A cost-benefit evaluation of housing insulation: results from the New Zealand 'Housing, Insulation and Health' study

Dr Ralph Chapman[1]
Associate-Professor Philippa Howden-Chapman[2]
Des O'Dea[3]

October 2004

[1] Maarama Consulting Ltd. www.maarama.co.nz
[2] *He Kainga Oranga* / Housing and Health Research Programme
Department of Public Health, Wellington School of Medicine and Health Sciences, University of Otago
[3] Wellington School of Medicine and Health Sciences, University of Otago

Executive Summary

The Housing and Health Research Programme at the Wellington School of Medicine and Health Sciences has undertaken a study to assess whether installing insulation in houses has any impact on the occupants' health or the energy they use. Benefits could accrue simply through the general effect of greater warmth and dryness on respiratory health, or through specific mechanisms such as less mould and allergens.

This analysis evaluates some of the **benefits** from housing insulation – tangible health gains and energy savings. **Health** benefits can accrue in a number of ways – a reduced number of visits to GPs, hospitalisations, days off school, and days off work. A significant potential health gain **not** valued here is the everyday enhancement of physical and emotional well-being arising from a warmer and/or more comfortable dwelling. Also, potential gains in avoidable mortality have not been valued. **Energy** benefits mainly accrue from reduced energy spending, and an estimate of the value of these benefits is also provided here.

The emphasis of this cost-benefit analysis is on the benefit side. The **costs** of installing insulation in the houses which were insulated was around $1800 per house.

The various forms of benefit, and a present value for each of the benefit streams (evaluated using a 5% discount rate over a 30-year horizon), are set out in the following table. These benefits accrue over time for the more than 4000 people in the sub-sample of **1281** households (from the initial 1400 selected), whose dwellings were insulated (either in the first year or the second year of the study).

Form of benefit						
	Reduced GP visits (self-report)	Reduced hospital admiss-ions	Reduced days off school	Reduced days off work	Energy savings	Total benefits (**excl**. GP visit svgs)
Present value of benefits ($m)	**[0.92]***	**1.41**	**0.20**	**1.01**	**1.36**	**3.98**
PV benefits per hsld ($)	[715]*	1100	150	790	1060	3110

*indicates that this particular benefit, because it is based on self-report, is not included in the total.

Table of Contents

An evaluation of the costs and benefits of housing insulation

1 Aim

This analysis quantifies (and, where possible, places values on) two types of benefits from housing insulation – health gains and energy savings. Not all health benefits can be quantified and valued. However, those which can be quantified and valued are reported here.

Health benefits can accrue in a number of ways; four are quantified and valued here:

(i) a reduced number of visits to GPs
(ii) a reduced number of hospitalisations
(iii) a reduced number of days off school
(iv) a reduced number of days off work.

Potential health gains **not** valued here include the everyday enhancement of physical and emotional well-being arising from a warmer and/or more comfortable dwelling, and avoidable premature mortality. The former is a subjective variable. Though it is measured in the study using a reliable survey instrument (SF36), which assesses changes over time, more complex assumptions, as well as 'willingness to pay' data collected during the study, are needed to give an economic value estimate. This is not attempted here.[4]

Cold housing in New Zealand has also been associated with avoidable excess winter mortality among people 65 or older.[5] Insulation is likely to reduce this rate of mortality, although the number of lives saved may be very small. Another gain accrues if healthier children receive some long-term health benefit in later life. However, we do not estimate these effects here, as methodological issues have yet to be resolved (and we have yet to obtain death certificates for those in the study who have died).

Energy benefits were expected to accrue principally from reduced energy spending, and an estimate of the value of these benefits is provided here. Additional economic benefits can accrue to the electricity network companies in the areas where the houses are located, if households reduce peak demand. This benefit includes the value of avoided additional lines investment to cope with peak loads. The peak load electricity reduction was

[4] Potential morbidity/disability and mortality averted by improving the indoor housing environment is also to be estimated, based on the British Housing Conditions Survey.
[5] Isaacs and Dunn (1993).

measured by one electricity company (for a subsample of 116 households in the Christchurch area). In this analysis, the load reduction is reported, but an economic value is not ascribed to it.

This cost-benefit analysis emphasises the benefit side. Details of costs of installing insulation (including the cost of the insulation itself) are not discussed. The overall cost per household is $1800. In assessing the overall costs of insulating the dwellings in the study, unit costs of insulation should be multiplied by the number of dwellings actually insulated, 1281, containing 4183 people.

2 Background

The Housing and Health Research Programme at the Wellington School of Medicine and Health Sciences has undertaken a study to assess whether installing insulation in previously uninsulated houses has any impact on the occupants' health or the energy they use. Benefits could accrue simply through the general effect of greater warmth and dryness on respiratory health, or though specific mechanisms such as less mould and allergens.

