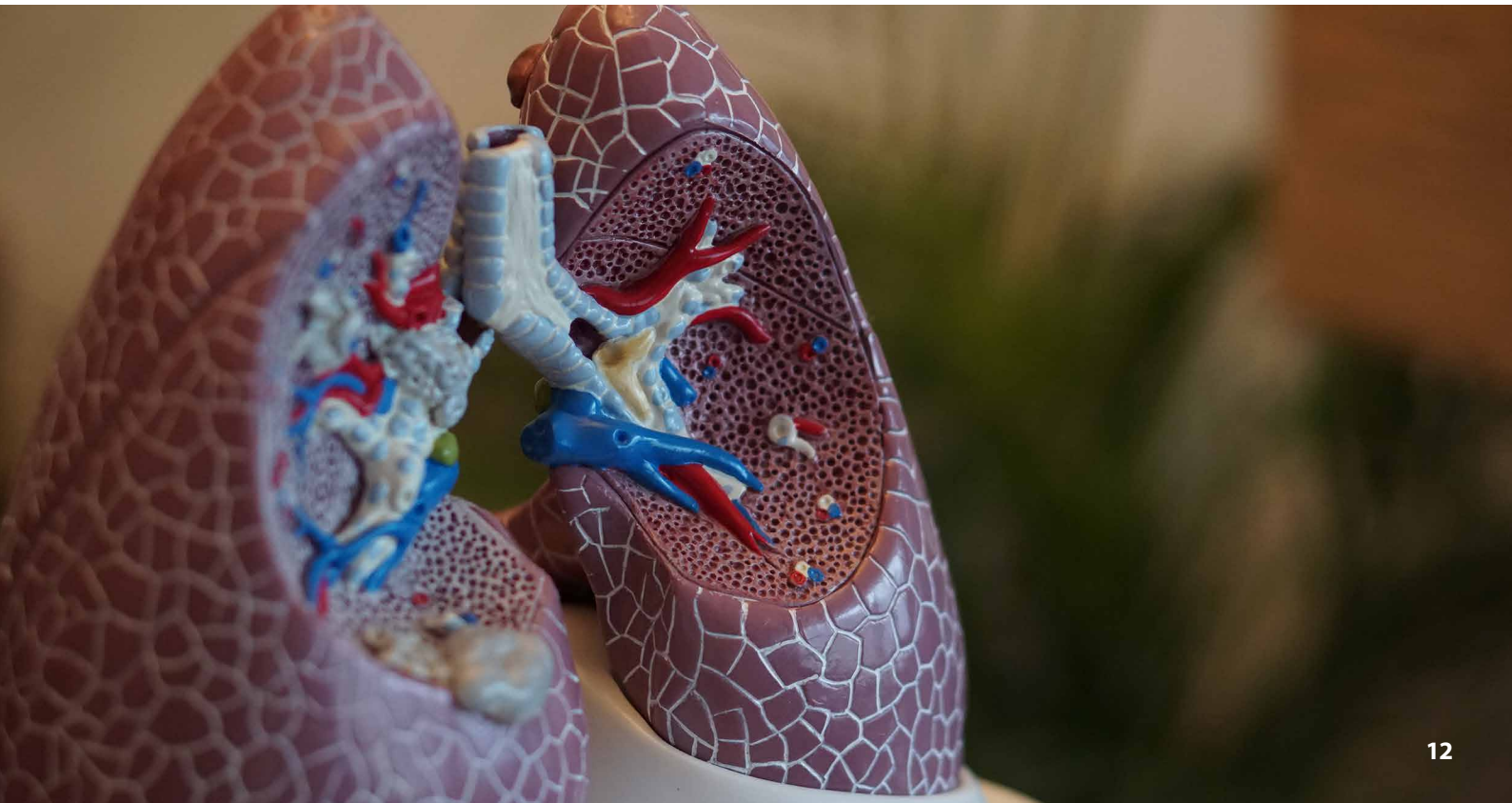
Types of Costs Averted	#	Cost per Unit	Years Post-Intervention			
			Year 1	Year 2	Year 3	Total Years 1-3
Hospitalisations	1,533	4,090	6,269,579	5,914,697	5,579,903	17,764,178
Hospitalisations -- Reduced Severity	6,101	541	3,302,906	3,115,949	2,939,575	9,358,431
GP Visits	9,443	80	755,440	712,679	672,339	2,140,458
Prescription Dispensings	8,784	8	74,225	70,023	66,060	210,308
Total			**10,402,150**	**9,813,349**	**9,257,876**	**29,473,374**

