HOME TRUTHS AND COOL ADMISSIONS:
New Zealand housing attributes and excess winter hospitalisation.

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ABSTRACT

Background: The ratio of winter to non-winter mortality rates, or excess winter mortality (EWM), is higher in temperate countries, including New Zealand. Many studies suggest housing differences as a possible explanation. Home heating and insulation levels have been found to be associated with health outcomes and some studies have implicated housing faults as contributing to EWM. In contrast, excess winter hospitalisation (EWH) in general, and the contribution housing makes to EWH in particular, has been little explored.

Aims: This research aimed to describe EWH, and investigate whether housing attributes were associated with any excess.

Method: A retrospective cohort study was conducted of 1,596,126 acute overnight hospitalisations, over 11,477,510,015 person days, between 1 February 2000 and 31 January 2006, using the full National Health Index (NHI) database as the cohort. Using address data, 2,405,070 NHI records were matched to 689,185 Quotable Value NZ Ltd (QV) dwelling records. Winter was defined as 1 June to 30 September. Poisson regressions with robust standard errors were used to calculate both winter:non-winter incidence rate ratios (also known as the excess winter hospitalisation index, or EWHI) and relative rate ratios (RRR). RRRs were used to identify differences in EWHI within demographic variables earlier found to be associated with level of winter excess (sex, age, ethnicity, and Census meshblock rurality, NZDep decile, and annual average minimum outdoor temperature) and within the dwelling attributes (construction decade, insulation era, dwelling type, floor area, condition, tenure index, and capital value).

Results: Hospitalisation rates were 8.3% higher in winter than the rest of the year, with 7,166 excess winter hospitalisations per year. All-cause EWHIs were highest in the very young and older people, higher for women than for men, and higher in Māori and Pacific Peoples than in NZ Europeans. However, the higher EWHI for

Māori was due to higher rates of respiratory illness (which has the highest EWHI). EWHIs increased with increasing socio-economic deprivation (NZDep decile) and with decreasing annual average minimum temperature, but were lower in Rural Centres than in Main Urban areas. Similar patterns for age, gender, NZDep and temperature were observed in respiratory EWHIs, but while Pacific Peoples had higher respiratory EWHIs than NZ Europeans, Māori did not. Only age showed significant differences in circulatory EWHIs.

By dwelling type, EWHIs were higher in Villas (RRR 1.0297, 95% CI 1.0012-1.0591, p=0.041) and in Pre-war Bungalows (RRR 1.0296, 95% CI 1.0089-1.0506, p=0.005) than in Post-war Bungalows, and lower in Quality Bungalows (RRR 0.9781, 95% CI 0.9580-0.9985, p=0.036). EWHIs also increased as the proportion of rental households in a Census meshblock increased, and NZ Europeans living in "Poor" condition dwellings had higher EWHIs than those living in "Superior" dwellings. There was no difference in EWHIs by construction decade or insulation era.

Conclusion: Both demographic and environmental factors are associated with differences in EWHIs. Dwelling type is associated with EWH and probably overall hospitalisation rates. Further research to identify whether dwelling design or construction features are behind these differences in EWHIs could suggest areas for public health intervention.

ACKNOWLEDGEMENTS

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- Quotable Value New Zealand, and their decision to allow me to demonstrate how their data could be used in a novel (for QV) area of research;
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PREFACE

Before I embarked on this research, I knew nothing at all about excess winter health events. I did know a fair bit about housing, from an architectural/historical point of view, and I would have guessed that it intersected with health, but not how.

My interest in housing styles began in adolescence, when I accompanied my mother in her search for a house to buy. Later, a school social studies unit taught my class to identify different eras of New Zealand architecture, and included fieldwork roaming the streets of Palmerston North to find examples of each style.

In my late teens and early twenties, the suburb where I lived enjoyed a real estate boom, and I discovered the delights of the Open Home: at first most properties for sale were former renters, and my mother and I could puzzle over the layout of the rooms, and consider what we would change if we lived there ourselves. Later, there would be properties, sometimes the same ones, that other people had bought and renovated: had they done what we would done? Had they done something better, or, more entertaining, something worse?

In my late twenties, I moved from being a tenant and 'tyre-kicker'[*]*, to being a buyer. For a brief period I was a landlord, culminating in the shame-inducing moment of delivering notice while the tenant was in hospital delivering her fifth child. Since then I have been an "owner-occupier", a vendor, and now (sort of) a developer. So I think I've had every possible legal relationship with a house except a mortgagee.*

This life relationship with New Zealand housing means I have internalised a large amount of knowledge on the subject. Writing Chapter Six expanded and developed that knowledge, and was therefore perhaps easiest to write. I am certainly pleased to present it as a summary of the main New Zealand housing styles.

Thus, I now know rather more about housing (though never, ever enough); and far more about excess health events than most other people would want to know.

Over the course of this study, as for any PhD student, I have whittled my topic description down to its marrow. In earlier days, I began by explaining that excess winter mortality rates in New Zealand were higher than in much colder places like Scandinavia. The most common interjection was that that must surely be because our houses were "so rubbish" and/or that we don't dress properly for the cold. I would reply that although that seemed like an obvious explanation, many other people had done studies looking for the housing connection, but very few had been able to find one; and that "no, we don't dress properly for the cold, and when you go outside, put a hat on."

I now work with "more people are admitted to hospital in winter than over the rest of the year, and I'm looking at whether it's because of our housing." However, the response

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[*] Real estate agents' slang for people who are there to look, not to buy. I prefer to call myself a real estate voyeur, but then I'm not the one trying to make a living out of it. However, voyeur might be a euphemism for 'addict'. Hello, my name is Lucy, and I'm a Real Estate addict. It's been 115 days since I last went to an Open Home. Let me know if you hear of a twelve step programme.

from anyone not involved in housing and health research has been varying degrees of surprise that it should be necessary to test for something so blindingly obvious. Mind you, I suspect such a response is not limited to my research, and it is probably better than surprise that it should be thought necessary to test something blindingly pointless. However, I have sometimes had elements of the second reaction, mostly accompanied by some comment about how if people are cold, they should just go and put on a jumper. These are often the same people who argue with my advice to wear a hat outside when it's cold.

Still, for all my knowledge of housing, and excess winter events, I feel I am only just beginning to get an overview of the many intersections of housing and health. I look forward to a career travelling this new territory, both charted and uncharted.

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LIST OF ABBREVIATIONS

BRANZ	Building Research Association of New Zealand
CV	Capital Value
EWH	Excess Winter Hospitalisation
EWHI	Excess Winter Hospitalisation Index
EWH_n	Excess Winter Hospitalisation for ICD-10 Chapter n
EWM	Excess Winter Mortality
EWMb	Excess Winter Morbidity
EWMI	Excess Winter Mortality Index
NHI	National Health Index
NMDS	National Minimum Dataset (Hospital Events)
NZHIS	New Zealand Health Information Service
QV	Quotable Value New Zealand Ltd
RRR	Relative Rate Ratio

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

In 1988, the final report of the soon to be disestablished New Zealand National Housing Commission included "substandard housing" within its definition of serious housing need. Substandard housing was housing "without adequate physical protection or lacking basic washing or cooking facilities". Substandard housing was noted to occur among rural Māori, young people, and ex-psychiatric patients. The report made no mention of the general inadequacy of the national housing stock.[1]

Over the two intervening decades this general inadequacy has gained recognition, such that previous and current governments have funded subsidies for insulation and home heating; and popular media regularly include pieces reporting the inadequacy of houses' protection against cold and advising how best to maximise the amount of heat retained in a dwelling for each heating dollar spent.[*] It is possible that New Zealand's culture of virtuous cold may finally be in decline.

Over the same time frame, the long-recognised phenomenon of poorer health in winter than in summer has received increased attention in public health research. Hippocrates' quote bidding medical researchers to "consider the effect of each of the seasons of the year and the differences between them"[2] has now been so well quoted as to become cliché. Most of this research has focussed on mortality, which has perhaps the most immediately shocking seasonal differences. However, as this thesis will show, mortality represents only a part of the health burden imposed by winter.

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[*] E.g. "Tips and tricks that save you money" Sunday Star Times 12/6/2008 http://www.stuff.co.nz/sunday-star-times/features/energy-make-a-difference/485766/Tips-and-tricks-that-save-you-money, downloaded 10 June 2009.
"Heating your home and saving money" Sunday Star Times 25/5/2008 http://www.stuff.co.nz/sunday-star-times/features/energy-make-a-difference/456443/Heating-your-home-and-saving-money, downloaded 10 June 2009.
"Bad insulation linked to health woes" The Southland Times 3/12/2008 http://www.stuff.co.nz/southland-times/news/744766, downloaded 10 June 2009.

While media reports about fuel prices or insulation often reference excess winter mortality[*], and insulation and heating have been shown to improve objective health measures[3 4], the actual evidence for an association between housing conditions and excess winter morbidity or mortality has been variable: that evidence is discussed in detail in the literature review in Chapter Two.

This thesis, which adds to that evidence, began shortly after the completion of Gabrielle Davie's dissertation showing New Zealand's excess winter mortality rate, at 21%, to be as high as, or higher than, other comparable temperate countries. Concurrently, the University of Otago's Housing and Health Research Programme/He Kainga Oranga was increasing national recognition that indoor temperatures in New Zealand dwellings were inadequate – so cold, in fact, that International Energy Agency researchers thought reported indoor temperatures must be the result of data error, since it was "unlikely in practice that comfort levels are so low in New Zealand."[5]

1.2 AIMS

New Zealand's high winter excess of health events, poor housing stock, and good quality datasets, presented an ideal combination to test the association between this winter excess and housing conditions. Testing for such an association became the broad aim of this thesis, with the goal of contributing to the ongoing debate on the role of housing in contributing to and potentially alleviating winter excess morbidity

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[*] "Cash cow utilities `creaming off profit'" The Dominion Post 14/3/2009 http://www.stuff.co.nz/national/2260485/Cash-cow-utilities-creaming-off-profit, downloaded 10 June 2009
"Mother, child face winter in damp home" The Press 27/5/2008 http://www.stuff.co.nz/the-press/news/christchurch/461303, downloaded 10 June 2009.
"Expect a tight Budget" The Marlborough Express 27/5/2009 http://www.stuff.co.nz/marlborough-express/news/opinion/2447734, downloaded 10 June 2009.
"Power-price rises `may kill' elderly" The Press 1/1/2009 http://www.stuff.co.nz/the-press/news/national/173090, downloaded 10 June 2009.
"State housing needs a boost" Waikato Times 23/1/2009 http://www.stuff.co.nz/waikato-times/opinion/editorials/806921/State-housing-needs-a-boost, downloaded 10 June 2009.
"Winter cold is a killer" Whangarei Leader 16/6/2008 http://www.stuff.co.nz/auckland/northland/490769, downloaded 10 June 2009.

and mortality. An additional goal was describing New Zealand winter excess in hospital admissions, since hospitalisations have received comparatively less attention than mortality; literature on winter excess includes few studies of hospitalisations, and those there are focus on respiratory or circulatory admissions only. My literature search suggests that this is the first description, with any detail, of the difference in all-cause hospitalisation rates between winter and summer.

It should be noted that the difference between winter and other seasons is not purely a question of temperature, or even weather patterns. People change their diet, dress, and other aspects of behaviour, in response to winter. "Winter" is thus shorthand for a much broader collection of climatic and behavioural patterns than just temperature.

Overall, therefore, I sought to answer the following questions:

1. Are winter hospital admission rates different from rates in the rest of the year, and if so, by how much?
2. Which demographic characteristics modify that difference?
3. What aspects of housing modify that difference?

1.3 HYPOTHESES

For each of these questions, my initial hypotheses were as follows:

1.3.1 Differences in winter and non-winter hospital admission rates

I expected winter hospital admission rates to be higher than the rest of the year, but I had no basis for hypothesising how much they would differ by season other than the difference between winter and non-winter death rates, which I did not expect to be indicative.

1.3.2 Demographic modifiers

I expected the difference between winter and non-winter rates to vary by age and sex. I did not expect the difference to vary by socio-economic status, because previous researchers had not found any such variation, at least for mortality; but I thought that it should, because socio-economic status makes such a large difference to so many other health outcomes. For the same reasons, I did not anticipate any variation by ethnicity or rurality. However, I did expect there to be a temperature gradient to the difference.

1.3.3 Housing modifiers

As shelter is intended to ameliorate the effects of adverse climatic variations, those dwellings which do a better job at that amelioration ought to better protect their occupants from winter-related illness. Dwellings which were better insulated, better maintained, and with a design more likely to allow occupants to maintain comfortable indoor temperatures, should therefore have a smaller difference between winter and non-winter hospitalisation rates. I therefore hypothesised that dwellings built before the 1978 Building Code change in insulation standards would have a smaller winter: non-winter difference; that `modern' housing (i.e housing built after the Second World War) would have less difference between winter and non-winter than 'character' housing; and that the winter: non-winter difference would lessen with improved dwelling condition.

I also expected people living in rental tenure to have a larger winter: non-winter difference than owner-occupiers, given that rental tenure was not only a common marker of lower socio-economic status, but also signalled less occupant power to commission housing modifications to improve winter comfort.

It was unclear whether differences would vary by housing value or size, since these were as much additional measures of socio-economic status as of housing quality or ability to maintain a comfortable indoor environment.

Additional housing factors, such as heating source or household crowding, might also modify winter: non-winter hospitalisation differences, but were not able to be measured.

1.4 THESIS OUTLINE

This thesis presents a description of New Zealand excess winter hospitalisation (EWH) between 1980 and 2007 in general, and between 2000 and 2006 in detail; and differences in the latter period's excess by demographic sub-groups and by dwelling attributes.

Chapter Two presents a review of the literature on excess winter events and housing and represents my introduction to research on both those themes and their intersection. In that chapter, I spend a little time on each individual theme, and more time on that intersection, as it is the main point of this research.

Chapter Three describes the methods used for the analysis presented in subsequent chapters. It outlines not only the ratio method chosen as the basis of my definition of winter excess, but also the rather more arduous tasks of deciding which hospitalisations to include, which population to use as the denominator, and why, and the myriad other smaller decisions that had to be made about demographic descriptors. It also outlines the dwelling attributes able to be measured for this study, introducing, for the first time, the Quotable Value (QV) dataset, which has been a wonderfully rich resource to have been able to work with. The work presented here appears to be the first time QV data have been used for public health research.

Having established the methods to be used for the research, I move on in Chapter Four to describing the effects of those methods: the hospitalisations that were and were not able to be included in the study; and their winter:non-winter ratio, both overall, and by demographic variables.

Chapter Five provides a breakdown of the winter: non-winter ratio for specific ICD-10 chapters, particularly ICD1-10 Chapter IX, which covers circulatory illness; and ICD-10 Chapter X, which covers respiratory illness. I also provide the age distribution of EWHIs for other ICD-10 chapters which showed a winter excess, or an age distribution important to the overall study.

In Chapter Six, I describe New Zealand dwellings by type, as initially defined by Quotable Value New Zealand, in order to provide very necessary background for Chapter Seven, the crux of the research, which looks at the differences in excess winter hospitalisation ratios between those dwellings types, and between the other housing attributes available: dwelling age, condition, tenure index, value, size. The chapter also includes the results of some associated investigations: whether Capital Value, as a combination of housing variable and socio-economic variable, works as an alternative to the census area unit-based NZDep as an indicator of socio-economic status; and the association between dwelling condition and levels of rental tenure in census area units.

Penultimately, before the Chapter Nine conclusion, Chapter Eight discusses the validity of those results, and what they mean for New Zealanders' health, and housing, and for the wider field of research in excess winter events. Ultimately, I conclude that along with other demographic factors, housing attributes do make a difference to winter excess hospitalisations, but which aspects of those housing attributes are making the difference is still unclear: in the meantime, however, there is sufficient research showing the health benefits of improving New Zealand's housing stock that such work should continue, along with further research into exactly what aspects of our housing continue to make us sick.

CHAPTER 2 LITERATURE REVIEW

This study encompasses two themes: housing attributes, and excess winter morbidity. While these themes could include a very wide range of literature, I have focussed on literature which includes both excess winter morbidity and housing (or socio-economic status), given less coverage to literature covering only housing and health (limited to the health effects of cold and damp), or only excess winter morbidity, and less still to work on housing or health alone. Literature on New Zealand housing is covered in Chapter Six, or, in relation to tenure, in Chapter Seven.

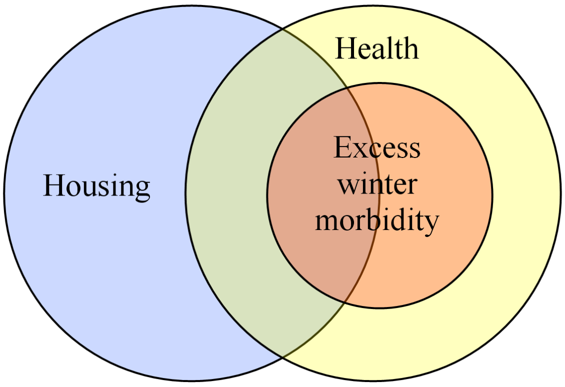

Figure 2.1 Intersects of literature on housing, health, and excess winter morbidity

2.1 EXCESS WINTER MORBIDITY LITERATURE

Excess winter mortality (EWM) has been widely documented around the world, with winter death rates in temperate climates 10% to 28% higher than expected, and higher still among the elderly.[6-9] Excess winter morbidity (particularly excess winter hospitalisation, EWH) shows similar patterns to EWM, though is far less studied.[10] Research in this area had not been subject to a published systematic review prior to this thesis.

Excess winter mortality literature has been well reviewed by Davie.[11] Rau has reviewed literature on the causal chain for EWM.[12]

Literature on excess winter morbidity as a phenomenon is limited. Most references which identify seasonality or winter excess are disease-driven, rather than phenomena-driven: the focus is on the description of a disease, rather than on winter excess. Further, where studies do focus on winter or temperature-related excess, they generally look at a limited range of conditions. However, there are a few exceptions.

2.1.1 All-cause hospitalisations

Crighton et al. examined all-cause hospitalisations in Ontario between 1988 and March 2000, comparing rates for peak and low months.[13] They found seasonality in hospitalisations for every age and gender group, except males between 20 and 39. Over the 12 years of the study, there was a mean difference of 21% between the highest and lowest monthly hospitalisation rates, with an overall Spring peak and Autumn trough. However, "minimum and maximum admission months [varied] by age group." Greatest variability appeared in the youngest age groups (0 to 4 and 5 to 9 years), while adolescents and young adults experienced less variation. Variation increased slightly after 30 years, particularly among women, then rose again for 70+ ages. However, hospital data were not filtered - results for women of child-bearing age may have been affected by the inclusion of birth-related admissions in the data; while results for holiday months would be affected by the inclusion of elective surgery.