3 Method

Although there was randomisation between the control group and the intervention group in terms of the health of household members, we nevertheless allow for baseline health differences between the control and intervention groups, and changes over time in health conditions and outcomes for the control group. To do this, we assess the change in health outcome for the control group between year 1 and year 2, and compare this with the change in health outcome for the intervention group

Figure 1 illustrates this schematically (the numbers are illustrative only). Hospital admissions may have fallen 6%, say, in the intervention group, but 2%, say, in the control group. The net reduction, after allowing for the changes in the control group, and which can be ascribed to the intervention, is (in this example) 4%.

For the estimation of energy savings, the picture is similar. Full records over the two years of the study were used for energy consumption, but these were obtainable only for 526 households. Energy savings are calculated by comparing the change in energy consumption for the intervention group (2002 consumption less 2001 consumption) to the change in consumption for the control group.

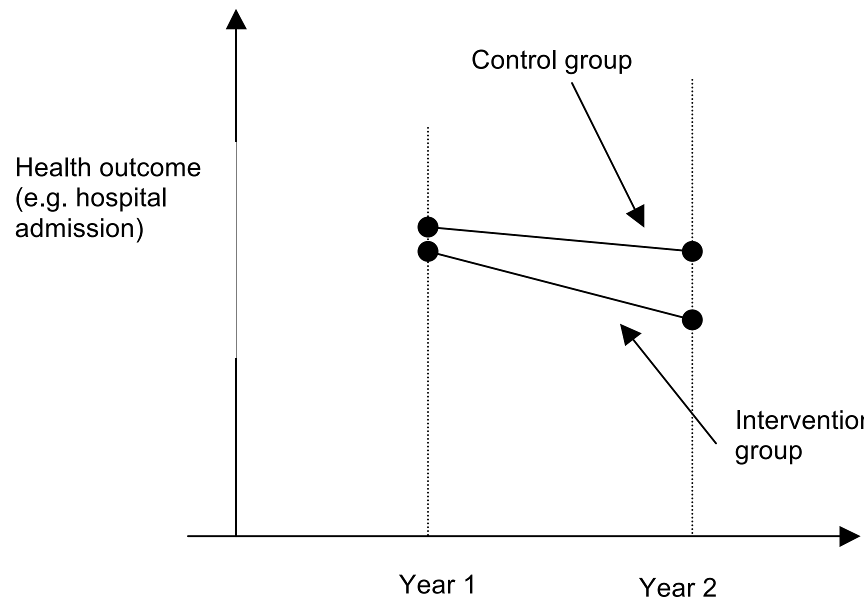

Figure 1: Allowing for changes in the control group

In one of the experimental localities, Mahia/Nuhaka, some of the insulation installations done in the first year were not properly carried out. Although there is a case for exclusion of these cases, for this analysis they are nevertheless included in the assessment, because the analysis is based on 'intention to treat.' Inclusion gives a more conservative estimate of the impact of insulation in terms of health benefits and energy savings.

The health and energy savings benefits are calculated without attempting to partition the sample of households by region.

Factors to be considered in extrapolating effects found in this study to a broader population include:

a. the condition of the (uninsulated) houses in this study relative to the condition of houses nationally. We note that with its relatively old housing stock, New Zealand has a large number of pre-1977 dwellings (a significant change in the enforcement of the building code was made in 1977), so the houses in the study, although typically in poor repair, are not atypical. The houses in the study are, however, on average likely to be in worse condition. An independent sample of 10% of the houses in the study, conducted by BRANZ, suggests that most (86.5%) of the dwellings are greater than 25 years old, and over half are poorly maintained or beyond repair (45.4% poorly maintained and 5% beyond repair). On the other hand, a recent study of temperature and humidity in similar houses in Dunedin has found comparable indoor temperatures to those in the present study (Lloyd, 2004).

b. The socio-economic circumstances of the people in the study relative to the general New Zealand population. We note that the houses which were chosen for inclusion in the study tend to be older dwellings in high-socioeconomic deprivation areas. Therefore, although the results can be extrapolated to households in relatively high-deprivation areas elsewhere in the country, some adjustment will be necessary to extrapolate to newer dwellings and/or higher-income areas.

c. The age distribution of people in the study relative to the distribution in the general New Zealand population. We note below that GP visit numbers vary considerably by age group (they are higher for children and older people).

3.1 Estimating benefits from fewer GP visits

The potential benefit of a reduction in the number of self-reported visits to general practitioners (GPs) is estimated using:

(i) estimates of any **reduction in the number of visits** to GPs, using respondent **self-reports** of GP visits.

(ii) an estimate of the **'cost' of a GP visit** (decomposed into the direct cost to the household, and the fiscal cost; together, these approximate the overall resource cost to society). An estimate of the overall cost of a GP visit is $45,[6] and we use a very approximate estimate of $18.50 per visit for the government-funded general medical services (GMS) benefit component of respiratory consultations.[7] This estimate of fiscal costs includes an allowance for the cost of GP-related primary care expenditures (benefits for practice nurses, rural practice bonus etc.) raising the fiscal cost to around $24.