In total, the HHI programme is expected to avert approximately $30 million in costs over a 3-year period. Using the programmatic cost of approximately $18.5 million, the expected return on investment would be realised in Year 2 of the program. There are a number of assumptions underlying these estimates. Hence, robustness checks are provided in Appendix E.

This analysis only includes the direct medical costs averted for the referral child and does not include other potential benefits. For example, it is expected that the health gains would mean that these children are absent from school less often and that their parents are also absent from work less often. For example, the reduction in nights spent in hospital attributable to the programme (approximately 7,510 due to both hospitalisations prevented and the reduction in severity) should represent a substantial reduction in absenteeism as well as an improvement in wellbeing for children and parents alike. Moreover, the 9,443 GP visits prevented would be expected to further reduce absenteeism for both parents and children as they do not need to take time out of work and school to visit the doctor.

DISCUSSION

The results of this analysis show that the HHIs appear to be making a difference to health of the children referred to them and that from the Ministry's perspective the programmatic costs are recouped in a very short amount of time. After adjusting for age and bias effect where appropriate, we estimate that in the 12 months following the intervention period the average referral had 0.1 fewer hospitalisations, 0.6 fewer GP visits and 0.6 fewer pharmaceuticals dispensed than would have otherwise been the case. Over the 15,330 referrals already seen this means there was a reduction of 1,533 hospitalisations, 9,443 GP visits and 8,784 prescriptions being dispensed. These reductions are expected to result in a savings in direct medical costs of approximately $10.4 million in the earliest year after the intervention and almost $30 million in the earliest three years after the intervention. With the programmatic costs estimated at $18.5 million, we would expect the costs of the programme to be recouped in the secondearliest year, assuming the same effectiveness of the programme in the earliest and second year post-intervention.



Comparison with health effects as identified in other housing intervention studies

Comparative studies are difficult given the wide breadth of possible interventions carried out by the HHI providers. In our opinion the most useful comparison is with the effect of insulation delivered under the EECA: Warm up Zealand scheme. In low-income families with children, insulation delivered a reduction of 0.06 hospitalisations per child. There are many contrasts between the relatively narrow EECA scheme, which delivered one intervention, and the HHIs that deliver most of a potential wide range of interventions as well as an information component. The EECA project has been the subject of numerous analyses and this group of families (low income with children) was its most cost effective subgroup for health benefits at 15:1. While the two programs are highly complementary, the HHIs appear to be a very valuable addition to this program.

Limitations of analysis: Age and selection bias effects

To estimate effect sizes of the HHI, this study would ideally have had an element of randomisation. However, given the reality of targeted public policy – where only some households would then have received the HHI interventions - this was not the case. We are therefore limited in study design for this initial analysis to a before and after analysis as detailed in this report. This has two predictable biases due to age and selection effects that have been discussed earlier and that we have attempted to account for.

Limitations of analysis: Age effect

Age is an issue because younger children are, on average, hospitalised more often than older children. This means that we need to try and account for this decrease in hospitalisations over time due to aging, so as to not attribute it to the effect of a programme. We have adjusted for the age effect by using a linear model. In this case we have made the assumption that the reduction in the rate of hospitalisation is linear over the ages 2 to 15. The true relationship between age and hospitalisations is an exponential decay curve, therefore our adjustment will underestimate the effect of changes in age for those in the younger groups, and overestimate the effect of changes in age for the older group. It is however an unbiased estimator of the average effect. The overall effect of the age adjustment is reasonably small when compared to the average before and after difference observed. We have also adjusted for age in each of the analyses using the Pharmaceutical Collection data. This included our analysis of a likely observed reduction in GP visits and of overall pharmaceutical dispensings. The effect of age on pharmaceutical dispensings was unusually large and resulted in a smaller effect for pharmaceutical then expected, given the Hospitalisation and GP results.