Maheswaran et al. also examined hospital admissions: their study is also included in the section on housing and excess winter morbidity below, but their unmediated results are discussed here.[14] They analysed South Yorkshire emergency hospital admissions in the 45+ age group, between 1990 and 1999, categorising admissions as respiratory, cardiovascular, or all other causes, finding excess for respiratory hospitalisations (the winter: non-winter ratio was 1.80 for females and 1.58 for males), but not for the other two admission groups.

Moran et al. [10] analysed seasonal patterns in emergency hospital admissions for over-65 year olds in four areas of Ireland. While their results are only presented in graph form, the graphs show all-cause, respiratory and circulatory hospitalisation patterns having a winter excess, and tracking seasonal mortality patterns, with the closest tracking apparent in respiratory disease.

Garfield et al. analysed East Anglia adult intensive care admission data for 1992-2000, finding a clear winter peak in admission rates (between October and January); and a smaller summer peak. No age or demographic break-down was included.[15]

2.1.2 Respiratory hospitalisations

Researchers have published less on the difference between winter and non-winter rates of respiratory illness, and focussed instead on either the pattern of seasonality[16-18], or the relationship between respiratory illness and outside temperatures.[19] [20]

Crighton et al.'s work on influenza hospitalisations in Ontario falls into the former category, but does include an analysis of differences in seasonality by age and gender, finding the greatest seasonality in the 0 to 4 age group, followed by the 20 to 59 year age group, then the 80+ age group, and lowest seasonality in 10 to 19 year olds.

2.1.3 Circulatory hospitalisations

Interestingly, Maheswaran et al. suggest that the lack of a winter excess in heart disease might be "partly explained by clinical and management practice style, and the disruption in services due to holiday periods around Christmas and New Year."

Watkins et al. looked at Nov-Feb/May-August ratios for "Finished Consultant Episodes" (FCE) for ischaemic heart disease.[21] They used ACORN housing type[*] as an indicator of socio-economic status, and found the winter excess to be greater in more affluent areas.

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[*] **ACORN** is a geodemographic segmentation of the UK's population which segments small neighbourhoods, postcodes, or consumer households into 5 categories, 17 groups and 56 types, developed by CACI. More information on ACORN can be found at http://www.caci.co.uk/acorn2009/CACI.htm (downloaded 3 August 2010).

A study of New Zealand EWM from cardiovascular disease (EWMCVD) found EWMCVD increased with increasing age, and for NZ Europeans in the most deprived NZDep quintile. There was no significant difference by gender or ethnicity.[22]

2.1.4 Other causes of disease

Douglas et al.'s study used a cosinor analysis of hip fracture admissions to compare seasonality between Scotland, Hong Kong and Auckland, New Zealand.[23] Both Scotland and Hong Kong had highly significant winter seasonality, but Auckland did not. No analysis by demographic sub-group was included in the study.

2.2 HOUSING AND HEALTH LITERATURE

There is a large body of work examining associations between health and housing factors.[24] [25] [26] Housing factors implicated in poor health include low indoor temperatures[27] and associated indoor climate indicators[28]. There is a high degree of cross-over between research on low indoor temperatures as a function of housing fabric and as a function of fuel poverty, which includes the occupants' ability, particularly financial ability, to heat their homes.

There is also a significant body of work on other housing and housing-related factors which affect health, such as: indoor air quality; associated building products and heat sources; dust mites; and crowding. Factors such as these are not included in this study.

Intervention studies are few[29], but have found improving insulation to improve self-reported and objective measures of health[3 30]; and improving heating[4] to improve self-reported and objective measures of respiratory health in children.

2.3 HOUSING AND EXCESS WINTER MORBIDITY LITERATURE

2.3.1 Introduction

Excess winter mortality (EWM) has been widely documented around the world, with winter death rates in temperate climates 10% to 28% higher than expected, and higher still among the elderly.[6] Excess winter morbidity, particularly excess winter hospitalisation (EWH), shows similar patterns to EWM, though is far less studied.[10] Research in this area had not been subject to a published systematic review prior to this thesis.

To develop an effective public health response to EWM and EWH, it is important to identify social or behavioural factors that contribute to the excess, particularly those that might be modifiable. Few studies have investigated these factors, and fewer still have used individual-level exposure data. The large variations in EWM between different countries remain inadequately unexplained,[6] suggesting this is an important area for environmental health research.

This review was undertaken to summarise current research on EWM and EWH with a particular focus on assessing those studies that investigated the contribution of warm housing and relatively high socio-economic position to protecting against winter illness and death (or the corollary of cold housing and relative deprivation as risk factors for EWM and EWH).

2.3.2 Method

2.3.2.1 Locating studies

Initial searches were done in Medline, and Pubmed, using keyword combinations of "hospitalisations", "morbidity", "mortality", "seasonal", "temperature", "winter excess"; and "housing", "fuel poverty", "deprivation" and "socio-economic". Searches were limited to studies with an English, French or Spanish translation. Further literature was found by following reference trails (checking and following-up references in found articles).

2.3.2.2 Selecting studies

To be included, the reported study had to meet the following inclusion criteria: (1) have calculated EWM or EWH; (2) investigated the association between this and the SES or housing conditions (specific measures included social class and deprivation level; housing rated as "poor quality"; lack of central heating; or fuel poverty); (3)

used suburban or smaller ecological units, or individual data, for their investigation; (4) had adequate analytical methods that were fully described.

2.3.2.3 *Appraising studies*

Studies were appraised based on the following criteria:

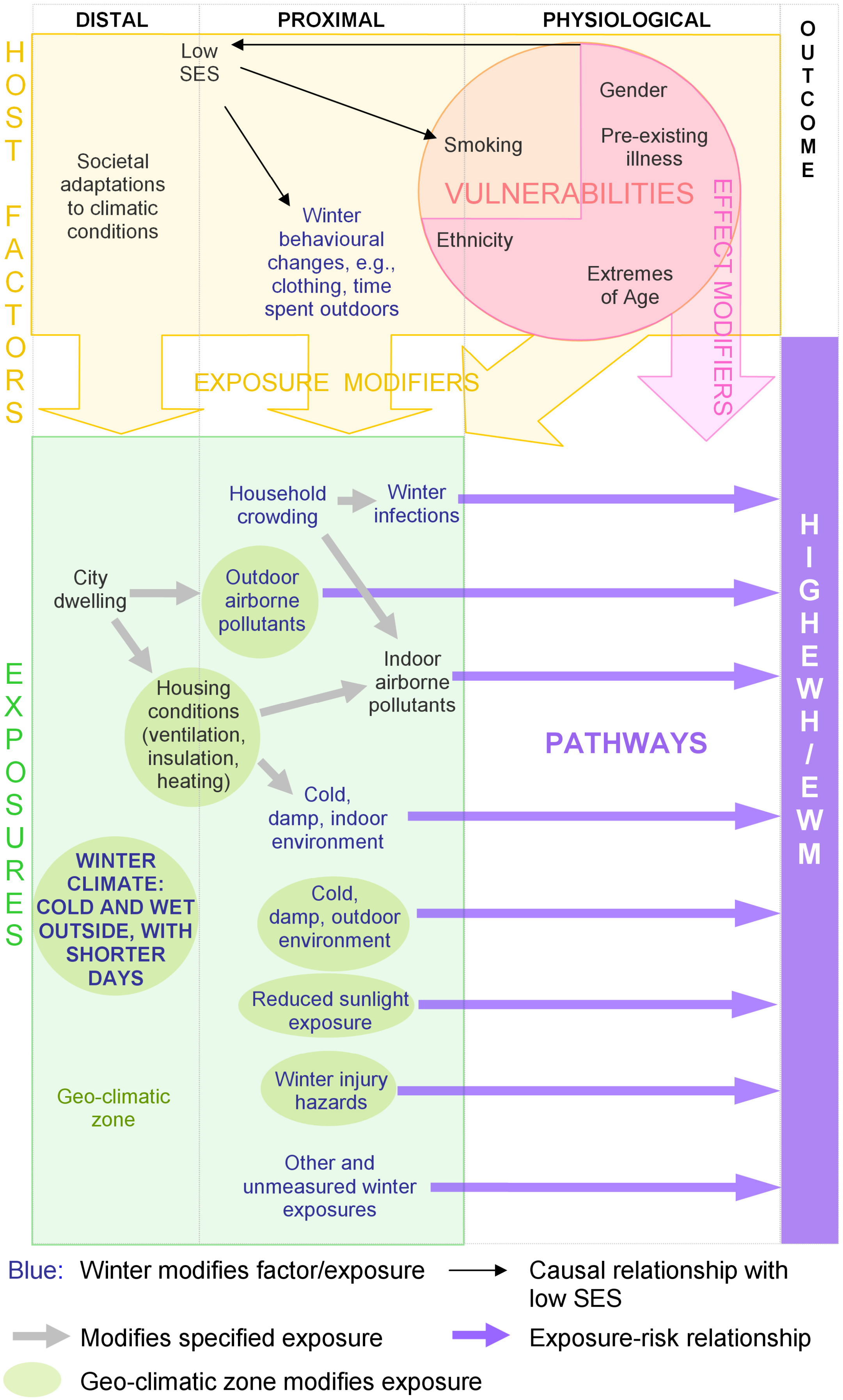
1. Used a design that allowed the participants to be accurately linked to their social and housing conditions (with emphasis placed on more rigorous designs that collected individual level exposure data);
2. Depending on the research question of the published study, this meant greater emphasis placed on more rigorous designs such as time-series studies that collected temperature exposure data, and less emphasis attached to studies which assigned cold exposure by season; and
3. Controlled for important confounders (see below).

2.3.2.4 *Conceptual framework*

To help assess these studies, we identified the hypothesised pathways mediating the effects of winter climatic conditions on EWH and EWM (Figure 2.2). This framework was used to assess the hypothesised pathways described by specific studies and the extent to which they identified and controlled for potentially important confounders.

Figure 2.2 shows hypothesised causes, or factors contributing to, high EWM, and the direction of the relationship between them. There are two hypothesised pathways from poor housing and housing-related conditions to EWM/EWH; directly, due to physical effects of the indoor environment (where poor quality housing results in cold, damp conditions); and indirectly via household crowding and the consequent increase in respiratory illness from infections and exposure to airborne pollutants.

Figure 2.2 [Facing page] Hypothesised pathways mediating effects of winter climatic conditions on EWH and EWM, showing the potential contribution of host and environmental factors which may act as causes, covariates, confounders or effect modifiers.


DISTAL
PROXIMAL
PHYSIOLOGICAL
OUTCOME
HOST FACTORS
Low SES
Societal adaptations to climatic conditions
Winter behavioural changes, e.g., clothing, time spent outdoors
Smoking
Gender
Pre-existing illness
VULNERABILITIES
Ethnicity
Extremes of Age
EFFECT MODIFIERS
EXPOSURE MODIFIERS
EXPOSURES
Household crowding
Winter infections
City dwelling
Outdoor airborne pollutants
Indoor airborne pollutants
Housing conditions (ventilation, insulation, heating)
Cold, damp, indoor environment
WINTER CLIMATE: COLD AND WET OUTSIDE, WITH SHORTER DAYS
Cold, damp, outdoor environment
Reduced sunlight exposure
Winter injury hazards
Geo-climatic zone
Other and unmeasured winter exposures
PATHWAYS
HIGH EWH / EWM
Blue: Winter modifies factor/exposure
Causal relationship with low SES
Modifies specified exposure
Exposure-risk relationship
Geo-climatic zone modifies exposure

This diagram shows potential confounders in studying the relationship between poor housing conditions and EWM to be SES, age, indoor and outdoor air pollution, winter behaviours (e.g. wearing warmer clothing, spending less time outdoors), seasonal physiological changes, and household crowding. In studying the relationship between SES and EWM, potential confounders would be the same except that SES would obviously not be considered a confounder.

2.3.3 Results

2.3.3.1 Number and characteristics of studies

No studies were found in languages other than English. The literature search identified 25 studies that were concerned with EWM and potentially modifying factors and four studies concerned with EWH. Of these 29 studies, 15 met the selection criteria and are summarised in the attached Tables 1A-2B. The other 14 studies were excluded because: their hospitalisation/mortality data were not linked to their SES/housing indicator data[31-34]; their analytical methods were not adequately described[7 35-37]; their ecological areas were too large to support conclusions linking outcomes to exposure[38-43]; or their conclusions linking SES/housing indicators to EWM were not based on new empirical findings.[44]

2.3.3.2 Design

The tables in Appendix 2 reference 15 studies. Two studies considered two separate datasets[12 14]; three used one dataset but two designs[8 45 46]; one used two ecological designs for its central dataset, and a cohort design for a sub-group with individual-level data[47]. Two other articles report essentially the same study, [48 49]but the later article modifies and improves the earlier method so they are listed together. Otherwise, all provide separate results for each design/dataset, so are listed separately. Thus, the 21 listings are comprised of seven cohort studies – five using winter/summer ratio methods, two using time-series; and 14 ecological studies, of which five used time-series methods, and nine used seasonal ratios.

2.3.3.3 *Location and time*

Thirteen studies were UK-based, one was from Sao Paolo, and one used data from two countries (USA and Denmark). The UK-based studies ranged from localised studies (Newham, Stockport, Bradford), through smaller and larger regions (South Yorkshire, Scotland) to sub- and full national datasets (England and Wales, Great Britain).

Study data ranged from two to 28 years, with study years falling between 1973 and 2000. Over half the studied years fell between 1989 and 1996.

2.3.3.4 *Subjects and size*

Studies generally included either the whole population of a given geographical region, or the population over a certain age. Maheswaran et al.[14] used 45+ (for both morbidity and mortality); Rau[12] used 50+ (USA) and 65+ (Denmark); Aylin et al.,[50] and Rudge and Gilchrist[48] used 65+; and Wilkinson et al. 2004[45] 75+. Study sizes varied from 3,373 hospitalisations (Newham 1993-1996) to 4,507,910 deaths (UK 1986-1996). The median number of deaths (where numbers were given) was 195,905.

2.3.3.5 *Exposure to winter*

Winter exposure was measured either by month of health event, with certain months designated "winter" months, or by temperature. Since all but one of the studies were based in the Northern Hemisphere, the winter months were typically December, January, February and March.

- Ratio methods:

Most studies (10) used, directly or indirectly, Curwen's[7] Excess Winter Mortality Ratio (EWMR) or Index (EWMI), calculated roughly as follows:

Curwen's EWMI =

$$\frac{\sum_{deaths}(Dec, Jan, Feb, Mar) - \sum_{deaths}(Aug, Sep, Oct, Nov, Apr, May, Jun, Jul)/2}{\sum_{deaths}(Aug, Sep, Oct, Nov, Apr, May, Jun, Jul)/2}$$

The EWMI is usually expressed as a percentage. EWMR=EWMI+1. There are variations in how the EWMR is calculated; some approaches divide by the number of days rather than the number of months.

Rau 2004[12] used a different ratio, comparing deaths from January to March with deaths from July to September, (for the Northern hemisphere). Maheswaran et al. 2004[14] used an alternative index for looking at morbidity data, comparing only December and January admissions with the rest of the year. The shorter 'winter' period was used because "inclusion of months with no excess would have diluted the excess winter admissions ratio … and reduced the chances of detecting any association…".

Watkins et al. 2001[21] also used a different ratio for their morbidity study, comparing 'Finished Consultant Episodes' (FCEs) from November to February with FCEs from May to August. They used the interval from November to February because these months were colder in the study period than the more usual December to March period.

Van Rossum used a further ratio method, initially using a time-series method to find peak and trough mortality rates by month, then using the ratio of highest to lowest monthly mortality rates as their comparative unit.

- Time-series methods:

Five studies used time-series methods. Gouveia et al. [51] used generalised additive Poisson regression models to estimate the relative risk of death associated with a 1°C change in mean temperature for each group.

Donaldson and Keatinge [52] used generalised linear Poisson modelling to estimate daily mortality at 18°C, using the regression coefficient of mortality on temperature and its standard error, expressed as a percentage of deaths at 18°C, to provide cold related mortality and standard error for each group. Shah and Peacock [46] included a monthly time-series analysis, using multiple linear regression to model monthly ward mortality. Gemmell et al. 2000[8] used lagged Poisson regression analysis of numbers of deaths and average weekly temperatures, for both ecological and individual level SES exposures. Wilkinson et al. 2004 used a modification of Schwartz et al.'s 1996 time series method.[53] .

2.3.3.6 *Effect modification by SES and housing*

The 20 studies that investigated the effects of SES used a range of measures, with a number including more than one indicator of SES. Socio-economic deprivation, as measured by Townsend scores and Carstairs groups, appeared in nine studies; social `class', as measured by male or head of household occupation, ACORN housing type or Super Profile group (derived from census demographic, household, and housing variables), appeared in seven. Gouveia et al.[51] approximated an index at district level. Other studies included education level, household income, housing tenure, and "self-assessed difficulty making ends meet". Seven studies used individual level SES data.

Only three studies looked directly at housing quality. Aylin et al.[50] and Wilkinson et al.[47] both used the English House Condition Survey and extrapolated conditions to the surrounding postcodes. Rau[12] used individual-level data, on how many of three possible installations a property had (toilet, central heating, bath.)

Rudge and Gilchrist[48] [49] derived an enumeration district Fuel Poverty Risk Index – something between SES and housing quality - from census household data on income; presence of pensioners; and under-occupation, supplemented by EHCS data on housing condition.

2.3.3.7 *Outcome measures*

The most common outcome measure was all-cause death (used in 14 studies). Wilkinson et al. [47] looked specifically at death from cardiovascular disease, while four studies included sub-analyses of death from cardiovascular, respiratory, and/or other causes. Nine studies limited cases to older age-groups, who have been shown to have strongest seasonal mortality patterns.

Only three studies looked at morbidity: Watkins et al.[21] examined "Finished Consultant Episodes" for ischaemic heart disease, while Maheswaran et al. [14] and Rudge and Gilchrist[48 49] examined emergency hospital admissions with respiratory diseases.

2.3.4 Discussion

There is little evidence of a relationship between socioeconomic status and excess winter health events, and only limited evidence that such events are associated with housing quality. However, we identified few high quality studies in this area. Only seven used methods that could assign SES and housing quality at the individual level[8 12 45 47 52 54*]; only two of those used time-series methods[8 52], with most based on simple ratio methods to assign mortality and morbidity events to winter or non-winter periods.