[6] Estimates based on data from Crampton (2003, pers.comm.) suggest the cost of a GP visit is around $40 for those over 6 years of age, and $35 for a child under 6. An average total cost figure of $45 is used, to include an allowance for pharmaceuticals prescribed and dispensed, lab tests, referrals to specialists etc. arising from GP visits.

[7] Holt and Beasley (2001) p36 use a figure of $14.8 million pa for the general medical services (GMS) benefit costs of some 800,000 GP consultations for asthma per year, or around $18.50 per asthma consultation. It is assumed that the GMS cost of the GP consultations for respiratory ailments in the present study approximate the GMS cost of asthma consultations.

However, there is a fiscal loss also if GP visits are reduced, leaving a net fiscal 'cost' per visit at around $18.45[8]

(iii) an estimate of a scaling up factor to allow for larger GP-visit gains over a **whole** year rather than just over the 3-month core winter period monitored in the study. A **full-year 'rating up'** factor estimate of 1.67 is based on how often cold days ('degree-days' involving temperatures below 15 degrees Celsius), occur over a 7-month period rather than just the central winter period of 3 months,[9] and is conservative to the extent that a few cold days fall before April and after October. Cold days are likely to be correlated with health impacts.

(iv) an estimate of **how long** those GP visit reductions might be sustained (the horizon of the gains), and the discount rate used in evaluating the present value of future benefits. An estimate of 30 years is used, since the insulation can be expected to continue generating benefits over its lifetime of around 30 years or more. A discount rate of 5% real is preferred, although estimates are also made for a rate of 10%, and a rate of 3%.[10]

(v) A factor to scale up the benefits per 1000 people, to the benefits for the study group as a whole. Since there were 4183 people whose dwellings were insulated (either in the first year intervention group or in the second year control group), the scale-up factor is 4.183.

As a cross-check of these self-reports of visits to GPs, data were also obtained from GPs. GP-based data are less complete and do not distinguish between respiratory and non-respiratory reasons for consultations (there is no consistent coding equivalent to the diagnostic related group coding for hospital visits). Because the data collected from GPs is nominal only (i.e. a count of the number of visits), and the self-report data on visits is more likely to indicate respiratory-related conditions, the latter is therefore preferred.[11] The relationship between self-reported visit data and GP-verified visit data is a complex one, summarised in Annex 1.

---

[8] Holt and Beasley use a figure of $4.5 m for these additional costs (benefits for practice nurses, rural practice bonus etc., against direct GMS costs of $14.8 m, i.e. an additional cost loading of 30%, which translates here to an additional $5.55 per visit. (Although not all the localities in this study are in rural areas, neither was that the case in the Holt and Beasley study). Deducting GST of $5.60 leaves a net fiscal cost per visit of $18.45.

[9] Estimated by Des O'Dea, WSMHS based on BRANZ data (Malcolm Cunningham) for degree-days.

[10] A 5% real discount rate is likely to be on the high side as an estimate of a social rate of time preference, but is a widely used figure. A rate of 10% is also used in sensitivity analyses and therefore is also set out here. There is comparable validity in using a lower rate such as 3%.

[11] The cost of a research nurse sorting through GPs' patient notes for a diagnosis (respiratory or otherwise) was prohibitive, and the process would also have been unacceptable to many GPs. In many rural areas, GPs' records are not computerised.

Note, however, that although we record the results of self-report data here, **GP-based** data suggest there may be a **negligible** reduction in overall GP visit numbers. For this reason, the self-reported data below, and the health cost saving estimate derived from this data, should be treated with caution. In the summary total of benefits, we have omitted this contribution, in order to keep our total benefits/savings estimates conservative.

3.2 Estimating benefits from fewer hospital admissions

The potential benefit of a reduction in the number of hospitalisations is estimated using:

(i) The estimated reduction in the number of hospital **admissions for respiratory** complaints, derived from estimates of the reductions in the number of admissions for respiratory complaints. Note that reductions in admissions from non-respiratory complaints are not valued.

(ii) an estimate of the **'cost' of a hospital admission** (ignoring the cost to the household). Estimates for the costs of asthma admissions are used: $1086; $1345; $2449 for children, adults and older people respectively for 1994/95; these prices are then updated using a component of the producer price index.[12]

(iii) an estimate of **how long** those admission reductions might be sustained, and the discount rate used in evaluating the present value of future benefits. As in paragraph 3.1, we use a 30-year horizon and a preferred discount rate of 5% real.

Factors to be considered in extrapolating this estimated benefit to a broader population are as in paragraph 3.1 above.

3.3 Estimating benefits from fewer days 'off school'

The potential benefit of fewer days of absence from **school** is estimated using:

(i) estimates of the reductions in the **self-reported number** of days off school, over and above the reduction found in the

[12] Holt and Beasley (2001) use data from New Zealand Health Information Service (1999), for hospital costs in the 1996-97 year. We apply the movement (10%) in the price index (for the 5 years from Dec 1997) for health and community service input prices, to adjust Holt and Beasley's cost estimates to 2001-02 levels. (The aim is to align all price data to around late 2001 / early 2002). For index data see Statistics New Zealand (2003).

control group, and hence attributed to the intervention, for the school age children in the study.