Limitations of analysis: Selection bias

The HHI is a targeted intervention, which also means that there is a selection bias to account for in any comparison of a pre-intervention/post-intervention comparison. The HHI is targeted at low-income families living in unsuitable housing with children who have high health needs. Referral to and acceptance into the HHI programme is partially based on a previous hospitalisation for a limited list of Housing Sensitive Hospitalisations. The fact that such hospitalisations are one of the eligibility criteria for two of the four referral groups creates a selection bias. Specifically, amongst our population of low-income families living in unsuitable housing with children who have high health needs, the programme is more likely to capture families whose children have been hospitalised for these diseases in the 12 months immediately prior to referral. Therefore, the 'pre-intervention' rate of hospitalisation seen in our sample group is higher than that of the population they are sampled from, which has the effect of making a difference between the observation periods appear larger than what can truly be attributable to the HHI programme itself. In order to estimate how large this selection bias is in the before rate, we needed to make the assumption that the HHIs prevent PAHHE hospitalisations and HSH at exactly the same rate, with the critical difference between them being that only HSH are used as indicator conditions for programme eligibility in many referrals. This is likely an overestimate of the selection effect because the HSH were chosen at least in part on their assumed preventability. This means our estimate for the number of hospitalisations prevented is conservative.

GP visits and pharmaceuticals were not explicitly entry criteria for the HHI. We therefore did not adjust these estimates for selection bias. However, there is likely some underlying correlation between hospitalisation and GP visits and, as a result, dispensings at community pharmacists. Therefore, there may be some selection bias in these numbers although this effect is likely to be small.

Limitations of analysis: Observation period

The analysis is also limited in the follow-up period after the intervention due to the recent implementation of the programme and the small sample size currently available. Ideally, the costs would be estimated beyond year one using empirical estimates of the effectiveness of the program to see if the effects persist or possibly even get stronger. This will be more feasible in subsequent phases of evaluation as more closed referrals can then be evaluated for a longer post-intervention period.

Costs and benefits of the programme

There are also limitations in the measures of the costs and benefits of the programme. For example, not all of the costs of the programme have been included because the data are not sufficiently detailed in this phase of the evaluation. This is an important component to a cost-benefit analysis from the social welfare perspective. More importantly, however, is the fact that many of the health gains from the programme are likely due to the provision of some of these interventions for which we do not have cost information. As such, the benefits realised from this programme may rely heavily on these additional funds, and if there is a drop in donations for these interventions, it is likely to take longer to recoup the programme's costs.

On the other hand, not all of the benefits of the program have been quantified and valued. For example, the entire household is likely to benefit from the programme but only the costs averted from the referral child are included in this initial analysis. This means that the costs of programme should be recouped even more quickly if these benefits are included. Moreover, the benefits to the families from these programs such as reductions from out-of-pocket expenses, absenteeism, and improved wellbeing have also not been quantified as part of this analysis.

CONCLUSION AND FUTURE RESEARCH

The HHIs are a broad, multifaceted, holistic programme in the community. Restricting evaluation to just the major health effects for one child per household underestimates the effects of the HHIs. For the second phase of this outcomes evaluation, HHI providers are making more detailed information available to be able to control for which specific interventions individual referrals have received. This dataset will be placed in the Integrated Data Infrastructure (IDI), which will also allow for an extension of this initial analysis by enabling a broader range of outcomes (social, as well as health) to be captured for the primary child referred, as well as other household members. Use of the IDI will also allow us to identify a control population. This will ensure that a wider range of HHI referrals (including 0-2 year olds) can be included in the evaluation and appropriate adjustments made for effects such as age and selection bias. This extension of the scope of the evaluation will allow a broader range of outcomes across a more representative sample of HHI referrals to be captured to better inform future developments in the delivery of housing and health interventions.