2.3.4.1 Socioeconomic status and excess winter mortality.

Five of the seven cohort studies found no significant relationship between SES and EWM. Rau's Denmark study[12] found no relationship between 'wealth' (based on a composite index at the household level) and EWM, though the narrow SES range in Denmark is an important limitation of this study. Wilkinson et al.[45] also found no relationship, but relied on self-reported economic status. Van Rossum et al.'s[54] study also found no relationship, but used occupational class data that in some cases were 28 years out-of-date.

Donaldson and Keatinge's 2003 study[52] found significant, but not necessarily graduated, differences in EWM rates in different classes, sexes, and ages. However, the researchers' inference from these results, that internal heat production from manual work protects lower class men from daytime cold stress, is overly speculative, ignoring the manual work requirements of women in the home, their possibly greater exposure to outdoor cold on household errands[55], and the large

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[*] Rau's study is counted as two, as it measures EWM for two different groups.

proportion of "unskilled" workers whose employment does not involve manual labour, or who are unemployed.

Wilkinson et al.'s 2001 study[47], also using head of household professional group, again found no statistically significant trend across groups – if anything, results pointed to a higher EWM rate among "Professionals" than "Unskilled manual" workers.

Only Rau's analysis of US data showed any relationship between SES and EWM, finding EWM rates lower among those with more education.[12] It is unusual among other studies in that it used education as its SES indicator, and used a January-March/July-September mortality ratio rather than Curwen's. However, Rau's findings may be confounded by location, given possible geographical differences in education levels, seasonal temperatures or winter air pollution.

Overall, only one study[48] found any association between EWM ratios and SES as measured by a deprivation index. If there is any association between deprivation and EWM, index-based studies would appear not to be the best design for estimating it. Among the time-series designs, again, the balance of evidence would indicate no association with SES.

2.3.4.2 Housing

Two cohort studies[12 45] which included housing factors had null findings. Rae et al's study from Denmark showed no housing effect, but considered there to be little variation in Danish housing.[12] Wilkinson et al.[45] relied on self-reported data, and the small numbers of people admitting frequent difficulty in keeping their house warm left wide confidence intervals.

Among ecological studies, three included analysis of housing/heating factors. Using Curwen's EWMI, Wilkinson et al.[47] found significant relationships between EWM and living in postcodes where surveyed dwellings were poorly heated, had low energy-efficiency, were built before 1850, or had low indoor temperatures. They also used time-series methods to demonstrate a relationship between cold housing and mortality. Aylin et al.[50] showed central heating to be associated with a higher risk of dying in winter. Lawlor et al.'s[56] 2000 study, while looking at SES, had results consistent with housing being a factor in EWM, as there were general housing differences between the Super Profile groups, and it was these differences which the authors speculated might be behind 'Thriving greys' and 'Hard-pressed families' appearing to have higher EWM than other Super Profile groups.

2.3.4.3 *Methodological issues*

Curwen's EWMR has become the de-facto standard for seasonality studies, and is the clear contender for inter-study rate comparisons. However, there are some problems with ratio methods, whether winter:summer or winter:rest-of-year. First, where locations experience summer heat-related morbidity, a blunt seasonal ratio cannot establish how many deaths are due to 'winter'. Second, season or temperature-related morbidity may exist outside the months defined as 'winter'. Excess seasonal events may be better established by determining an 'optimum' event rate, and using that as the baseline measure for comparison with other seasons, whether hot or cold. Third, as Wilson et al. 2001[57] point out, comparisons of studies in different regions can be misleading, as the selected winter period may not be most appropriate to all regions' weather patterns.

The generalised linear model used by Gemmell et al.[8] has the advantage of still producing a winter/summer mortality ratio, but avoiding the problems they identify with the usual ratio method of "predetermining where the peak in mortality is expected to occur". Other time series models may also avoid the above problems, although the methods used in the other time series studies included here do not attempt to identify an overall seasonal pattern and instead measure short-term temperature related changes. Also, the variety of models makes cross-study comparisons more difficult.

2.3.4.4 Hypothesised Pathways

Of the 15 studies referenced, nine included some comment on the hypothesised pathway linking exposure to winter conditions to negative health outcomes and the potential modifying effects of SES and housing quality.[8 12 14 45 47 50 54 56] Researchers cited studies showing that cold exposure leads to increased circulatory illness via increased blood pressure, fibrinogen, cholesterol, platelet, red cell and white cell counts; and to increased respiratory illness (which in turn raises fibrinogen levels) via increased susceptibility due to cold-induced inflammation of respiratory tracts, and adverse immune system responses to cold. One study noted that respiratory death increases might be attributed to cross-infection from indoor crowding, and to micro-organisms' improved survival in droplets at low temperatures.[14]

Several of the studies discussed how the SES and housing conditions they measured might relate to exposure to cold indoor or outdoor environments. It is often assumed that socio-economic deprivation would contribute to indoor cold exposure via fuel poverty. However, Wilkinson et al. 2001[47] found that while larger and urban homes were warmer, so too were housing association dwellings; privately rented accommodation was coldest, but people in lower SES groups did not, on average, have cooler homes than those in higher SES groups.[47] Aylin also found little correlation between Carstairs deprivation index and having "no central heating".[50] Gemmell et al. also note that "area-based measures of deprivation and individual-based social class data are not adequate proxy measures of housing conditions and fuel poverty."[8]

2.3.4.5 Control for confounders

There was surprisingly little discussion of possible confounders in this literature, which may reflect different undeclared assumptions about EWM and its causal pathways. Our assessment is that research on the role of housing factors in contributing to or mediating the effects of EWM/EWH needs to consider the role of SES, age, indoor and outdoor air pollution, winter behaviours, seasonal physiological changes, and household crowding. All studies controlled for age, by design or analytical method. Four studies controlled or attempted to control for influenza outbreaks.[8 45 52 56] Others have either not mentioned controlling for it, or perhaps consider influenza deaths part of the winter effect. I also take this view (see Figure

2.2). One ratio-design study controlled for temperature, presumably seeing EWM as an additional effect.[45] Another controlled for the presence of nursing and residential homes in the areas under study;[46] a third noted them as a possible confounder.[56] Wilkinson et al.'s 2001 ratio-design analysis of housing factors controlled for SES. Gouveia et al. controlled for humidity and air pollution at a city-wide level in their Sao Paolo study. Both Lawlor et al. 2000[56] and Shah and Peacock[46] cited Mackenbach[58] as a reason not to control for air pollution. However, Mackenbach's finding that air pollution has little effect on temperature-dependent variations in mortality applies to short-term patterns rather than long-term, including seasonal, relationships.

The potential for confounding by air pollution levels was rarely discussed. It may be that, like Van Rossum et al. 2001, researchers have implicitly considered air pollution to be one of the many climatic factors that contribute to the 'winter' effect. However, if air pollution levels vary between wards (the most common ecological unit measure), then failure to control for air pollution could confound results for relationships between EWM and SES or housing quality. Given that we might expect higher levels of air pollution to be associated with poorer housing, the lack of association between poor housing and higher EWM/EVH tends to count against this exposure making a large contribution.

Other potential confounders not accounted for were winter behaviours, seasonal physiological changes, and household crowding. Current models for studying EWM would not lend themselves to controlling for the first two of these, nor crowding due to time spent indoors, so their contribution to EWM can only be estimated from larger-area studies[31 59], which is outside the scope of this review. Overall household crowding, however, could perhaps be more widely accounted for in future studies.

2.3.4.6 Limitations of review

This review was limited to studies reported in the indexed medical and public health literature. Because few studies have been reported, it was necessary to include those with less robust design, such as ecological studies, though the criteria used to appraise the studies took account of these limitations.

2.3.4.7 Implications for public health

Although the lack of SES gradient in EWM is counter-intuitive, the present balance of evidence supports this conclusion. Interestingly, the lack of socio-economic gradient in EWM does not carry over as clearly into housing factors: it may be that in the UK, where most studies were carried out, the range of energy efficiency is as variable in the dwellings of the rich as it is in the poor. Rudge and Gilchrist, among others, note that, at least in Europe, "social ownership does not normally equate with the worst energy ratings".[48]

Some studies attempt to explain why expected differences might not appear. Lawlor et al. state:

> "[E]xcess winter mortality is not associated with area deprivation …. Although people living in deprived … areas are likely to have greater difficulties keeping their houses warm during the winter months they may protect themselves from the extreme effects of cold by wearing extra clothing, living predominantly in one or two heated rooms, and keeping physically active. Alternatively the overall increase in ill health and total mortality associated with deprivation may mask any seasonal variation in deprived groups." [60]

Others are unconvinced by their own findings. Despite failing to find a social gradient to EWM, Gemmell et al.[8] conclude that the strength of the relationship between temperature/season and mortality is likely to be the result of "the population being unable to protect themselves adequately from the effects of temperature rather than the effects of temperature itself."

Public health recommendations, where present, call for population-wide measures. For example, Maheswaran et al.[14], supporting Lawlor 2000,[56] suggest that "measures to reduce excess winter mortality, such as improving indoor heating and dressing appropriately whilst outdoors, are implemented on a population-wide basis and not specifically limited to deprived areas."

Others temper their recommendations: Aylin et al.[50] note that if the relationship identified between lack of central heating and higher EWM:

> "were causal … then there could be policy implications in providing central heating to people who were not able to afford it. However mechanisms would also have to be in place to ensure that people were able to run and afford their central heating once installed. Further work is needed to disentangle the complex relationships between different indicators of housing quality and other measures of socioeconomic deprivation and their relationship to the high number of excess winter deaths in Britain."

Some initially in favour of targeted intervention have later shifted position. In 2001 Wilkinson et al.[47] asserted that, "people in poorly heated homes are indeed more vulnerable to winter death than those living in well-heated homes. This suggests that substantial public health benefits can be expected from measures that improve the thermal efficiency of dwellings and the affordability of heating them." But in 2004, following their cohort study, Wilkinson et al.[45] concluded: "The lack of socioeconomic gradient … has implications for public health policies aimed at reducing the burden of winter death, as fuel poverty relief alone may be only partially successful. The fact that the risk of excess winter death seems to be widely distributed in elderly people suggests that additional measures are needed to reach all those at risk."

Subsequently, Rau wrote that his results "support[ed] the findings of Wilkinson et al. that fighting fuel poverty might not significantly reduce the annual, cold related death toll."[61] However, his assertion neglects the substantial difference between Denmark's housing stock, which is predominantly homogenous and high quality, and that of the UK, which is neither.

Shah and Peacock[46] speculate that "people in deprived areas are more likely to adopt individual protective measures in response to fuel poverty that reduce its impact or that smaller, crowded accommodation in deprived areas may allow maintenance of adequate indoor temperatures."

Rudge and Gilchrist, however, argue for interventions aimed at fuel poverty rather than overall deprivation or energy conservation.[48] They see no contradiction in their own results, which found a relationship between EWH and fuel poverty, but not between EWH and Townsend score. They observe that housing tenure is the only building-related component in the Townsend index, and that it also includes unemployment, which is not relevant for older households, who have an increased EWH risk. They assert that their Fuel Poverty Risk Index is better designed to capture the likelihood of cold homes because it includes energy ratings of dwellings, and benefit receipt.

An alternative reason for the lack of an association between SES and EWM/EWH, is that the exposure that is responsible for EWM/EWH is ubiquitous in winter time. A plausible candidate would be a highly infectious respiratory disease like influenza or other respiratory pathogens. While some studies did attempt to control for influenza epidemics, none controlled for respiratory tract infection more generally. There is good evidence that such infections are associated with a marked transient increase in the risk of vascular events such as myocardial infarction and stroke.[62]

2.3.4.8 Further research needed

The most obvious research gap in this area is the lack of studies with good quantity individual level data on housing, indoor temperatures and SES. Rau's 2004 Denmark study[12] was well-executed, but the lack of social and housing gradient in Denmark made it unlikely to detect an effect, and difficult to extrapolate the findings to other locations. Second, it would be useful to use methods that more accurately measure exposure to cold temperatures and winter weather conditions, rather than simply assigning such exposures based on season (though these measures have a role if the exposure of interest is season rather than a specific weather variable). EWM and EWH measurement should ideally account for regional and national weather pattern differences and dual morbidity peaks (e.g. summer and winter). Third, studies investigating the role of housing factors need to consider the likely pathway(s) under investigation and control for potential confounders, including greater consideration of variations in air pollution levels. Fourth, there is surprisingly little work done on excess winter morbidity rather than mortality. Finally, it could also be potentially useful to conduct further studies on EWM and EWH outside the UK, in particular in countries that have less social housing, to provide input on whether social housing tempers the effects of deprivation on EWM.

Ultimately, questions about the relationship between SES, and housing conditions, and EWM/EWH may only be resolved by intervention studies. Opportunities for such studies could be provided by 'natural experiments' or controlled trials of housing improvements.[3]

2.3.5 Conclusion

On the basis of the studies reviewed, it would appear that there is no SES gradient in EWM, in the UK at least. Whether housing conditions play a part in EWM is less clear, but appears more likely than SES. There is an outstanding need for more discriminating measures of housing, SES, and specific causes of mortality in EWM research. Further studies based on ecological-level SES/housing data are unlikely to give us a better understanding of the causes of EWM. Instead, further individual level studies are needed, preferably including objective measures of housing quality and indoor temperatures. Intervention studies in countries with different housing stock and different tenure patterns would provide even more robust evidence. Given the lack of strong evidence for a positive health effect from differences in housing quality, it would also be ethically sound to include a control population in such trials.

My thesis picks up on some, but not all, of the challenging research requirements identified by this literature review. It focuses on hospitalisation, rather than mortality, and does not include a measure of indoor temperature, but does provide individual level housing data, including dwelling condition, and analysis to ICD-10 Chapter level. As well as an ecological-level SES indicator, it also includes a derivative of property value as a measure of individual-level SES.

CHAPTER 3 METHODS

3.1 INTRODUCTION

This chapter describes the study design, the types of analyses, and the five major datasets used. It then assesses the quality and limitations of each dataset and analytical method.

3.2 OVERVIEW OF STUDY DESIGN

This study sought to estimate EWH ratios for the New Zealand population, describe these rates according to important demographic and environmental characteristics, and then test hypotheses about the role of dwelling attributes in EWH.

Data for this study came from: The National Health Index (NHI) database; The National Minimum Dataset (Hospital Events) (NMDS); Quotable Value (QV) New Zealand Ltd data; Statistics New Zealand (SNZ) census data; and Landcare Research/Manaaki Whenua climate data. Choice of methods, and the strengths and weaknesses of each dataset, are described later in this chapter.

The major components were:

- The first, brief, analysis used poisson regression of NMDS data with SNZ population denominators to look at longer-term annual EWH patterns for the period 1980-2006.
- The main analyses used the NHI, NMDS, and Landcare Research/Manaaki Whenua datasets for a cohort analysis of EWH and demographic factors between 2000 and 2006, including sub-analysis by ICD-10 disease codes.
- The third analysis extended this cohort study to include QV data, to allow an analysis of relationships between housing variables and EWH.

3.3 DENOMINATOR POPULATIONS AND DATA

3.3.1 Census population denominators 1980 – 2006

Statistics New Zealand provided counts from the 5-yearly censuses, and estimates for the non-census years, stratified by age group and gender, for the period 1991-2006. Census-data-derived population estimates were used for the period 1980-1990.[*] These populations were used as the denominator for analysis of annual variation in EWH indices between 1980 –2006.

3.3.2 The NHI Cohort

For the main analyses, the NHI database was used as the cohort. This database includes all people in New Zealand with an NHI number, a unique number assigned to each person using health and disability support services.

3.3.2.1 NHI Information

- 2007 NHI data included the following fields:
  - date of birth
  - date of death
  - gender
  - ethnicity (three codes)
  - domicile code, mapped to Census Area Unit (CAU)[†], then cross-referenced to:
    - NZDep Index
    - Rurality Code
    - Territorial Authority (TA)

3.3.3 Climate Data

Annual mean minimum temperature by Census Area Unit was sourced from Landcare Research/Manaaki Whenua, which had sourced temperature data for 346 geographical points from the New Zealand Meteorological Service.

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[*] Gabrielle Davie prepared these estimates for her earlier study of excess winter mortality 1980-2006[*]

[†] Where the NHI data did not include a domicile code, but QV was able to match the address (see below), QV meshblock was used to provide a CAU instead.

> "Estimates of the mean minimum temperature in July, the coldest month of winter, were derived from a surface fitted to monthly estimates of mean daily temperatures."[*]

This annual mean minimum temperature was preferred over other temperature measures because it was easily available by Census Area Unit.

3.3.4 Quotable Value New Zealand Ltd Data

Quotable Value New Zealand Ltd (QV) was established as a crown-owned entity in 1998, its role having previously been filled by the Valuation Department, and became a state-owned enterprise in 2005. When QV was first established it purchased all existing Valuation Department property data, and continued as New Zealand's largest valuation and property information company. That purchased data, continually updated from sales data and local councils, forms the basis of QV's three operating arms: Valuations, which provides registered valuations; Online Services, which makes housing and sales data available online; and Rating and Taxation, which calculates property values for City and/or Regional Councils, who use them to set rates.

For this research, QV performed an automated match of their property data address fields to NHI address fields. They were able to match addresses for 3,734,464 (68%) of the 5,509,687 NHI records for people alive on any date 1 February 2000-31 January 2006. These matches covered 1,084,282 of New Zealand's estimated 1.8 million residential dwellings. Missing data are discussed in Chapter Seven.

QV data fields used in this study were:

- Decade of dwelling construction;
- Dwelling type;
- Dwelling floor area;
- Dwelling condition[*];

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[*] Technical documentation for the Landcare Research climate data is available at http://www.landcareresearch.co.nz/services/informatics/lenz/downloads/LENZ_Technical_Guide.pdf (downloaded 19 December 2007).

- Dwelling meshblock;
- Dwelling Territorial Authority (TA); and
- Capital Value (CV).

3.3.4.1 *QV data-derived variables*

From the QV data fields listed above, I derived the following additional variables:

- Pre- or Post-1980 "Insulation era", from decade of dwelling construction;
- Tenure index, from dwelling meshblock and 2006 census data on household tenure by meshblock;[†]
- CV decile, from CV and TA; and
- CV/m^2 decile, from CV, TA, and dwelling floor area.

3.4 OUTCOME (EWH) AND EXCLUSION CRITERIA

3.4.1 Cases: Hospitalisations

3.4.1.1 *Hospitalisation Data*

I obtained routinely collected hospitalisation data from the New Zealand Health Information Service (NZHIS), Ministry of Health, for all hospitalisations discharged between 1 January 1980 and 31 January 2007. I then excluded discharges for admissions before this period. I also excluded a large number of other hospitalisations, as discussed below.