(ii) an estimate of the **benefit** to the child and to society of avoiding a day's absence from school. Days off school are difficult to place a value on, but it is clear that they do represent a cost in terms of forgone education, and may also cause a parent to have to take a day off work in some cases. Days off school can be approximated for a teenager using labour market wage rates, on the basis that – for a teenager – we would expect the value per day of education to approximate the minimum wage (in terms of public good benefit, it is likely to exceed the minimum youth wage). A conservative estimate is then derived, using 2/3 of this figure.

(iii) A figure for the cost of a day off school for a primary school age child is estimated at half the value of a day off for a teenager.

(iv) an estimate of the likely number of school absence days avoided over a full year. Again, an appropriate scaling up factor is taken to be the number of cold degree days over the year vis a vis the number in the core 3 winter months of the study (a conservative estimate of the scale factor is 1.5, taking into account the shorter school year).

(v) an estimate of **how long** these reductions in school absences might be sustained, and the discount rate used in evaluating the present value of future benefits. Again, the assumption is that, given that the insulation generates ongoing benefits, the dwelling will continue to generate benefits for families (and hence for families with school age children) occupying the dwelling. It is assumed that dwellings will vary in whether they contain school age children or not, but on average the proportion of dwellings with school age children will stay about the same over the 30 year horizon.

3.4 Estimating benefits from fewer days 'off work'

The potential benefit of fewer days' absence from **work** is estimated in a similar way using:

(i) estimates of the potential reductions in the **number** of days off work, over and above the reduction found in the control group, and hence attributed to the intervention, for household members employed during the study.

(ii) an estimate of the **benefit** to society of avoiding a day's absence from work. This is conservatively estimated at 2/3 of the average daily wage rate for New Zealand workers.[13] Note that this is based on an estimate of the value of a day's lost production (approximated by the gross daily wage rate), rather than an estimate of the value to the worker of avoiding a day off (the latter may be considerably less, especially where the day off is covered by sick leave). However, we consider that the value of lost production is the relevant yardstick.

(iii) an estimate of the likely number of work 'days off' avoided over a full year.

(iv) an estimate of **how long** these reductions in work absences might be sustained, and the discount rate used in evaluating the present value of future benefits. The assumption is that, given that the insulation generates ongoing benefits, the dwelling will continue to generate ongoing health benefits for families occupying the dwelling. The standard 30 year horizon is therefore assumed.

3.5 Estimating benefits from energy savings

The potential benefit of **electricity** savings is based on:

(i) an estimate of the **number of units** (kWh) of electricity saved during the three winter months of the study (comparing the insulated houses to the uninsulated houses)

(ii) an estimate of the **value of an electricity unit** at around the time the insulation was installed (using weighted average residential retail electricity prices for New Zealand). The price figure used was for the year ended March 2002: 12.86 c/kWh.[14]

(iii) an estimate of real residential electricity **prices** applicable for the estimation period. There is a strong likelihood that wholesale electricity prices will rise, given recent increases, driving a continuing increase in *residential* prices (their increase averaged over 4% pa in recent years).[15] However, a conservative estimate of a zero real price increase is used.

---

[13]The average hourly wage was, in Sept. 2003, $19.65 per hour: QES (Dept. of Labour) http://www.dol.govt.nz/lmr-qes-lci.asp ; or $148 per day (assuming a 7.5 hour day). A discount of 33% is used to allow for the disutility of work avoided, and workers' ability to make up work after a day off, or have a co-worker make up. This gives a daily rate of $99.

[14] Ministry of Economic Development (2004) Energy Data File: the figure of 12.86 c/kWh for residential electricity excludes GST, and is for the year to March 2002. The aim is to use prices applicable around the end of 2001.

[15] Ministry of Economic Development (2004) gives an increase of 20.2% between Nov 1999 and May 2004, implying an average annual rate of increase of 4.2%. http://www.med.govt.nz/ers/inf_disc/prices/prices-16.html

For this reason, this study's electricity saving estimates will tend to understate the true market value of savings.[16]

(iv) a full-year **'rating up'** factor estimate to adjust from the three winter months of the study to the whole year. This estimate, 1.67, is based on how often cold days ('degree-days' involving temperatures below 15 degrees Celsius) occur over a 7-month period rather than just the central winter period of 3 months,[17] and is conservative to the extent that cold days fall before April and after October (i.e. outside the 7 month period).

(v) an estimate of **how long** these reductions in electricity use due to the insulation might be sustained, and the discount rate used in evaluating the present value of future benefits. It is estimated, as usual, that the energy savings are robust for a period of 30 years. Again, a real discount rate of 5% p.a. is preferred.