I counted an exposed or unexposed person-day as a "case" if a hospitalisation occurred on that day, and a "non-case" if no hospitalisation occurred on that day.

3.4.1.2 *Exclusions: when is a hospitalisation not a hospitalisation?*

Most excess winter illness research has looked at mortality rather than morbidity, and there are immediate advantages to doing so. Mortality records may have inaccuracies around cause of death, or ethnicity, but where there is a mortality

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[*] Derived from the "Category" field.

[†] Census data does not distinguish between public and private rental tenure, so differences between the two rental tenure groups could not be considered in this study.

record, the researcher can be reasonably certain that someone has suffered a serious health event on approximately that date.

Raw New Zealand hospitalisation records, however, do not necessarily all represent serious health events occurring on or near the date of hospitalisation. Some admissions are not new health events – they may be transfers, or routine ongoing treatment such as renal dialysis or rehabilitation therapy. Others are not adverse health events, such as routine pregnancy and birth admissions; or even a health event at all, as with boarders (a family member admitted to accompany a patient). Then, there are "waiting list" and "arranged" admissions, where admission dates reflect administrative decisions over hospital occupancy management, rather than the actual date of the health event. Differences in admission type patterns are discussed further below.

Hospitalisation patterns also reflect changes, and regional differences, in admission policies. It would appear, for example, that some hospitals or regions admit people as day patients more readily than others.[63]

3.4.2 Cases: Deaths

For all-cause death analysis, I used date of death as recorded on individual NHI records, so as to have death data matched to QV data for the same time period as hospitalisation data.

However, the NHI includes only date of death, and not cause. For technical reasons, deaths by ICD-10 Chapter matched to QV data were unavailable after 31 December 2004, and unreliable after about November 2004.

In order to account for all these particularities, and to limit the data to more serious health events, I decided to include for analysis only new, "acute", publicly-funded, NZ resident hospitalisations where the patient was admitted overnight, and to also exclude a number of other admissions. Exclusions and reasons for them are listed in Table 3.1; proportions of hospitalisations for each exclusion category are outlined in Chapter Four

Table 3.1. Admission exclusion sequence and reasons.

Action	Reason
Starting point: All hospitalisations 1 February 1980 – 31 January 2007	1 February – 31 January year used to allow winter/non-winter analysis
Excluded:	
1. Non-publicly funded and/or private elective admissions	In New Zealand, private hospital admissions are relatively small in number (6.2% of hospital discharges for the 2000-2006 study period) compared to public hospital admissions and are almost entirely for elective procedures Private admission data are far less complete and timely than public hospital data and are not available for much of the study period.
2. Non-NZ residents	More overseas visitors in summer than in winter. NHI population denominator data are for people usually resident.
3. Transfers	Transfers are not new admissions; they reflect administrative decisions about the location of patient care.
4. All ICD-10 Z codes (Chapter 21)	Chapter 21 includes a wide variety of vague and non-relevant diagnoses, including boarders, pregnancy and birth related codes not included in Chapters 15 or 16, follow-up care, dialysis rehabilitation, screening, immunizations, prosthetic fittings, and social factors which do not represent an acute health event.
Disability support admissions.	Admissions do not represent a health event.
5. Admissions for pregnancy, birth, and in the perinatal period.	Most births in New Zealand take place in hospital. Birth is not an adverse health event. Births have a seasonal pattern; but the pattern is driven by factors nine months previous. Admissions related to pregnancy, and perinatal admissions, will reflect that seasonal pattern. It would not be practical to the scope of this research to adjust for that pattern. Perinatal events are also primarily driven by birth patterns.

Action	Reason
6. Waiting list admissions. Arranged admissions Admissions of psychiatric patients returning from leave. Admissions with no diagnosis data.	Admissions from waiting lists reflect availability of health specialists and hospital beds rather than time of onset of health event. There are strong variations over time in what is coded as an arranged admission and what is not (see Figure 4.2 in Chapter Four); Arranged admissions, like waiting list admissions, are strongly influenced by administrative decisions rather than the time of onset of the health event. Excluded because it is unclear whether these are arranged or acute Excluded because data are poor quality.
7. Admissions discharged on the same day as admission.	There is large regional variation in whether or not day patients are recorded as "admissions". These regional variations, and the overall rate of increase in day-patient admissions appear to be a response to health funding policies and changes in treatment methods. Including these admissions in the data would create data artefacts for years in which funding policies change – artificially inflating or deflating the admission rate in one season. Same-day discharge admissions do not represent the most severe admissions.

For analysis of deaths by ICD-10 Chapter, I obtained routinely collected mortality data from the New Zealand Health Information Service (NZHIS), Ministry of Health, for all deaths registered between 1 January 2000 and 31 January 2007.

3.4.3 Exposure and units of measurement.

The exposure variable was defined as "winter". In line with seasonal mortality research in the Northern Hemisphere, winter in NZ was defined as 1 June to 30 September.[40] Non-exposed cases and non-cases for any given "excess winter hospitalisation year" were person days in 1 February to 31 May, and 1 October to 31 January in the following calendar year.

Selection of "winter" as an exposure variable does create a difference between the method used and standard cohort methods. The usual cohort approach is to start with a population, establish who was exposed to the exposure of interest, and who was not, and how many cases of interest occurred amongst the exposed and unexposed. However, in this case, not only is everyone exposed for some periods, and unexposed for other periods, but everyone is exposed or unexposed at the same time.

The unit of measurement, therefore, was person-days. A person-day was either exposed, if it was a "winter" day, or unexposed, if it was a "non-winter" day.

So, in any given year, any person would generally contribute 122 winter person-days to the study, and 243 (244 in leap years) non-winter person-days. This number would be less if the person was born, or died, during that given year. Person-days for each year were aggregated separately to allow for increasing age over the period under study.

3.4.3.1 Non-study days

Person-days were excluded from the study for the duration of any individual's hospital stay, as people could not be hospitalised if they were already in hospital – if someone was re-admitted the same day they were discharged the readmission would be excluded as a transfer: only the first non-consecutive day of hospital admission was included in the study, as a case. While on an individual level this convention might bias results, since having a case would automatically reduce the number of non-case person-days for that season, at a population level it made little difference, as the approach was applied both in winter and non-winter.

3.5 KEY VARIABLES

The key variables, the level at which they were measured, their possible values, and their sources, are described in Table 3.2 below.

Table 3.2. Key included variables and sources.

Variable	Level	Values	Source(s)
Case/non-case days	Individual	Non-case Case	Non-excluded NMDS entry NHI dates of birth and death (if any)
Cases by ICD-10 Chapter	Individual	See ICD-10	NMDS Diagnosis code
Winter/non-winter	Individual	Non-winter Winter	NMDS admission date
Demographic data			
Sex	Individual	Male Female	NHI sex
Age	Individual	0-100 years	NHI date of birth
Ethnicity (prioritised)	Individual	NZ European Māori Pacific peoples Asian peoples Not elsewhere identified Other	NHI first ethnic group code
NZDep (main analysis)	Ecological, by CAU	1-10 (deciles) 1-3 (tertiles)	NHI domicile code Statistics New Zealand CAU code Ministry of Health NZDep deciles by CAU.
NZDep (dwelling analysis)	Ecological, by meshblock	1-10 (deciles)	QV 2006 Census meshblock Ministry of Health NZDep deciles by meshblock.
Rurality	Ecological, by CAU	1. Main urban 2. Secondary urban 3. Minor urban 4. Rural centre 5. Other rural 6. Other	NHI domicile code Statistics New Zealand CAU code Statistics New Zealand Rurality by CAU.
Annual Average Minimum Temperature	Ecological, by CAU	-4 to 10, by half degree Celsius.	NHI domicile code Statistics New Zealand CAU Landcare Research/ Manaaki Whenua annual average minimum temperature by CAU

Variable	**Level**	**Values**	**Source(s)**
Housing data			
Dwelling construction decade	Individual	1840-2000	QV “House Age” field
Dwelling type	Individual	Apartment Bach Contemporary Cottage Post-war Bungalow Pre-war Bungalow Quality Bungalow Quality Old Spanish Mission State Rental Terrace Apartment Townhouse Unit Villa	QV “House type” field
Dwelling floor area decile	Individual	1-10	QV “Building floor area” field
Dwelling condition	Individual	Poor Average Superior	QV “Category” field
Tenure index	Ecological	1-10	QV “Meshblock” field Statistics New Zealand Census 2006 household tenure data by meshblock
Capital Value Decile	Individual	1-10	QV “Capital Value” field QV “Territorial Authority” field
Capital Value/m^2 decile	Individual	1-10	QV “Capital Value” field QV “Territorial Authority” field QV “Building floor area” field

3.5.1 Ethnicity and prioritisation.

Analysis by ethnic group used Statistics New Zealand 2001 Level 1 ethnic classification codes, as follows: NZ European; Māori; Pacific Peoples; Asian Peoples; Other; Not elsewhere included. Ethnicity was prioritised according to ethnicity data protocols for the health and disability sector.[*] The Ministry of Health describes prioritisation of ethnic group as follows:

> "In prioritised output, each respondent is allocated to a single ethnic group using the priority system (Māori, Pacific peoples, Asian, other groups except NZ European; and NZ European). The aim of prioritisation is to ensure that where some need exists to assign people to a single ethnic group, ethnic groups of policy importance, or of small size, are not swamped by the NZ European ethnic group.
>
> This output type is the one most frequently used in Ministry of Health statistics and is also widely used in the health and disability sector for funding calculations, monitoring changes in the ethnic composition of service utilisation, and so on. Its advantage is that it produces data that are easy to work with as each individual appears only once so the sum of the ethnic group populations will add up to the total New Zealand population.
>
> … Limitations are that prioritised output:
>
> - places people in specific (high priority because of policy importance) ethnic groups which simplifies yet biases the resulting statistics;
> - over-represents some groups at the expense of others — for example, Māori gain at the expense of Pacific peoples (approximately 31,542) and Pacific peoples gain at the expense of other groups (34,602) of which most are Pacific/European (30,018); and
> - goes against the principle of self-identification."

Using prioritised ethnicity is not ideal, particularly when considered in relation to anthropological notions of ethnicity; it is reductionist and, as acknowledged by the Ministry of Health above, pays scant attention to the principle of self-identification. At the same time, the Public Health framework takes what Linnekin and Poyer and

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[*] http://www.nzhis.govt.nz/moh.nsf/pagesns/402?Open downloaded 30 April 2009.

others would describe as a Mendelian framework, in that it assigns a biological component to ethnicity;[64] the anthropological approach is generally much more Lamarckian.

However, how ethnicity is interpreted is always dependent "on the framework within which the researcher places her discussion".[65] Within the epidemiological framework, the meaning of ethnicity can be (though is certainly not necessarily) far removed not only from the meanings of ethnicity within anthropological discussion, but also from the meanings of ethnicity likely understood by the people checking form boxes upon hospital admission. Alternative, or additional, methods of measuring ethnicity would have gone beyond the scope of this research, and would have had little meaning to policy-makers. Therefore, only prioritised ethnicity was included in models in this study.

What is important is the implication of this choice. It means that results associating EWH with ethnicity must be understood within the context of prioritisation, and should be treated as a starting point for further research as much as a description of health status.

3.5.2 NZDep

Small-area level socio-economic deprivation scores were assigned using the NZDep ordinal scale, which is based on 9 census variables that reflect aspects of material and social deprivation.[66] NZDep01 and NZDep06, available for all of NZ's 1700 Census Area Units (CAUs), assign a score of 1 to the decile of census areas with the least deprivation and 10 to CAUs with the most deprived scores.

NZDep was assigned according to the census year closest to admission date: NZDep01 for admissions 2000-2003, and NZDep06 for admissions 2004-2006.

3.5.3 Rurality

Rurality was measured according to 2001 Statistics New Zealand Census Area Unit rurality classifications, described as follows:[67]

1. Urban
    a. Main Urban Area: Very large urban areas centred on a city or major urban centre, with a minimum population of 30,000
    b. Secondary Urban Area: Centred on larger regional centres, with a population between 10,000 and 29,999.
    c. Minor Urban Area: Urbanised settlements (outside main and secondary urban areas), centred around smaller towns with a population between 1000 and 9999.
2. Rural
    a. Rural Centre: Population between 300 and 999. These allow users to distinguish between rural dwellers living in true rural areas and those living in rural settlements or townships.
    b. Other Rural: Remainder of the statistically defined rural population of New Zealand.
3. Other: An area not defined above, in other words a residual category.

3.5.4 QV detail

QV provided the CV and 2006 Census area meshblock for all 3,492,930 matched addresses (66% of all addresses). Otherwise, percentages of data missing varied by field. Detail on match rates and missing data is provided in Chapter Seven.

3.5.4.1 Capital Value data

The CV estimates a property's market value at the date of valuation. It includes buildings and land, but does not include chattels, stock, crops, machinery or trees. The CV is intended to estimate what price the property would fetch if sold on the open market. It is usually based on sale prices for similar properties in the surrounding area, and general property price trends, rather than on an individual property assessment. People may request a reassessment of their CV, but in general would only be likely to do so to lower their council rates assessment (if they believe the property has been over-valued), or to attract a higher sale price (if they are selling and believe the property has been under-valued). QV reassess a property's CV every 1 to 3 years.

A property's CV may be viewed as an indicator of the socio-economic status (SES) of its occupants because it represents either a capital asset and/or an indicator of the aspirations of the occupant. It is not an exact reflection of the household's minimum net worth, as it does not show whether the occupant household owns or rents the property, nor, if they do own it, how much mortgage is owing on the property. In addition, some properties have a high value by virtue of their size and location, but attract low rents because of their condition: in these cases, the CV overestimates the SES of the occupants, though may still say something about their aspirations, in that they have opted for location over condition.

3.5.4.2 Dwelling condition data

QV assessors assign dwelling condition based on a walk-by viewing, usually conducted yearly; or, in areas where QV is contracted to determine rateable valuations, based on a fuller internal and external examination following work on the dwelling which has required a building consent.

Criteria used for assigning condition were not available when this thesis was submitted. However, QV ratings for overall dwelling condition have been found to be broadly similar to standardised assessment-based ratings assigned by the Building Research Association of New Zealand (BRANZ) in its 2005 House Condition Survey[68],[*] though QV had slightly more properties in the "Superior" and "Average" categories, and fewer in the "Poor" category, than did BRANZ.

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[*] BRANZ is a research, testing, consulting and information company funded by a levy on new construction. The 2005 BRANZ House Condition Survey "summarises the results of on-site inspections of the physical condition of 565 houses during 2004 and 2005, [and] a telephone survey of more than 500 homeowners, including owners of those houses inspected. The telephone survey recorded demographic, economic and maintenance information about the homeowners."[68] The major limitations of the BRANZ survey are that it includes only stand-alone owner-occupied dwellings located in or near one of New Zealand's three largest cities (Auckland, Wellington and Christchurch).

3.5.4.3 Dwelling type and construction decade data

QV assign and maintain dwelling type and age data in the same was as dwelling condition. However, dwelling construction decade is only rarely changed, i.e. following renovations and/or additions to an existing dwelling sufficiently extensive that the original construction decade no longer describes the bulk of the dwelling.

Critiria used for assigning dwelling type are attached in Appendix 7

3.5.4.4 Capital Value decile description

Capital Value (CV) deciles were assigned based on the decile of the capital value within each Territorial Authority, so as to provide some control for variations in property value by broader location – for example, the most expensive 10% of properties in Auckland has a higher total capital value than the most expensive 10% of properties in Christchurch, but the difference does not necessarily reflect an equivalent difference in socio-economic status. Similarly, the CV/m^2 decile was set by dividing the CV of the property by the floor area of the dwelling, and ranking and dividing that value into deciles by Territorial Authority.

CV and CV/m^2 deciles were included as an alternative, individual measure of socioeconomic status. The association between these deciles and NZDep is discussed in Chapter Seven. However, CV and CV/m^2 deciles, and any analysis based on them, are less likely to be meaningful for farmers, where the property value also represents a business value; and for people in rental accommodation, where the value of the property does not represent a cash asset for the tenant. However, New Zealand's 68% home ownership rate[*] makes CV deciles more meaningful than they might be in some other locations.

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[*] http://www.dbh.govt.nz/soi0508-14 downloaded 20 November 2007

3.6 DATA SOURCE STRENTHS AND WEAKNESSES

3.6.1 Census data

SNZ recognises that census data are an undercount. Undercount varies from census to census. SNZ Post-Enumeration Surveys have estimated total undercounts to be 2.0% in 2006, 2.2% in 2001, and 1.6% in 1996, with sample errors of 0.2%-0.3%. Undercounts do vary by sub-group, but this study used only total populations for annual variation analysis.

3.6.2 National Health Index (NHI) Data

Using the NHI database as a cohort not only enabled the use of cohort statistical methods, but also avoided many of the problems which may arise from differences between census denominator data and NHI data, particularly differences in the measurement of ethnicity.

NZHIS estimates that 98% of New Zealanders have a National Health Index (NHI) number, and therefore appear in the NHI database.[*] The main problem with NHI data quality is the presence of duplicates: NZHIS estimates the database includes about 1 million duplicates, about 20% of the total database. As the duplicates are unidentifiable, it is not possible to tell whether duplicates are more likely for any particular demographic groups. Some of these duplicates will have been excluded by using only records which had a date of last update,[†] but most remain.

There are also data quality issues with some dates of birth: if all dates of birth were correct, New Zealand would include some 3,700 people over 115 years of age, including about 108 206-year-olds. Almost all of these entries are likely to be incorrect, and it would therefore seem likely that there are other entries with more believable ages which are also incorrect.

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[*] http://www.nzhis.govt.nz/moh.nsf/pagesns/60 downloaded 30 April 2009.

[†] The NHI was introduced in 1993, replacing the National Master Patient Index instituted in 1977 (see website in previous reference). Where a record has been updated since 1993, it is more likely to represent an extant person, and the data in the record is more likely to be reliable. 92% of records have been updated since 1993.

However, overall comparisons of NHI age, sex, and ethnic group distribution show it to be sufficiently close to Census information to make it a useful cohort group.