The potential benefit of **mains gas savings** is estimated in a parallel way, but based also on the following:

(i) an estimate of the **value of a unit of mains gas** (using average retail gas tariffs for New Zealand). The average residential gas tariff at December 2001 was 5.40 c/kWh.[18]

(ii) as with electricity, there is a strong likelihood that gas **prices** will rise, given recent increases (around 6% in the period 2000-2003). However, again, a conservative estimate of a zero real price increase is used. For this reason, this study's gas saving estimates will tend to understate the true market value of savings.

Similarly, estimation of the potential benefit of **bottled gas savings** relies on the following:

(i) an estimate of the **value of a unit of bottled gas,** 7.49 c/kWh.[19]

---

[16] MED (2003a) projects the annual average growth rate in wholesale electricity prices for the period 2005-2025 at 1.4%. However, it is assumed here that residential prices rise more slowly - a zero price increase figure is conservatively assumed.

[17] Estimated by Des O'Dea, WSMHS based on BRANZ data (Malcolm Cunningham) for degree-days.

[18] The average residential gas tariff in 2001 was 16.87 $/GJ, or 6.07c/kWh. Deducting GST gives 5.40c/kWh.

[19] In the absence of better data for bottled gas, an estimate of the residential price of LPG as at September 2000 was used: $23.41/GJ in 2000 or 8.43c/kWh (Gas Appliance Suppliers Association): http://www.gasa.org.nz/index1.html [Conversion factor is 277.78 kWh/GJ]. The price excluding GST is 7.49c/kWh. This is likely to be an underestimate of bottled gas prices as at late 2001, if prices rose over the 2000-2001 period. Thus, energy savings estimated using this number are likely to be understated.

(ii) an estimate of real bottled gas **prices** applicable for the estimation period. As above, a conservative estimate of a zero real price increase is used, with the implication that this study's bottled gas saving estimates will tend to understate the true market value of savings.

Data were also collected on usage of the heating resources of **wood and coal**, and estimates are available (and reported below) of the savings in these energy forms.

However, a difficulty exists in assigning 'objective,' reliable commercial values to these forms of fuel. This problem arises because a number of the households received their supplies at less than full commercial prices (e.g. free firewood). 'Objective' data do exist, however, on electricity, mains gas and bottled gas prices paid by households (as noted above). More weight is therefore placed on information about savings in these energy forms.

4 Results

4.1 GP visit results (self-reports)

Table 1: Estimated reductions in GP visits

	No. of GP visits (self-reported)		*Reduction* in GP visits (per 1000 people)
	Control group (n=1637)	Intervention group (n=1643)	
Children (1-5)	410	361	218
Children (6-11)	360	319	108
Teenagers (12-18)	164	85	421*
Adults (19-64)	1015	911	95
Elderly (65+)	612	407	382
All age groups	**2561**	**2083**	**190**

*Data for the teenage group are subject to revision

The table above shows a reduction in the number of GP visits (over the 3 months of winter), with the reduction varying by age group, being high for young children, teenagers and the elderly. For simplicity in this analysis, we use a simple average in the reduction in the number of GP visits i.e. a reduction of 190 per 1000.

For reasons of simplicity, a standard cost per GP visit is assumed, as noted in section 3 above, of $18.45 for the fiscal cost components, and $45 for the total resource cost. This allows the estimation of cost savings (initially per 1000 people, and then for the intervention group as a whole) as **Table 2** below shows. This table also allows for a scaling factor of 1.67 to adjust cost savings to account for a full-year effect.

A sensitivity analysis shows the following:

- If a **10%** real discount rate is used (rather than 5%), the present value of resource savings in GP visits over the 30-year horizon for the full group who had their houses insulated would be $561,700.
- If a **3%** real discount rate is used, the PV of resource savings in GP visits over the 30-year horizon for the full group who had their houses insulated would be $1.168m.

Table 2: Cost savings from reduced GP visits ($)

	Fiscal cost saving	Resource cost saving
Annual value of GP visit reductions, per 1000 people	$7,616	$14,250
Present value of GP visit reductions, over horizon, assuming 5% real discount rate (saving per 1000 people)	$89,811	$219,052
Present value of benefits of GP visit reductions (estimated for those in the study as a whole)	$372,700	**$915,600**

For the reasons discussed in the Method section above, these self-report estimates should be used with caution, and they are reported in brackets in the summary.

4.2 Hospitalisation results

Hospital respiratory admissions data are used in **Table 3** below, for both outpatient and inpatient admissions. Teenage admissions data are not included, because hospitalisations are a very rare event in this age group.

Table 3: Estimated reductions in hospital respiratory admissions

	Control group Change 2001 to 2002		Intervention group Change 2001 to 2002		Change in hospital admissions	
	Inpatient admns	Outpatient admissions	Inpatient admissions	Outpatient admns	Inpatient	Outpatient
Children	-2	2	2	-2	4	-4
Adults (19-64)	0	-1	0	-1	0	0
Elderly (65+)	0	47	-1	28	-1	-19
Total	-2	48	1	25	3	-23

As noted above, the unit costs of inpatient hospital admissions are taken as[20]:

- For children, $1195
- For adults, $1480
- For the elderly, $2694;

and the costs of outpatient admissions are estimated at half these cost levels.