3.6.2.1 Age and sex distribution

The population pyramids in Figure 3.1 below demonstrate that although total numbers are higher, the population spread of the NHI population generally matches that of the 2006 Census. The most obvious differences are:

- the lump of NHI entries over 100 years of age, as discussed above; and
- that the Census's late 20s population dip is less pronounced in NHI data. This may be due to a combination of people overseas still being recorded in the NHI – borne out by comparison with 2006 NZ resident permanent and long-term migration numbers - and 15-29 year olds being the largest under-counted Census age group, with an undercount of 4%.[*]

Note that the "waist" on Figure 3.1 is a reflection of a low 1980s fertility rate, as shown in Statistics New Zealand' Figure 3.2:

3.6.2.2 Age and ethnicity distribution

Figure 3.3 shows NZ ethnic group total responses as a percentage of all responses, for the 2006 Census, and for "updated" NHI database entries, by age group. There are some differences between the two population sources, both overall and within different age groups – the predominant difference is the larger number of NHI entries recorded as "Not Elsewhere Included", which includes "unknown". However, these differences favour use of the NHI as denominator, since recorded ethnicity at hospitalisation is more directly comparable with recorded ethnicity in the NHI database than with Census ethnicity.

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[*] http://www.stats.govt.nz/products-and-services/Articles/2006-post-enumeration-survey/results.htm

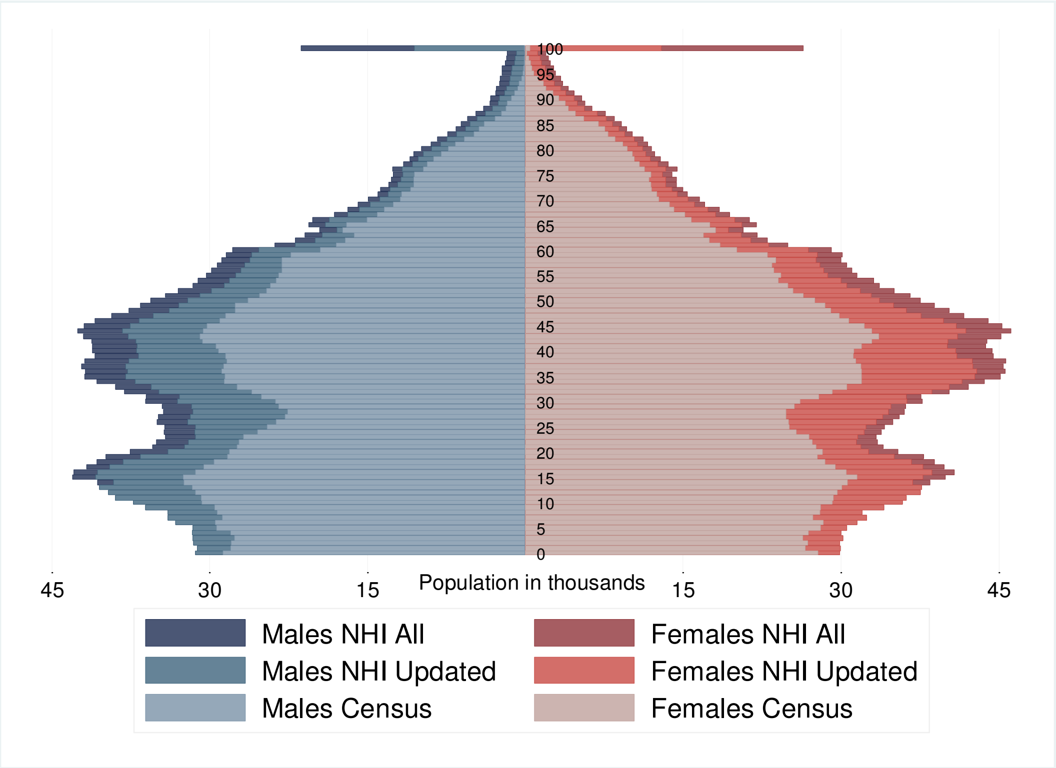
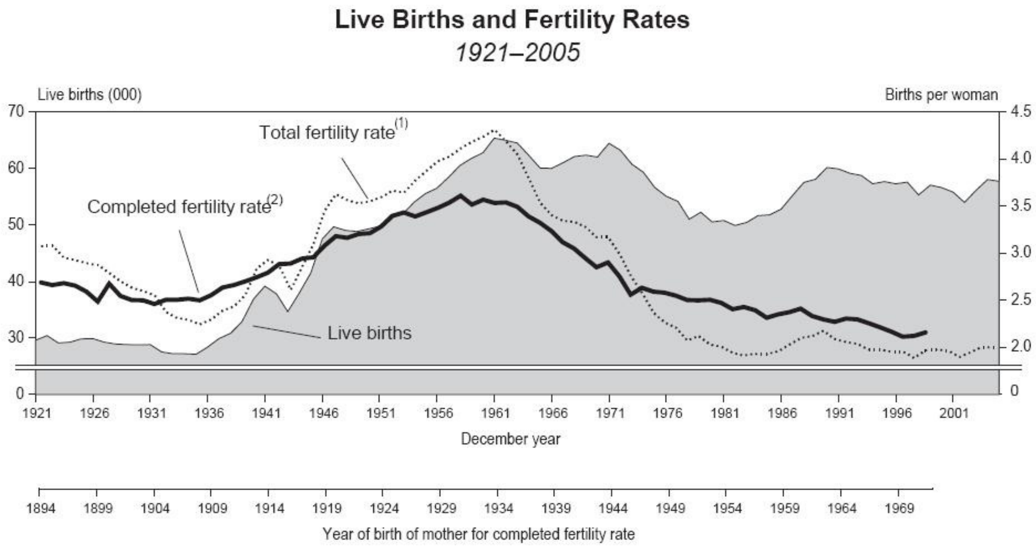


Figure 3.1. **NZ male and female populations for 2006 census and NHI database, updated since 1993, and all entries.**


Live Births and Fertility Rates

1921–2005

(1) The average number of births a woman would have during her life if she experienced the age-specific fertility rates of that year. It excludes the effects of mortality.

(2) The average number of children a woman born in a particular year has had during her life. The figures for 1957–1972 birth cohorts are estimates only.

Figure 3.2. **New Zealand Live births and fertility rates 1921 – 2005 (Source: Statistics NZ).**[*]

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[*] http://www.stats.govt.nz/NR/rdonlyres/24F0EC6D-A386-4DE5-B069-9E71BAE5BD20/0/Chapter2.pdf

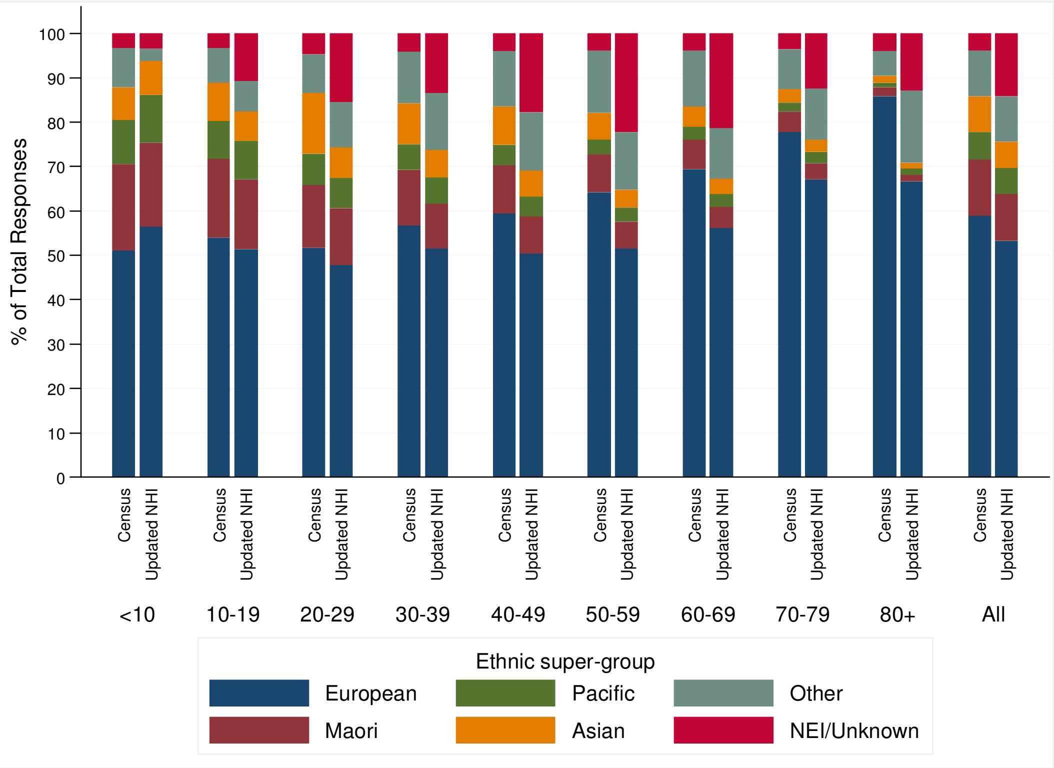

Figure 3.3. **NZ ethnic group total responses as percentage of all responses, for 2006 census and updated NHI database entries, by age group.**

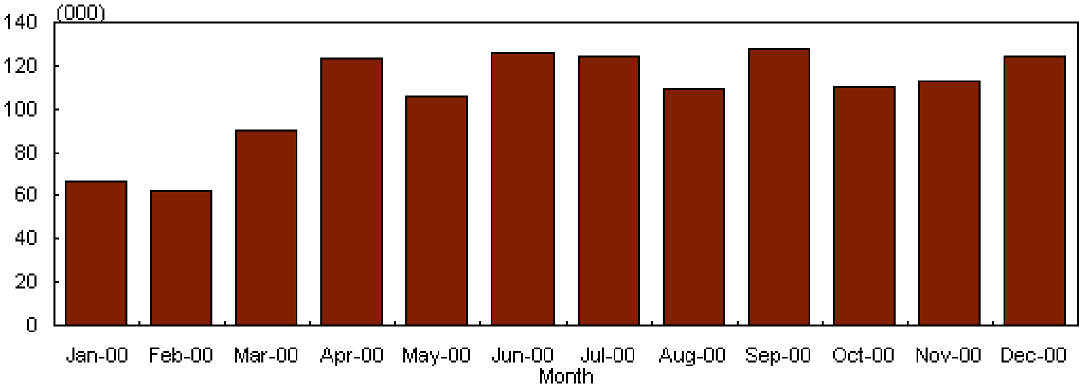

Figure 3.4. **New Zealand Resident Short-Term Departures by Month January-December 2000.**[*]

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[*] Chart from Statistics New Zealand; http://www.stats.govt.nz/analytical-reports/tourism-migration-2000/tourism-and-migration-overseas-trips.htm downloaded 30 April 2009.

3.6.2.3 Overseas travel and EWH

Lastly, the NHI database will include some people who were not in New Zealand for some or all of the study period. Statistics New Zealand notes that "the number of New Zealanders living overseas is not known precisely, though various estimates have been attempted ranging from 500,000 to 750,000", and that "in 2001, there were 58,280 people born in New Zealand living in Britain and 355,765 in Australia."[*] External migration levels fluctuate from year to year, but the relevant years had the following long-term or permanent departures from New Zealand (see Table 3.3).

Table 3.3 Permanent and long-term departures 2000 – 2006 (Statistics NZ data)

Year	Permanent/long-term departures
2000	71,045
2001	78,755
2002	59,848
2003	54,733
2004	62,277
2005	70,546
2006	69,388
Total	466,592

Permanent and long-term departures include New Zealand residents departing for an intended period of 12 months or more (or permanently), plus overseas visitors departing New Zealand after a stay of 12 months or more.

Some of those 466,592 people will have returned before 2007; others who intended to be away less than 12 months will have stayed away longer. The crux is that it is not possible to tell whether the person referred to by an NHI entry is actually in the country on any given day, unless they are hospitalised.

Total net permanent and long-term arrivals for 2000 – 2006 show a December quarter peak and June quarter (negative) nadir. While Statistics NZ's use of quarters makes it difficult to compare directly with winter: non-winter data, which have a 4/8 month split, it appears that there were slightly more residents "permanently" in New

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[*] http://www.population.govt.nz/faqs/frequently-asked-questions.htm accessed 8 October 2007.

Zealand in the four winter months than in the eight non-winter months.[*] However, the total difference was small, averaging only 400 more people per month in the winter months.

This difference is more than outweighed by month-to-month differences in short-term overseas travel, with least overseas travel in January, February and March, and three of the four peak travel months (June, July and September) falling within the winter period. Other Statistics NZ figures show over 80% of short-term travellers return within a month of departure[†].

Since there are fewer people in the country to be hospitalised during the four winter months, the overall effect of resident travel patterns on EWH would be a bias towards the null. However, there could be stratified effects if those who take overseas holidays are more commonly from low NZDep (i.e. higher socio-economic) groups without strong overseas ties: Statistics NZ do not show data by traveller ethnicity or socio-economic status, so the relative rate ratio between low and high NZDep categories may be artificially inflated, particularly among NZ Europeans. However, as it can not necessarily be assumed that those who travel are more likely to be low NZDep NZ Europeans, this bias is not a given.

There are also likely to be stratified differences by age-group, since children may be less likely to travel overseas (except perhaps in Pacific Peoples). Therefore, older age-groups' relative rate ratios may undercount the difference from the 5-14 year old baseline category.

3.6.3 Climate data

There are no obvious problems with the climate data.

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[*] http://www.stats.govt.nz/NR/rdonlyres/CE9A96D3-F1AA-42D4-931F-A398EBDBDFF9/0/TablesPart5v2.xls, accessed 8 october 2007

[†] Statistics New Zealand; http://www.stats.govt.nz/analytical-reports/tourism-migration-2000/tourism-and-migration-overseas-trips.htm downloaded 30 April 2009.

3.6.4 Quotable Value Data

QV state that their data are accurately collected and recorded, but may not be up-to-date. Date of last update is not recorded. The two variables most used in this study are building age, which is relatively easy to ascertain; and "house type". QV note that "`house types' are used by valuers as a general way of characterising a house. They are not strictly defined or mutually exclusive, and there can be overlaps between different house types." For example, it could be a subjective decision whether to define a house as a villa, or a cottage. "House type is chosen by the first Registered Valuer to inspect and value a property."

QV also notes that not all councils maintain the "house type" field:

> "where QV is the Valuation Service Provider, the `house type' field is generally complete, but for some [Territorial Authorities] who employ other providers, the field is generally empty."

QV criteria for assigning house type are included in Appendix 7 .

3.6.5 National Minimum Dataset (Hospital Events) Data

Some steps to eliminate National Minimum Dataset (NMDS) hospital events of low relevance to the study have been described above, under "exclusions", but these exclusions are based on the data as provided. NZHIS, and hospitals, have a number of checks in place to ensure the quality of the data entered in the NMDS. A study of NMDS accuracy in ICD-9 injury coding found errors in 5% of entries[69], but there is no other work to indicate whether this error rate is representative of all disease coding, or for recording or data entry quality in fields not requiring coding. The Ministry of Health has an active programme to improve the quality of data coding, including efforts to develop the skills and career path of professional coding staff employed by DHBs. Consequently, the quality of coding may have improved in more recent years, though this effect is hard to quantify.

3.7 ANALYTICAL METHODS

Stata version 10.1 was used for all statistical analysis.[70]

3.7.1 The Excess Winter Hospitalisation Index (EWHI)

Absolute winter excess refers to the difference between the number of health events in the four winter months (in New Zealand, June - September), and the number of health events in the preceding summer/autumn (February - May) and successive spring/summer (October - January) divided by the number of non-winter months/winter months as:

Relative winter excess is the ratio of winter and non-winter event rates. When used for mortality, this has also previously been referred to as the Coefficient of Seasonal Variation in Mortality (CSVM) and the Excess Winter Death Index (EWDI).[7 40]

The standard (southern hemisphere) formula for the EWDI is as follows:

$$\frac{\sum_{events}(Jun, Jul, Aug, Sep) - \sum_{events}(Feb, Mar, Apr, May, Oct, Nov, Dec, Jan)/2.}{\sum_{events}(Feb, Mar, Apr, May, Oct, Nov, Dec, Jan)/2}$$

In this analysis, the events are hospitalisations rather than deaths, resulting in the Excess Winter Hospitalisation Index (EWHI). The EWHI less one gives the percentage that the observed winter hospitalisations is above that expected from non-winter hospitalisations.

The main limitation of the index approach is the implied sudden change in morbidity rate at the start and end of winter. Using actual weather data as the measure of exposure to adverse environmental conditions, rather than season, would solve this problem, but would only capture some of the excess: Keatinge and Donaldson have shown that there is an additional, albeit smaller, winter effect in addition to temperature.[33]

Readers should also note that although absolute differences in winter excess are important, they are not widely measured in this study. I use the term "excess winter hospitalisation" to refer to the winter excess in general, and "excess winter hospitalisation index" to refer to the measure of that excess.

3.7.2 Data-specific methods

3.7.2.1 1980-2006 Data

Monthly admission rates per 100,000 people were calculated with all months standardised to 30-days with adjustment for leap years.

Annual EWHIs and confidence intervals were estimated using poisson regression on yearly winter and non: winter hospitalisation counts, with census population as the exposure variable.

3.7.2.2 2000-2006

Analysis for the 2000-2006 period used a cohort study design as outlined earlier: i.e., with the NHI database as the cohort dataset, with days when a hospitalisation occurred counted as "cases"; non-hospitalisation days counted as "non-cases"; and "winter" as the exposure variable, resulting in a distribution table as follows:

Table 3.4 Total cohort days by winter exposure and case or non-case status

Day	Winter		Total
	Exposed	**Not exposed**	
Cases	561652	1034474	1596126
Non-cases	3831413501	7642904262	11474317312
Total	3831975153	7643938736	11475913438

Winter: non-winter risk ratios, and unadjusted risk ratios for demographic sub-groups, were calculated using using Stata version 10's "cs" command for cohort studies. These risk ratios were effectively a statistical estimation of Curwen's EWHI.

3.7.3 Hospitalisation Rates

Hospitalisation rates were calculated for winter and non-winter periods, as the number of hospital admissions per day per 1000 people. Total hospital admission numbers are also listed.

3.7.4 Ratios of Relative Risk

Rates between different groups were compared using incidence rate ratios from Stata 10 poisson regression, which provides a ratio of relative risks (RRR). Using multiple logistic regression instead of poisson regression gave results identical to 3 decimal places.

The Chi-square test can be easily used to establish winter:non-winter relative risks. The subsequent challenge was how best to measure the difference between those relative risks, and whether it was significant, controlling for other variables of interest.

I chose to use Poisson regression with robust error variance to establish the relative risk ratio (RRR) between different values of variables within the model.

Poisson regression is traditionally used to compare distributions of counts of independent events, but can also be used to measure relative risk.[71] Further, where relative risk is the primary measure of interest, Guangyong Zou has recommended the use of a Poisson regression model with a robust error variance,[72] particularly when (as in this case) the model includes confounders.