The cost savings are scaled to allow for the larger impact on admissions of considering a full year, as opposed to just the impact in the three winter months (again, using estimates of cold ‘degree days’). A scale factor of 1.67 is again used.

Table 4 below converts the savings estimates into present value terms, on the basis that the admission gains (from a one-off insulation intervention) can be expected to continue to be provided by the dwelling, and thus continue occurring over the 30 year horizon. The gains are discounted to the present using a 5% real discount rate.

[20]See estimates (and the basis for their adjustment) in section 3.2 above.

Table 4: Estimated savings from reduced hospital admissions (outpatient and inpatient)

	Annual savings ($)	Present value of savings over 30-year horizon ($)
Children	3,990	61,300
Adults	0	0
Older people	87,727	1,348,400
Total	**91,717**	**1,409,700**

A sensitivity analysis shows the following:

- If a **10%** real discount rate is used (rather than 5%), the present value of savings would be, in total, $0.865m.
- If a **3%** real discount rate is used, the present value of savings would be, in total, $1.623m
- If a more conservative full-year scale-up factor of **1.50** is used (rather than 1.67), the present value of savings at a 5% real discount rate would be $1.266m.

4.3 Days 'off school' results

For the purposes of this evaluation, the costs to children aged 1-5 (i.e. preschool children) of days "off school" are not quantified.

Table 5: Reductions in days 'off school'

	Control group	Intervention group	Reduction in days off school
Children 6-12	1094	923	171
Teenagers 12-18	498	301	197
Total (school age children)	1592	1224	368

Using the method described in section 3.3 above (i.e. employing estimates of daily 'costs' of days off school of $30 and $15 respectively for teenagers and primary school children), the following cost savings figures are estimated (Table 6).

Table 6: Benefits of reduced days 'off school'

	Reduction in days off school (days)	Benefit of avoiding 'days off school' ($)	Annual benefits from days off school avoided ($)	Present value of benefits ($)
Children 6-11	171	2565	3,848	59,140
Teenagers 12-18	197	5910	8,865	136,260
Total (school age children)	**368**	**8475**	**12,700**	**195,400**

A sensitivity analysis shows the following:

- Using more conservative estimates for the **value** of a day off school ($20 and $10 respectively) gives a total present value of the benefits of $130,900, rather than $195,400.
- Using a **10%** real discount rate, rather than 5%, gives a total present value of the benefits of $119,900.
- Using a **3%** real discount rate gives a total present value of the benefits of $249,200.
- Using a more conservative estimate (**1.25**) for the full-year scaling factor gives a total present value of the benefits (at 5% discount rate) of $162,800.

4.4 Days 'off work' results

For the purposes of this evaluation, the costs to adults 65+ in age of days "off work" are not evaluated (few are in the workforce in any case). However, days off work for working age adults are quantified and valued in **Table 7** below.

Using the method described in section 3.4 above (i.e. employing estimates of daily 'costs' of days off work of $99 for adults, making a full-year adjustment, and discounting future benefits back to the present to give a present value, cost savings figures are estimated (**Table 8**).

Table 7: Reductions in days 'off work'

	Control group days off work	Intervention group days off work	Reduction in days off work
Adults 19-64	1029	632	397

Table 8: Benefits of reduced days "off work"

	Reduction in days off school (days)	Benefit of avoiding 'days off work' ($)	Annual benefits from days off work avoided ($)	Present value of benefits ($)
Adults 19-64	397	39,303	**65,640**	**1,008,800**

A sensitivity analysis shows the following:

- Using a **10%** real discount rate, rather than 5%, gives a total present value of the benefits of $618,900.
- Using a **3%** real discount rate, rather than 5%, gives a total present value of the benefits of $1,286,500.
- Using a more conservative estimate of the full-year scaling factor, of **1.50**, gives a total present value of the benefits (at a 5% discount rate) of $906,100.

4.5 Energy saving results

There are 526 households for which full data are available (i.e. energy use in both 2001 and 2002 are reported). Most households used more than one heating type. **Table 9** below reports average kWh used, of the various forms of heat.

Total energy saved is estimated by comparing year 2 with year 1, **and** adjusting for control group changes from year 1 to year 2. For example, average electricity use fell (between 2001 and 2002) by 7% for the intervention group, but also by 3% for the control group; hence net electricity saving able to be ascribed to the intervention was 4%. The net savings for the various energy types are set out in **Table 10.**

Table 9: Energy savings by heating type

	Baseline consumption per household	No of households with full heating data	Energy saving, 2001 to 2002 (%)	
Type of household heating	**(kWh, 2001)**	**n**	**Control group**	**Intervention group**
Electricity	2450	479	3.1	7.2
Mains gas	2470	31	3.4	16.5
Bottled gas	1623	125	6.6	68.4
Wood	5680	155	8.3	38.7
Coal	4377	38	-253.5*	-160.1
All heating types			-13.5	14.9

*A negative saving means that between 2001 and 2002, consumption of this form of energy rose.