In applying such a Poisson model, the two main concerns are overdispersion[73] and conservative confidence intervals.[71]

In this study, the data cannot be over-dispersed because the outcome data are binomial (case or non-case day), and binomial data are always underdispersed. Although this might suggest the use of a binomial model, the binomial model is inappropriate because it is the interaction between the two variables that is being measured rather than the distribution of the variables themselves. It is for this reason that poisson is more appropriate.

The problem of conservative confidence intervals is partially addressed by using robust error variance and furthermore with the large sample sizes in the study, slightly conservative confidence intervals are desirable. This approach has been used in many recent studies of relative risk.[74 75]

3.8 CONCLUSION

Establishing a method for measuring EWH was relatively straightforward: the real challenge was in identifying which data to use, both as numerator and denominator. The use of the NHI database as the denominator variable, or cohort group, is unorthodox, but offers some clear advantages over the census. While there are certainly some unknowns, particularly round misclassification bias for address data, in general possible biases would appear to tend towards the null. While this tendency means that some differences may not show up, it also means that those differences that do show up are likely to be underestimates of the true effect, and treated accordingly.

CHAPTER 4 NEW ZEALAND EXCESS WINTER HOSPITALISATION

4.1 INTRODUCTION

This study examines the effect of poor housing on New Zealand's excess winter hospitalisation (EWH). However, before that effect can be measured, the magnitude and characteristics of EWH must first be described. These results not only set a baseline for the later housing chapter, but also identify other effect modifiers implicated in EWH, notably age, sex, ethnicity and socio-economic deprivation, or variables which appear to have little or no effect, such as rurality and latitude.

This chapter begins by describing the data that were used, detailing the impact of exclusions on hospital admission data. It goes on to describe intra-annual differences in hospitalisation rates and inter-annual differences in excess winter hospitalisation indices (EWHIs) between 1980 and 2006. This first period of interest was chosen based on the availability of historic hospitalisation data in electronic form, and its analysis looks only at long-term trends in the magnitude of EWH.

A more detailed analysis of EWH was conducted for the 2000-2006 period, including demographic and geographical factors. The starting point for this later period was chosen because of the introduction of the most recent discharge coding system (ICD-10), which is important for the ICD-10 disease chapter-specific analyses in the following chapter and general improvements in the quality of data coding in areas such as ethnicity. The end-point was dictated by the availability of matched housing data.

The chapter concludes with a brief comparison of New Zealand EWM and EWH.

4.2 RESULTS

4.2.1 Method summary

Hospitalisations were filtered to exclude non-relevant health events. EWH, and differences in EWH by demographic sub-groups, were measured using poisson regression on filtered hospitalisations, with the NHI population as denominator.

4.2.2 Exclusion results

Rationalisations for data exclusions and methods used are provided in detail in Chapter Three.

The original raw dataset contained 16,875,982 hospital admissions within the first time period of interest, the 27 years from 1 February 1980 to 31 January 2007. Filtering reduced the useable dataset to 6,087,977 admissions.

For the second time period, the six years from 1 February 2000 to 31 January 2006, there were 4,976,470 admissions, reduced to 1,596,126 after filtering.

The distribution of excluded data over the 1980 to 2007 time period is shown in Figure 4.1 and Figure 4.2, and is also described in detail in Appendix 3 .

4.2.2.1 Admission types

The differences in admission patterns between same-day-discharge (or `day-patient') and overnight admissions, and between acute and other category admissions, are shown in Figure 4.2. These graphs demonstrate the changing administrative use of different admission categories. The graphs for non-acute admissions show the sharp drop in admissions in each Christmas/New Year period. They also show regular flattening over the winter months when it is likely that demand from acute admissions reduces bed availability for non-urgent surgery.

Note that the pairs of graphs for overnight patients and for day-patients are not directly comparable; they cover different time periods because day patients were not usually recorded as admissions before 1988.

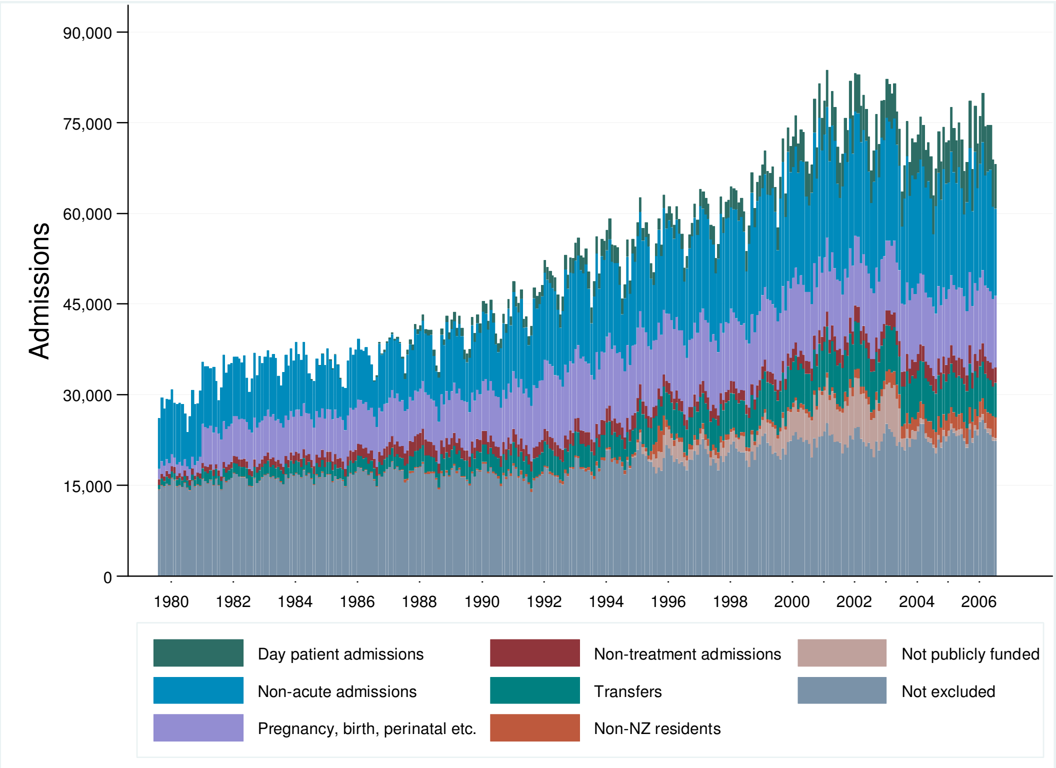


Figure 4.1 **Monthly included and excluded admissions 1 Feb 1980 - 31 Jan 2007, stacked by exclusion type.**

4.2.3 Winter: non-winter hospital admissions; 1980-2006

Hospitalisation data between 1980 and 1987 were less complete than after 1988, when the NHI was introduced nationwide, but they have been included in the results below to provide a longer time series for comparison purposes. While there is no reason why data should be less complete in one season than the other, some fields used to filter for changing admission policies (see Chapter Three) had different coding, or were not available in the 1980-1987 period. Admission policies can affect winter: non-winter ratios, so incomplete data in this earlier period mean results are not directly comparable with later years. Taking data from 1988, the EWHI peaked at 1.12 in 1999, and bottomed at 1.04 in 2005 (see Figure 4.3 and Figure 4.4). A logistic test for trend shows that while EWHIs have been increasing over the period 1988 to 2006, the rate of increase, although significant, is extremely small, at 1.0005 (1.0001-1.0008, p=0.006).

Overnight admissions

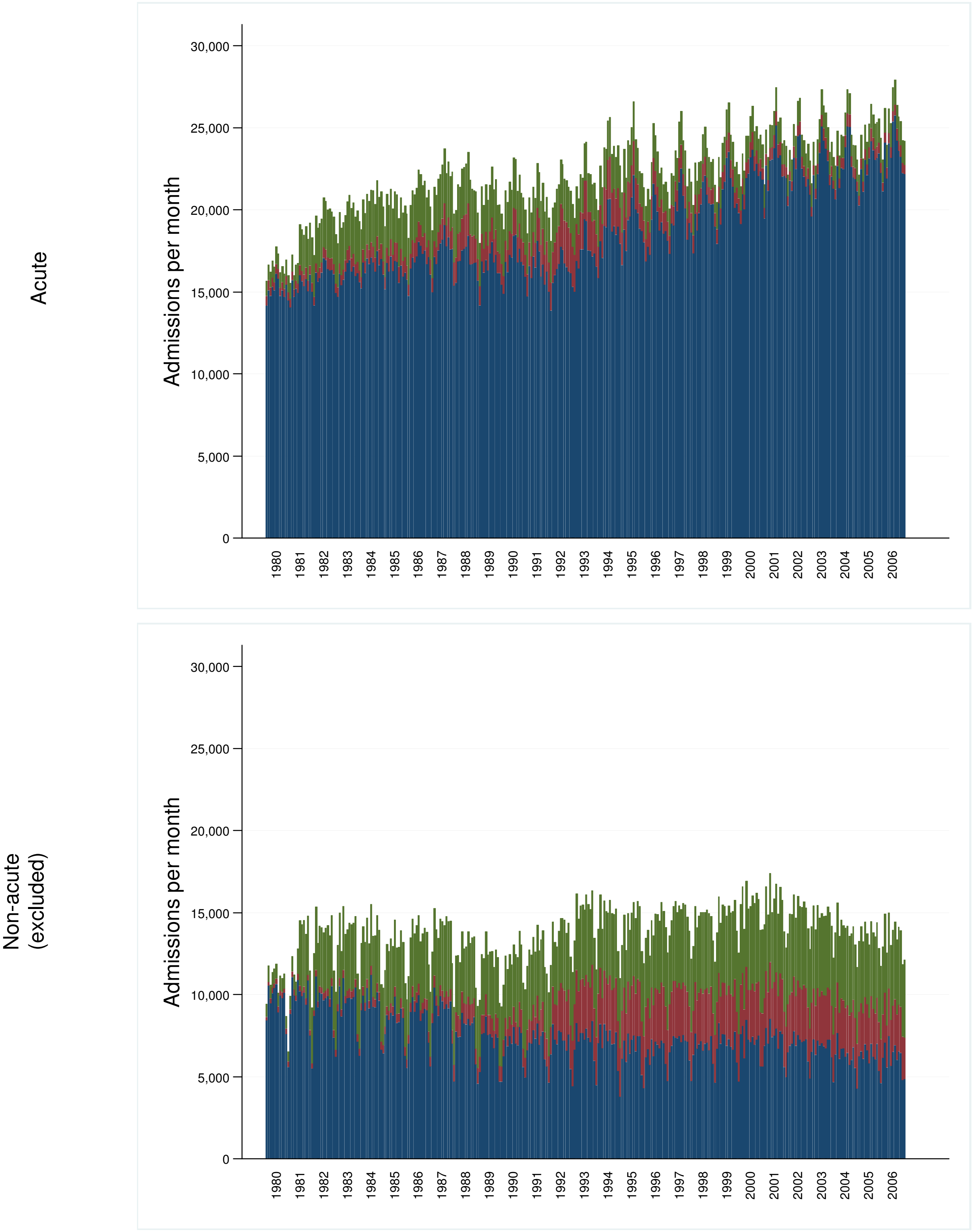
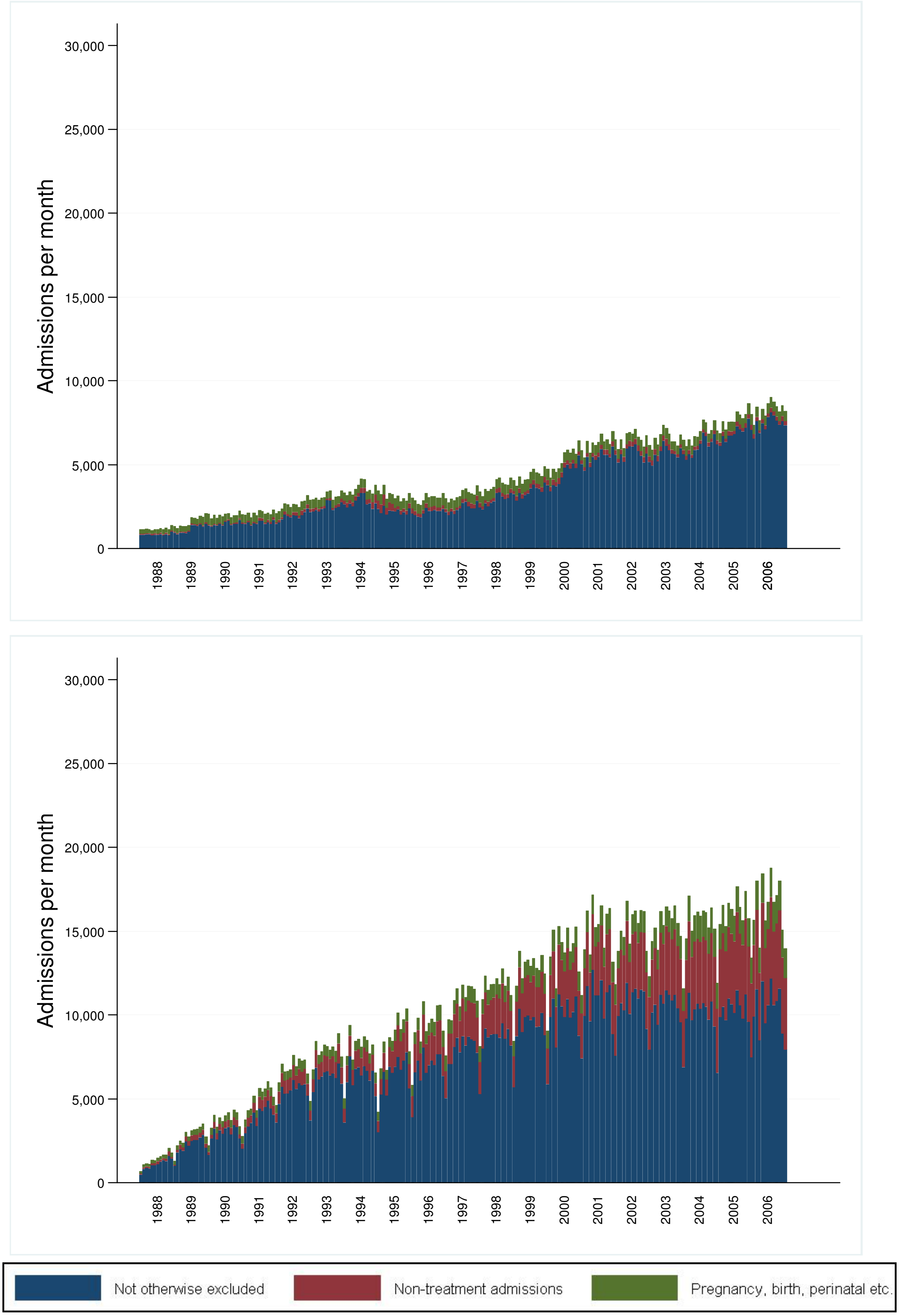


Figure 4.2 (across both pages) Public, NZ resident, hospital admissions by exclusion category*, admission type, stay type, month and year

Day-patients (excluded)



(*After primary exclusions (non-public; non-NZ residents; transfers).

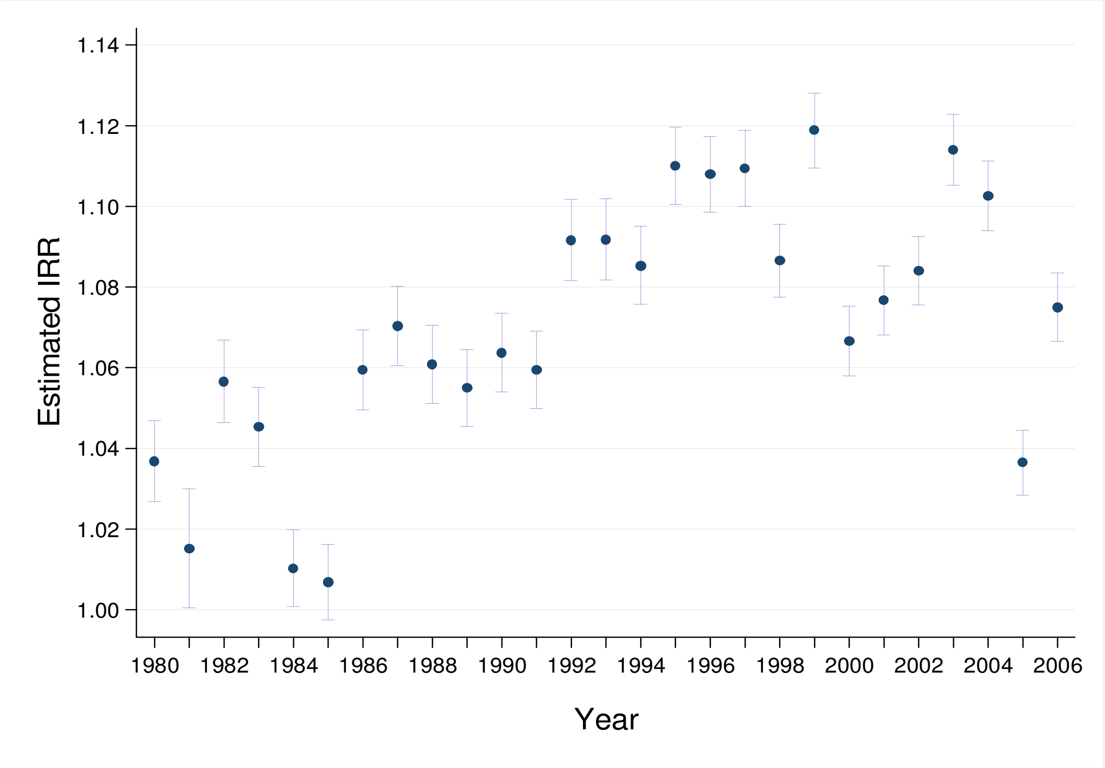


Figure 4.3 Annual estimated winter:non-winter all-cause hospitalisation incidence rate ratios from 1980-2006.