Table 10: Net energy saving by heating type

	Net energy saving (2001 to 2002, adjusted for change in control group saving)
Type of household heating	**(%)**
Electricity	4.1
Mains gas	13.1
Bottled gas	61.8
Wood	30.5
Coal	93.4
All heating types	**28.4**

Valuation of energy savings

As discussed in the Method section above, we limit consideration here to energy sources with **objective** energy price data (i.e. electricity, mains gas and bottled gas), a "typical" household[21] benefited from net energy savings of 15%, or 373 kWh (over the core 3 winter months). This amounts to 477,813 kWh, or 0.48 GWh across the 1281 households which were insulated.[22] On a full-year basis,[23] savings were 0.8 GWh.[24]

Table 11: Value of annual energy savings by heating type

	Energy savings	**Value of energy savings per unit**	**Value of (full year) energy savings**	
Type of household heating reported	**(kWh)**	**(c/kWh)**	**per household ($)**	**over the full sample of 1281 households ($)**
Electricity	101	12.86	21.69	25,303
Mains gas	338	5.40	30.48	2,301
Bottled gas	1604	7.49	200.63	61,077
Total			**252.80**	**88,681**

The annual value of these savings, over the full set of 1281 insulated households in the study, valued at current residential energy prices (excluding GST), is around $89,000 p.a. At a 5% discount rate, and conservatively assuming **no** increase in residential energy prices, the present value of future energy savings is **$1.36 million**.

A sensitivity analysis shows the following:

- Using a **10%** real discount rate, rather than 5%, gives a total present value of the benefits of energy savings of $0.84m.
- Using a **3%** real discount rate, rather than 5%, gives a total present value of the benefits of energy savings of $1.74m.

---

[21] This is a household having a heating pattern typical of the weighted average of all households in the study for which there is good data.
[22] We assume (to extrapolate) that the remaining households in the sample (of 1281) have the same pattern of energy uses as those households (526) for which complete data are available.
[23] To reiterate the explanation from section 3.5, the scale factor used measures the number of cold (less than 15 degrees) "degree days" for the 3 winter months and compares that with the number of cold degree days for the year, or to be exact with the number in the colder 7 months of the year. This produces a scale factor of 1.67 (averaged across the geographical areas in the study).
[24] By comparison, New Zealand consumes about 33,000 GWh of electricity annually.

- Using a more conservative estimate (**1.5**) of the full-year scaling factor, gives a total present value of the benefits (at a 5% discount rate) of $1.22m.

It is emphasised that these energy savings estimates make a number of **assumptions**, among which are two key conservative assumptions. The first is that energy prices will not increase over the estimation period. The second is that energy savings in respect of wood and coal heating are negligible. In practice, although the latter are difficult to value reliably, we know that quantities of wood and coal used did fall for insulated dwellings in the study. In fact, in terms of estimated kWh, energy consumed in the form of wood and coal fell at least as much as energy consumed in the form of electricity and gas. Thus the true value of energy savings is likely to be considerably greater than the conservative estimates given above suggest.

Peak demand savings

In addition, we note that the measured reduction in winter peak electricity demand in the Christchurch region, following insulation being installed, is estimated to have been around 18 percent.[25] The economic value to the lines network company (Orion) involved in this sub-study has not been estimated.

4.6 Aggregated benefit and cost results

Table 9: Estimated aggregate 'valued' benefits ($)

	Form of benefit					
	Reduced GP visits (self-report)	Reduced hospital admissions	Reduced days off school	Reduced days off work	Energy savings	Total benefits excl. GP visit svgs
Annual benefits per household ($)	[46.50]	71.60	10.00	51.30	69.10	202.10
Present value of benefits per household($)	[715]	1100	150	790	1060	3110
Present value of benefits ($m)	[0.92]	1.41	0.20	1.01	1.36	3.98

[25] Orion New Zealand Limited (2004) p1.

The above benefit estimates pertain to the 1281 dwellings in the study (after drop-outs largely due to death and mobility) i.e. the number of dwellings insulated. In effect, the total estimated tangible benefit, comprising tangible health and energy savings, amounts in present value terms to around **$3,110** per dwelling (at a 5% real discount rate, over 30 years).

5 Discussion

The benefit estimates in this study are generally based on the 1281 households and 4183 people for whom we have information (91% of the original sample of 1400 enrolled households). For energy savings estimates, however, we have less complete information, and estimates are based on a sample of 526 households for which we have complete energy use data.

The overall result of a benefit-cost ratio[26] close to 2 means that the benefits accruing over time, in terms of health gains and energy savings, are a comfortable margin in excess of the costs of installing insulation in the house in the study.

The estimated benefits are resource savings for the health sector[27] and energy sector, plus benefits to the individual of avoided GP visits, and of avoided days off school and work[28]. The overall benefit estimate of $3110 excludes the benefits of avoided GP visits, since these data are self-reported and should be interpreted cautiously. Energy saving estimates (electricity, mains gas and bottled gas) exclude other forms of energy saving – i.e. reductions in wood and coal use for those dwellings with these forms of heating (typically complementary to electricity use).
Exclusion of these fuels, together with conservative assumptions such as that of no assumed increase in energy prices over the next 30 years, means that overall energy savings estimates are conservative.

In addition, it is clear that there is an economic value of the reduction in peak winter electricity demand, at least in the Christchurch region. Orion (the Christchurch energy network management company) measured this peak demand reduction, due to the insulation of the houses in the Christchurch area, at around 18%. While encouraging, this estimate should be treated with caution, as the study was not designed to have enough

---

[26] Benefit (3110) / cost (1800) = 1.73
[27] Fiscal savings (reduced health spending by government) in the health sector will be less than resource saving estimates.
[28] Estimates are based on the value of production lost when a person is absent from work.

households in any particular region to enable statistically robust regional conclusions to be drawn.

The total benefit figures summarised above also exclude certain aspects of benefit identified in section 1 above, in particular, significant enhancement of physical and emotional well-being arising from a warmer and/or more comfortable dwelling, possible reductions in mortality, and long-term health benefits as a result of reduced childhood illness. Because these benefits are not readily valued does not mean they are any the less important.

References

Holt, S and R Beasley (2001) **The Burden of Asthma in New Zealand**. Wellington: Asthma and Respiratory Foundation of New Zealand (Inc.) http://www.asthmanz.co.nz/burdenfull.pdf

Isaacs, N and M Dunn (1993) "Health and housing – seasonality in New Zealand mortality", **Australian J of Public Health. 17**(1), pp68-70.

Ministry of Economic Development (2003) **New Zealand Energy Outlook to 2025.** http://www.med.govt.nz/ers/en_stats/outlook/2003/executive-summary/executive-summary.pdf

New Zealand Health Information Service (1999) **Selected Morbidity Data for publicly funded hospitals 1996/97**. Wellington: Ministry of Health. Cited in Holt and Beasley (2001)p36, ref 98.

Orion New Zealand Limited (2004) **Effect of improved insulation on peak period demand.** Christchurch: Orion. 24 August.

Statistics New Zealand (2003) **Producer Price Index** series: http://www.stats.govt.nz/domino/external/pasfull/pasfull.nsf/0/4c2567ef00247c6acc256cd9007d7877/$FILE/Alltabls.xls

Wilson, N (2000) **The Cost Burden of Asthma in New Zealand.** Wellington: Asthma and Respiratory Foundation of New Zealand & Health Funding Authority. http://www.asthmanz.co.nz/costcontent2.htm

Annex 1

GP visit data: relationship between self-reported visit data and GP-reported visit data

The following description is based on the recognition that self-reported visits data is likely to be more accurate than GP-reported data, as the evidence is that GP care is relatively uncoordinated in New Zealand and that records do not give an accurate picture. (Prior to the recent development of population-based primary health organisations, primary care, and data recording it, were relatively uncoordinated.)

It is worth remembering also that, while in this study patients gave the researchers the name of their GP, studies of primary care in other contexts have shown that patients often have other GPs whom they visit for different purposes (e.g. for family planning). Also, records of after-hours clinic visits may not be forwarded to the patient's main GP. This may be a relatively common occurrence in the case of respiratory conditions.

The analysis reported below is for one area, Christchurch. The geometric mean ratio is a ratio of GP-reported visits (the numerator) relative to self-reported visits (denominator). The ratio data suggests that, in general, the GP-reported visit data may be downwards biased (at least for the control group). For the elderly, there appears to be a mixed picture of under and over-reporting by GPs, while for children, there appears to be significant under-reporting by GPs. The concordance data (table A2) also suggests that greater discrepancies may lie with the children's data.

Table A1: Correspondence between self-reports and GP-based records – indicator 1

Correlation between GP-based GP visits & self-reported GP visits, measured by geometric mean ratio[29]

		Group	
		Control	Intervention
Overall (not including teenagers)		0.89	0.97
Children	(0-12 yrs)	0.91	0.76
Adults	(18-65 yrs)	0.9	1.09
Elderly	(65+ yrs)	0.73	1.31

Table A2: Correspondence between self-reports and GP-base records – indicator 2

Correlation between GP-verified GP visits & self-reported GP visits, measured by Lin's Concordance Correlation Coefficient

		Group	
		Control	Intervention
Overall (not including teenagers)		0.52	0.47
Children	(0-12 yrs)	0.54	0.43
Adults	(18-65 yrs)	0.35	0.42
Elderly	(65+ yrs)	0.81	0.70

[29] The ratio is GP-reported visits/ self-reported visits; e.g. 0.89 indicates GP-reported visits were on average 11% lower than self-reported GP visits. A figure of 1.09 indicates GP-reported visits were on average 9% higher.