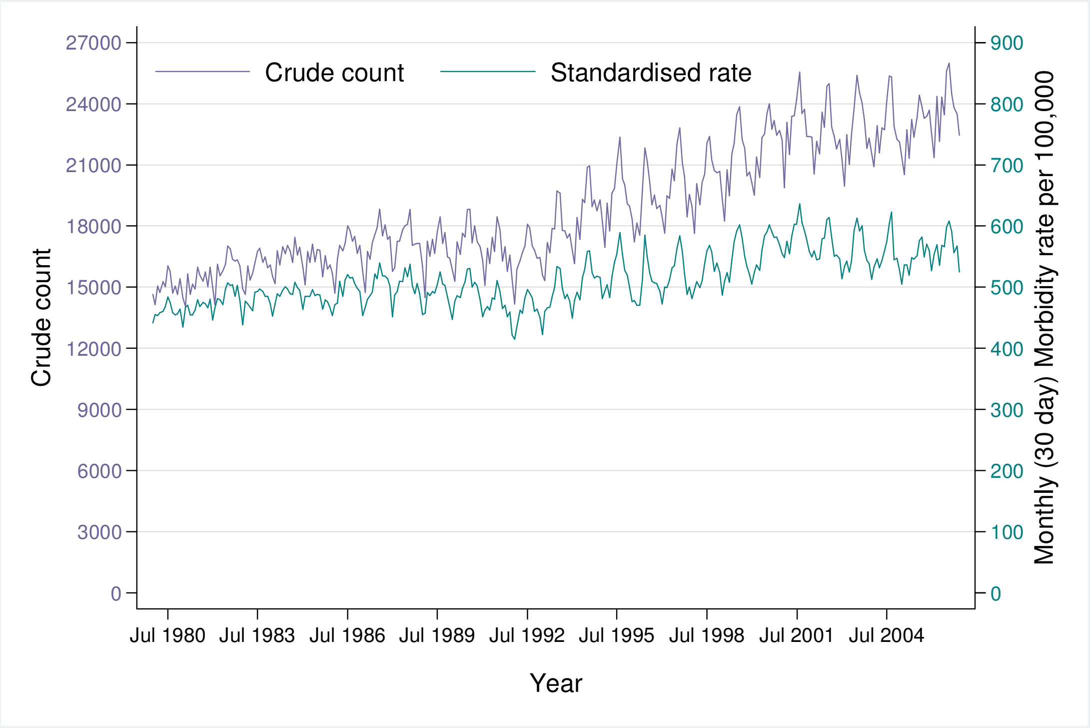
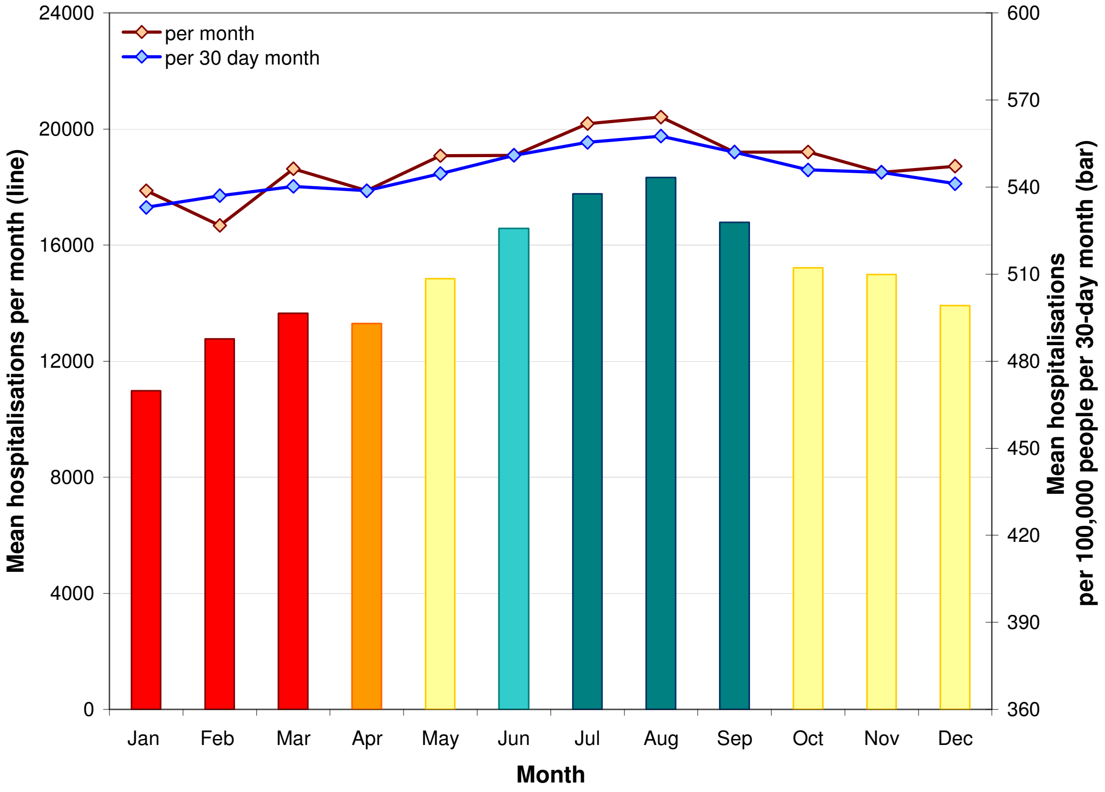


Figure 4.4 Crude filtered hospitalisation numbers, and monthly (30-day) hospitalisation rate per 100,000 people, 1980-2006.

4.2.4 Monthly Admissions

On average, hospitalisations peak in August and are at their lowest in January (see Figure 4.5). The four peak months are from June to September inclusive, as selected for study, and in common (by hemispheric seasons) with EWM studies overseas (see Chapter Two).



Bars per 30-day month & 100,000 population	
🟥 3 trough months	🟦 3 peak months
🟧 4th trough month	🟦 4th peak month
🟨 non-peak, non-trough month	

Figure 4.5 **Mean monthly hospitalisations, mean hospitalisations per 30-day month and mean hospitalisations per 30-day month per 100,000 population, 1980-2006.**[*]

It is conceivable that the timing of public holidays might influence monthly hospitalisation rates. Of New Zealand's 11 public holidays, only Queen's Birthday falls during 'winter'. Even using only acute overnight admissions, overall hospitalisation rates are lower on weekends and public holidays than on working days; between 1 Jan 2000 and 31 Dec 2006, working days averaged 796 admissions

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[*] See Table A 6.1 in Appendix 6 for data.

per day, and non-working days only 610. Using a similar method to that used for the winter: non-winter ratio, the workday:non-workday hospitalisation ratio was 1.3049 (95% CI 1.3003-1.3095, p=0.000).

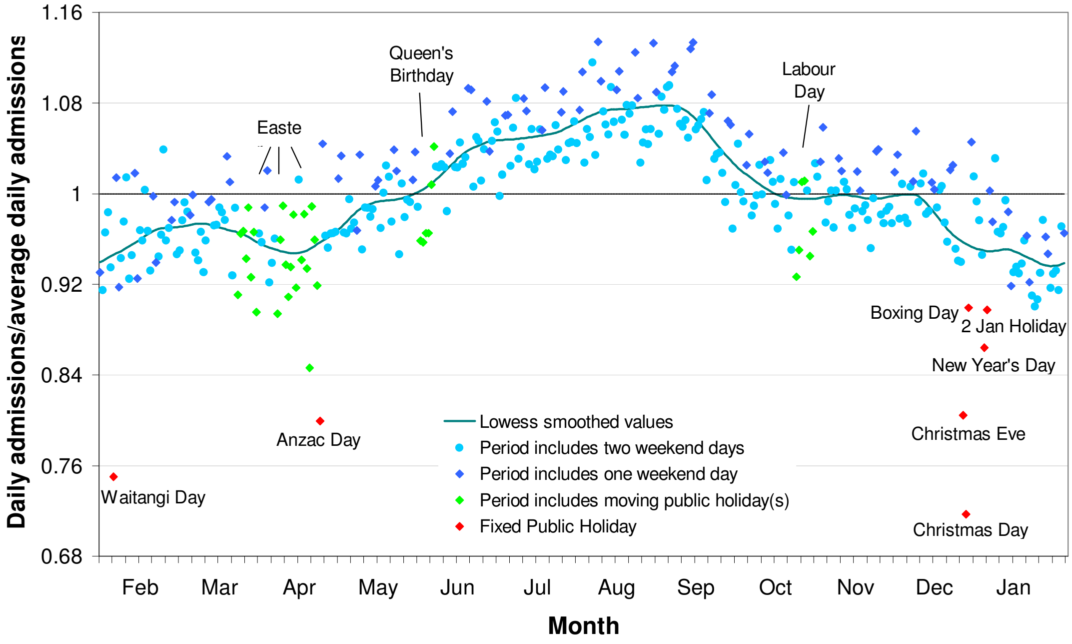

Figure 4.6 **Daily variation in all-cause admission rates with 14-day lowess smoothing, for the period 1 February 2000 to 31 January 2006. N.B. Shows 1 February to 31 January year to clarify Christmas/New Year distribution, excluding 29 February**

Figure 4.6 shows the distribution of average daily admissions over a 365-day year (29 February excluded) for the period 1 Feb 2000 to 31 Jan 2006. It illustrates the low rates for public holidays, and higher rates for periods which over the six data years included only one weekend day rather than two.

The dips in the lowess smoothed admission indices are important: Nayha hypothesised that a Midsummer spike in Finnish mortality rates might be due to "a combined effect of alcohol and cold, because in Finland excessive drinking, going to sauna and swimming in cold water are inseparably linked to the midsummer holiday."[76]

Table 4.1 below shows the lower winter: non-winter ratios when working and non-working days are considered separately, and the lower overall EWHI if the effect of working days are controlled for. Although the difference between working and non-working days does not vary by season, there is a significant difference between the adjusted and non-adjusted EWHIs, with EWHIs adjusted for working days 0.9950 (95% CI 0.9911-0.9989, p=0.011) of the unadjusted ratio. However, as the difference is very small (0.5%), I have chosen not to include any working: non-working day adjustment in the main analyses.

Table 4.1 Winter:non-winter hospitalisation rates by working and non-working day, 2000-2006.

	Rate per 1000 person years*^{1} (No of hospitalisations)		Winter:non-winter ratio (95% CI) Unadjusted (cohort analysis)		Winter:non-winter ratio relative to reference category (95% CI) *^{2}, p-value		
	Winter	Non-winter					
All	54.2 (569250)	50.1 (1049726)	1.0817	(1.0782-1.0852)	1	Baseline	
EWHI adjusted for working days	54.0	50.2	1.0763	(1.0729-1.0798)	0.9950	(0.9911-0.9989)	0.011
Weekend/public holiday	44.6 (138218)	41.5 (274113)	1.0740	(1.0670-1.0809)	1	Baseline	
Workday	58.2 (431032)	54.1 (775613)	1.0771	(1.0731-1.0811)	1.0029	(0.9955-1.0105)	p=0.440

4.3 DETAILED ANALYSIS OF EXCESS WINTER HOSPITALISATION 1 FEBRUARY 2000-31 JANUARY 2006

Table 4.2 shows overall EWHIs, but these should be used with care as there was significant variation by sub-group.

4.3.1 Age

As shown in Figure 4.8, EWHI by age has a U-shaped pattern. By age-group, as shown in Figure 4.7, under-5s have the highest winter:non-winter difference of all age groups, at EWHI 1.5348 (95% CI 1.5188-1.5509). As discussed below, primary and intermediate school age children (5 to 14 years) have a distinct annual hospitalisation pattern, with higher non-winter hospitalisation rates (EWHI 0.9726, 95% CI 0.9604-0.9850). There is a minor winter effect through the middle years; age-groups 15-29 and 30-59 have EWHIs of 1.0195 (95% CI1.0099-1.0292) and 1.0019 (95% CI 0.9958-1.0080) respectively. Rates then increase again in the later years, with an EWHI of 1.0701 (95% CI 1.0634-1.0767) for 60-79 year olds, and 1.1348 (95% CI 1.1256-1.1440) for the 80+ age group.

Table 4.2 Rates of all-cause hospitalisation in winter and non-winter months, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				Winter:non-winter ratio (95% CI) Unadjusted (cohort analysis)		Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value		
	Winter		Non-winter						
All	53.5	(561641)	49.4	(1034473)	1.0830	(1.0795-1.0865)			
Age (years)									
0-4	106.4	(62173)	69.5	(80979)	1.5348	(1.5188-1.5509)	**1.4108**	**(1.3930-1.4288)**	**0.000**
5-14	23.2	(35769)	23.8	(73354)	0.9726	(0.9604-0.9850)	**0.8962**	**(0.8831-0.9095)**	**0.000**
15-29	29.7	(64761)	29.1	(126694)	1.0195	(1.0099-1.0292)	**0.9420**	**(0.9309-0.9533)**	**0.000**
30-59	34.9	(154216)	34.8	(306999)	1.0019	(0.9958-1.0080)	**0.9298**	**(0.9214-0.9382)**	**0.000**
60-79	121.2	(152995)	113.3	(285168)	1.0701	(1.0634-1.0767)	1	Baseline[‡]	
80+	229.6	(91525)	202.3	(160864)	1.1348	(1.1256-1.1440)	**1.0611**	**(1.0501-1.0723)**	**0.000**
Gender									
Male	54.9	(281939)	51.0	(522480)	1.0764	(1.0715-1.0814)	1	Baseline	
Female	52.2	(279713)	47.9	(511994)	1.0898	(1.0848-1.0948)	**1.0155**	**(1.0087-1.0223)**	**0.000**
Ethnicity[§]									
NZ European	64.9	(389978)	61.1	(728510)	1.0626	(1.0594-1.0657)	1	Baseline	
Māori	113.2	(95765)	102.8	(169746)	1.1006	(1.0982-1.1031)	**1.0371**	**(1.0269-1.0476)**	**0.000**
Pacific	73.7	(36999)	64.8	(62651)	1.1362	(1.1330-1.1394)	**1.0830**	**(1.0669-1.0994)**	**0.000**
Asian	36.7	(14377)	34.2	(26643)	1.0745	(1.0703-1.0787)	1.0140	(0.9924-1.0362)	0.206
Other	12.1	(14181)	10.9	(27061)	1.1100	(1.1024-1.1177)	1.0008	(0.9795-1.0225)	0.943
Unknown	10.0	(10352)	9.2	(19863)	1.0839	(1.0757-1.0921)	1.0042	(0.9796-1.0295)	0.740
NZDep01/06									
1-3	42.9	(105322)	40.3	(197723)	1.0626	(1.0546-1.0705)	1	Baseline	
4-7	52.6	(211220)	49.1	(392703)	1.0729	(1.0672-1.0786)	1.0045	(0.9951-1.0141)	0.349
8-10	62.1	(234742)	56.3	(424547)	1.1029	(1.0974-1.1085)	**1.0170**	**(1.0072-1.0270)**	**0.001**
1-10 (Continuous)							**1.0026**	**(1.0013-1.0039)**	**0.000**
Rurality									
Main Urban	52.1	(383834)	48.0	(705570)	1.0852	(1.0809-1.0894)	1	Baseline	
Secondary	63.8	(44151)	59.1	(81509)	1.0805	(1.0681-1.0931)	0.9969	(0.9841-1.0098)	0.637
Minor	66.4	(58894)	60.9	(107697)	1.0908	(1.0799-1.1018)	1.0036	(0.9924-1.0149)	0.529
Rural Centre	50.2	(12625)	47.6	(23853)	1.0557	(1.0332-1.0788)	**0.9762**	**(0.9548-0.9981)**	**0.033**
Other rural	46.7	(34506)	44.2	(65041)	1.0583	(1.0446-1.0722)	0.9885	(0.9747-1.0025)	0.108
Other	55.9	(116)	51.6	(212)	1.0914	(0.8703-1.3686)	0.9519	(0.5122-1.7690)	0.876
Mean min. temp.							**0.9982**	**(0.9965-1.0000)**	**0.045**

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

[‡] Selected as baseline age group because EWHI closest to mean.

[§] Morbidity rates and winter:non-winter ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

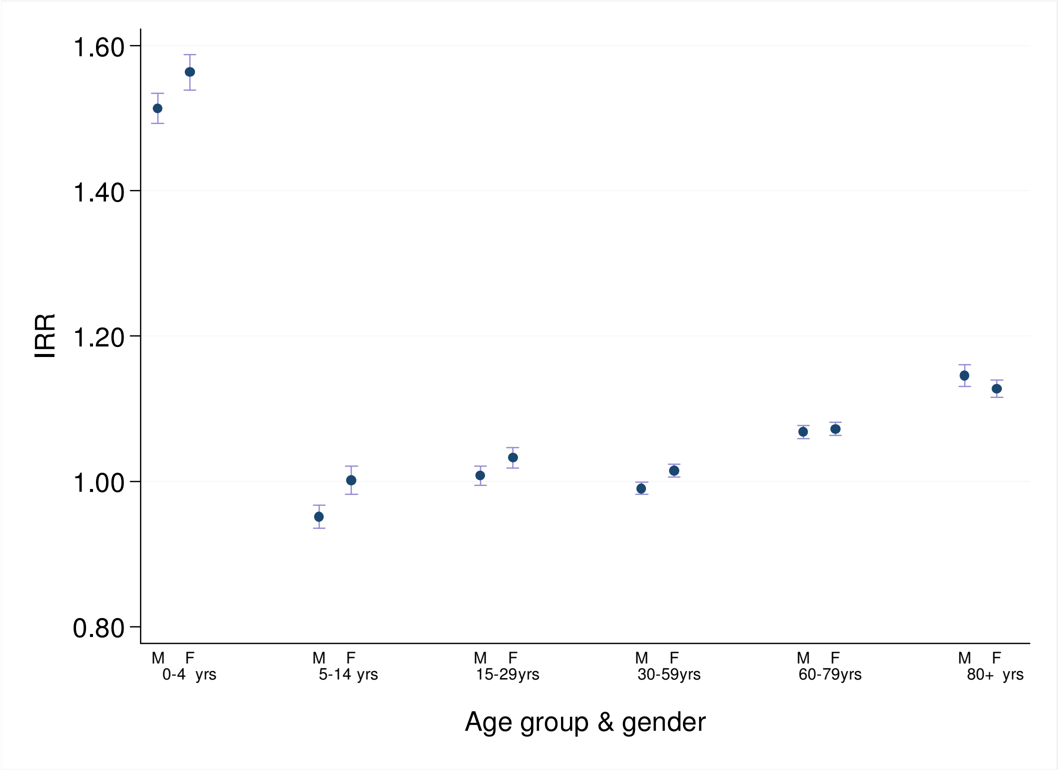

Figure 4.7 **Winter:non-winter incidence rate ratios by age group and gender, 2000-2006 (cohort method).**

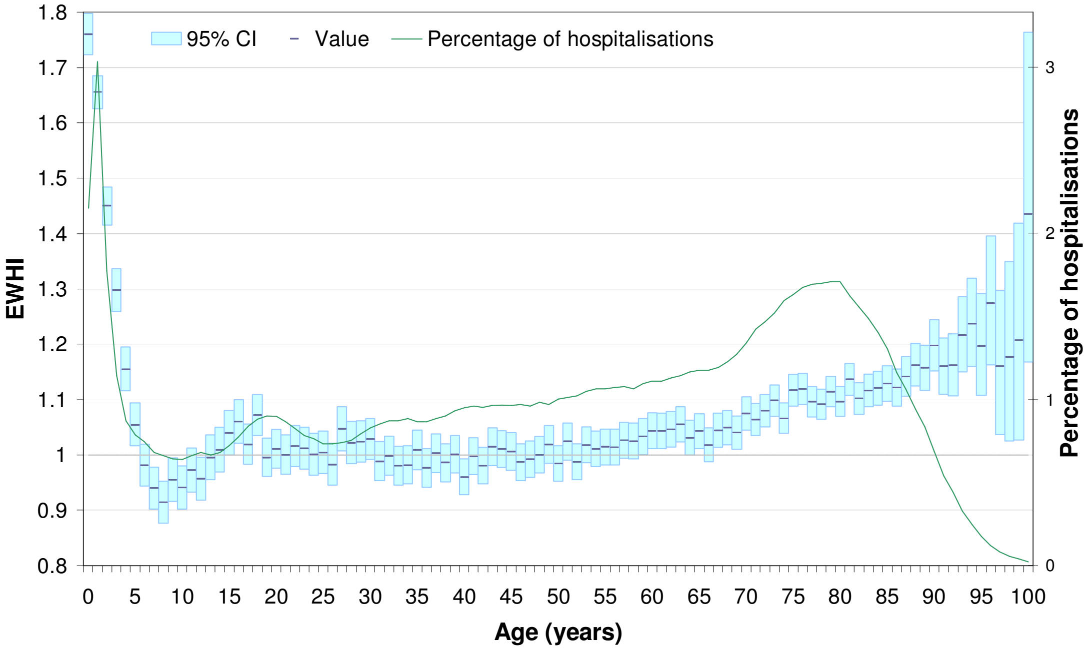

Figure 4.8 **Winter:non-winter all-cause hospitalisation incidence rate ratios by year of age, 2000-2006 (adjusted for sex, ethnicity, NZDep decile, rurality and annual average minimum temperature), with percentage of total hospitalisations by year of age.**

Looking specifically at age rather than age-group (Figure 4.8), EWHIs peak in the first year of life at 1.7599 (95% CI 1.7230-1.7975), closely follows a polynomial curve ($y = 0.0123x^2 - 0.2351x + 2.0359$, $R^2=0.995$) until age 11, climbs up to a mini-peak of 1.0711 (95% CI 1.0346-1.1089) at 18, drops back and fluctuates round 1.0000 until about age 53 (59+ for lower confidence intervals), then increases slowly and exponentially ($y = 0.9953e^{0.0041x}$, $R^2 = 0.9011$) to a second peak of 1.4349 (95% CI 1.1674-1.7637) at age 100. Both the hospitalised and total populations for later ages are small, contributing to greater fluctuations in EWHIs, and larger confidence intervals, though lower confidence intervals remain above 1.0000.

In short, EWHI impacts most strongly on the very young (0 to 4 year olds) and those past 'middle' age (60+). Otherwise, New Zealand adults experience only very slightly more hospitalisation in winter than in summer. However, these general statements do not necessarily apply to ethnic or male/female sub-groups of the population. There are also marked variations in this pattern by ICD-10 chapter.

4.3.1.1 Hospitalisation in the 0 to 4 year age group

The 0 to 4 years age group not only experienced greater winter excess than other age groups, but also greater differences in EWH between sub-groups (see Table A 4.2 in Appendix 4 : RRRs were higher by gender (female RRR 1.0290 (1.0069-1.0516), p=0.010); by ethnicity (Māori RRR 1.1003 (1.0710-1.1302, p=0.000); Pacific RRR 1.1513 (1.1112-1.1928), p=0.000); and by NZDep tertile (NZDep 8-10 RRR 1.0443 (1.0093-1.0804), p=0.013) and NZDep trend (1.0062, 95% CI 1.0017-1.0107, p=0.007).

4.3.1.2 Hospitalisation in the 5 to 14 year age group.

Analysis suggests that youth in the 5 to 14 years category do not experience excess winter illness. In fact, school-age youth do experience an excess hospitalisation pattern, but it is dominated by the term/holiday variable rather than winter/summer.[*] Summer term-time has the highest hospitalisation rate and winter holidays have the

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[*] Similarly, Baker et al found New Zealand 2009 influenza rates reduced slightly at the start of the school holidays, and that the A(H1N1)V influenza pandemic accelerated again once the holidays had finished, though the overall effect on the pandemic was small.[77]

lowest rate, though the difference between winter and non-winter holidays is not significant. Looking only at term-time admissions, the winter: non-winter ratio was 0.9601 (95% CI 0.9466-0.9738), whereas the overall term: non-term ratio was 1.1660 (95% CI 1.1495-1.1827).[77]

Table 4.3 Winter:non-winter hospitalisation rates by term in 5 to 14 year olds, 2000-2006.

	Winter		**non-winter**		**IRR (p=0.000 except where stated, Poisson)**			
	rate	Hosps	rate	Hosps	winter		non-winter	
Holiday	26.2	(6709)	34.5	(17691)	0.9777	(0.9506-1.0055, p=0.115)	1	Baseline
Term	42.1	(29060)	41.6	(55663)	1.1283	(1.1074-1.1496)	1.1752	(1.1555-1.1953)

The EWHI for this age-group is below 1.0000, meaning it does not suffer from winter excess. Therefore, RRRs by sub-group are not included here, as describing any sub-group as suffering 'higher' or 'lower' EWH would be analogous to talking about greater and lesser degrees of iron deficiency amongst a group suffering from iron overload.

4.3.1.3 Hospitalisation in those aged 65+

Studies of EWH and EWM are often restricted to the 65+ age group, so that group is considered separately here (see Table A 4.3 in Appendix 4 .

The overall EWHI for those aged 65+ was 1.1011 (1.0953 – 1.1069). There was no significant difference in EWHIs by gender.

Differences by ethnicity were less pronounced than for all ages, with the RRR for Māori non-significant at 1.0209 (0.9972-1.0452, p=0.084) and for Pacific Peoples 1.0385 (1.0015-1.0758, p=0.041).

The gradient for NZDep was similar to that for all ages, at 1.0034 (1.0013-1.0055, p=0.002).

The difference in EWHIs between Rural Centres and Main Urban areas was greater in the 65+ age group, with an RRR of 0.9423 (0.9070-0.9789, p=0.002) for Rural Centres.

There was no significant gradient for annual average minimum temperature in the 65+ age group.

4.3.2 Ethnicity

By far the strongest influence on seasonal hospitalisation rates, after age, was ethnicity. While the EWHI for NZ Europeans was 1.0626 (95% CI 1.0594-1.0657), the EWHI for Māori was 1.1006 (95% CI 1.0982-1.1031); and for Pacific Peoples, 1.1362 (95% CI 1.1330-1.1394). These latter two were not only significantly higher than NZ European rates (RRRs Māori: 1.0371, 95% CI 1.0269-1.0476, p<0.000, Pacific: 1.0830, 95% CI 1.0669-1.0994, p=0.000), but also significantly different from each other.

EWHIs for other ethnicities were not significantly different from NZ European rates.

4.3.2.1 Age and ethnicity

EWHIs by age also vary by ethnicity; most patterns of excess visible in the general population are emphasised in Māori and Pacific populations (see Table A 4.1 in Appendix 4).[*] The peak is 1.8435 (95% CI 1.7776-1.9118) for Māori babies under 1 year of age, and 1.9272 (95% CI 1.8434-2.0148) for 1-year old Pacific babies, the early primary 'non-winter' excess is higher in Māori, and higher again in Pacific children, among whom the EWHI zenith is 0.7771 (95% CI 0.6775-0.8913), in 9-year olds. Among Pacific youth, the teen mini-peak is longer (14-18) and stronger, rising as high as 1.2850 (95% CI 1.1222-1.4715) for 16-year olds. However, the late-20s peak is less discernible for Māori and Pacific peoples than for NZ Europeans.

4.3.2.2 Gender

The difference between male and female EWHIs was less for NZ Europeans (RRR 1.0098, 95% CI 1.0017-1.0179, p=0.017) than for all ethnicities combined.

4.3.2.3 Socio-economic deprivation

Although results were in the same direction for other ethnicities, EWHI differences by deprivation tertiles were only significant for NZ Europeans.

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[*] Populations in other ethnic groups are smaller, and year-by-year fluctuations in hospitalisation numbers too large to show clear trends

4.3.3 Gender

After controlling for age group, ethnicity, rurality, deprivation tertile, and associated winter interaction terms, females have an EWHI 1.55% higher than males.

4.3.3.1 Age

As noted above, gender differences impact differently at different ages. Girls retain a high EWHI until age five rather than age four for boys, and experience a longer period of raised EWHI in teens (from 12 to 18 years rather than the boys' 14 to17 years) (see Table A 4.1 and Figure A 4.1 in Appendix 4). Women also experience a late-20s mini-peak, with significant EWHIs above 1.0654 between ages 27 and 30 inclusive, while the male winter: non-winter difference is non-significant for all ages in that age range. Overall, female EWHIs are generally higher than male until the early 70s, after which male EWHIs are generally higher than female. By age-group, female EWHIs were at least 2.5% higher than male up to age 59, but there was no significant difference between male and female EWHIs in the 60-79 and 80+ age groups.

4.3.4 Socio-economic deprivation group - NZDep

Though there was no significant difference between tertiles NZDep 1-3 and 4–7, NZDep tertile 8-10 had a slightly, but significantly, higher EWHI (RRR 1.0170, 95% CI 1.0072-1.0270, p=0.001)) than tertile NZDep 1-3. As noted above, however, the deprivation gradient is only apparent in the New Zealand European population, and not in other ethnicities. Other results by NZDep tertile were in general keeping with the main results.

4.3.5 Rurality

EWHIs varied little by rurality; the only significant finding was that EWHIs were lower in Rural Centres than in Main Urban Areas (RRR 0.9762, 95% CI 0.9548-0.9981, p=0.033)

4.3.6 Geographical differences

Data were analysed (results not shown) controlling for geographical region instead of temperature gradient, for both District Health Board (DHB) and Territorial Authority (TA). Which geographical control was used made little difference to results.

4.3.6.1 District Health Boards

Auckland DHB was chosen as the reference group because it had the largest population; its EWHI was 1.0901 (95% CI 1.0780-1.1024). RRRs were close to the baseline in all 20 other DHBs, and only significantly higher in Tairawhiti (RRR 1.0296, 95% CI 1.0001-1.0599, p=0.049) (see Table A 4.9 in Appendix 4 . There was no North-South gradient.

Controlling for temperature rather than DHB had minimal effect on results.

4.3.6.2 Teritorial Authorities

There are 74 Territorial Authorities (TAs) in New Zealand. As with DHBs, their assigned number corresponds roughly to their North-South location. East-West variation means DHBs are a better North-South indicator than TA, while TA, as an independent variable, provides a better control for climatic differences. Auckland City had the highest population and was therefore used as the baseline. Rodney, Hauraki, Opotiki and Stratford had significantly lower EWHIs than Auckland City, Queenstown-Lakes District significantly higher (RRR 1.0923, 95% CI 1.0310-1.1572, p=0.003) (see Table A 4.8 in Appendix 4). This latter is likely to be predominantly because in Queenstown-Lakes District injuries (ICD Chapter 19) make up a greater proportion of hospitalisations than in the rest of the country (25% rather than 17%), and show a winter rather than non-winter excess EWHI (1.1724, 95% CI 1.0527-1.2057), rather than 0.9115 (95% CI 0.9041-0.9189) for the rest of the country, reflecting the District's 'winter resort' status.

Controlling for both TA and temperature gradient removed significance from differences for Rodney and Hauraki, and made no meaningful difference to differences for Opotiki, Stratford or Queenstown-Lakes.

Controlling for TA, rather than DHB or temperature gradient, had miniscule effect on results other than rurality (which is likely to be correlated with TA), which would suggest that TA is a reasonable proxy for temperature, but, as a categorical variable, provides less useful information and less options for data manipulation.

4.3.7 Temperature

Overall, EWHIs decreased as annual average minimum temperature increased. This temperature gradient was miniscule, if significant, but some sub-groups did show a steeper, or different, temperature effect.

4.3.7.1 By age group

For those under five years (EWHI temperature gradient 0.9890 (95% CI 0.9832-0.9948, p=0.000)) and those aged from five to 14 years (EWHI temperature gradient 0.9876 (95% CI 0.9809-0.9943, p=0.000), EWHIs decreased with increasing temperature. For the 80+ years age group, the EWHI increased with increasing temperature (EWH temperature gradient 1.0062 (1.0020-1.0104, p=0.004). Other age groups had no significant EWHI temperature gradient.

4.3.7.2 By ethnicity

The 'European' ethnic category showed a slight temperature gradient (0.9980, 95% CI 0.9960-1.0000, p=0.045). No other ethnicities showed a significant temperature gradient.

4.3.7.3 Other variables

There was no temperature gradient by gender, deprivation tertile, or rurality sub-group.

4.3.8 Effect of using NHI rather than census population denominator

I ran a regression to test for differences in RRRs between NHI and Census population denominators. The regression included only sex, age group, ethnicity, and NZDep tertile, as census population data were not available for all variables of interest. Overall, adjusting for the listed variables, RRRs using the NHI cohort rather than Census denominator were 0.6% higher (95% CI 0.1% -1.1%, p=0.018). RRRs were lower for women, the NZDep 8-10 tertile, and the 'unknown' ethnic group; and higher for the 5 to 14 year age group and the Asian Peoples ethnic group. However, in all cases except the 'unknown' ethnic group, the difference was less than .01 and did not affect significance.

4.4 EXCESS WINTER MORTALITY 2000 – 2006

Excess winter mortality in New Zealand has already been well-described by Davie et al. for the period 1980-2000.[78] However, as that study used data from a

different time period and a different method, EWM is described again below, in order to establish whether patterns for the two datasets are similar, and whether, therefore, overseas EWM indices may be viewed as representative of overseas EWH indices.

Excess winter mortality is described by demographic subgroup in Table 4.4. These results are similar in some instances, but not identical, to those found by Davie et al. The overall EWM for 2000-2006 of 1.1674 (95% CI 1.1558-1.1790) was higher than Davie et al's 1.14 (0.98-1.33), and the method used in this study allowed tighter confidence intervals. The difference between male and female EWM was much less, with an RRR of 1.0190 (0.9985-1.0400) compared to Davie et al's 1.09 (1.01-1.19). EWMIs for younger age-groups also showed considerable variation between the two studies, though EWMIs for the 60-79 and 80+ years age groups were very similar. Neither study found any significant difference in EWM by ethnicity, deprivation or location (as measured by RHA in Davie et al's study).

Table 4.4 Rates of all-cause mortality in winter and non-winter months, ratio of rates, and relative change in winter:non-winter ratios, for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of deaths)		Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)	Winter:non-winter ratio relative to reference category (95% CI)[†], p-value
	Winter	Non-winter		
All	5.87 (61436)	5.03 (105335)	1.1674 (1.1558-1.1790)	
Age (years)				
0-4	2.87 (1674)	2.68 (3128)	1.0696 (1.0080-1.1350)	**0.9332 (0.8752-0.9951) 0.035**
5-14	0.13 (194)	0.12 (370)	1.0458 (0.8790-1.2442)	0.9008 (0.8752-1.0792) 0.257
15-29	0.51 (1103)	0.51 (2224)	0.9892 (0.9203-1.0632)	**0.8704 (0.8067-0.9392) 0.000**
30-59	1.66 (7339)	1.55 (13658)	1.0717 (1.0417-1.1026)	**0.9411 (0.9099-0.9735) 0.000**
60-79	17.37 (21981)	15.22 (38418)	1.1410 (1.1222-1.1601)	1 Baseline
80+	72.54 (29064)	58.98 (47105)	1.2300 (1.2122-1.2481)	**1.0735 (1.0493-1.0982) 0.000**
Gender				
Male	5.95 (30558)	5.18 (53087)	1.1482 (1.1321-1.1645)	1 Baseline
Female	5.79 (31088)	4.88 (52248)	1.1868 (1.1703-1.2036)	1.0190 (0.9985-1.0400) 0.070
Ethnicity[‡]				
NZ European	7.52 (48261)	6.36 (81650)	1.1818 (1.1715-1.1923)	1 (Baseline)
Māori	11.12 (5153)	9.69 (9317)	1.1467 (1.1385-1.1550)	0.9690 (0.9319-1.0076) 0.114
Pacific	6.00 (1724)	5.33 (3034)	1.1266 (1.1156-1.1376)	0.9752 (0.9145-1.0399) 0.444
Asian	4.08 (856)	3.71 (1596)	1.0986 (1.0857-1.1116)	0.9357 (0.8581-1.0203) 0.132
Other	1.80 (3034)	1.62 (5280)	1.1114 (1.0918-1.1314)	0.9535 (0.9076-1.0017) 0.059
Unknown	2.42 (2618)	2.08 (4458)	1.1658 (1.1479-1.1840)	0.9839 (0.9346-1.0358) 0.536
NZDep01/06				
1-3	5.19 (12771)	4.46 (21880)	1.1643 (1.1391-1.1900)	1.00 (Baseline)
4-7	6.29 (25270)	5.40 (43299)	1.1641 (1.1462-1.1823)	1.0003 (0.9730-1.0283) 0.983
8-10	5.95 (22514)	5.06 (38207)	1.1754 (1.1562-1.1949)	1.0167 (0.9876-1.0466) 0.264
1-10 (Continuous)				1.0037 (0.9998-1.0077) 0.065
Rurality				
Main Urban	5.64 (41614)	4.80 (70602)	1.1757 (1.1615-1.1900)	1 (Baseline)
Secondary	8.10 (5610)	7.05 (9739)	1.1490 (1.1119-1.1874)	0.9834 (0.9474-1.0208) 0.380
Minor	7.41 (6588)	6.43 (11393)	1.1534 (1.1189-1.1889)	0.9834 (0.9505-1.0173) 0.333
Rural Centre	5.63 (1419)	5.03 (2524)	1.1214 (1.0508-1.1967)	0.9610 (0.8988-1.0276) 0.245
Other rural	5.09 (3769)	4.46 (6583)	1.1421 (1.0972-1.1887)	0.9937 (0.9515-1.0377) 0.775
Other	11.04 (26)	10.86 (51)	1.0169 (0.6341-1.6307)	1.2448 (0.3950-3.9223) 0.708
Annual mean min. temp.				1.0034 (0.9984-1.0086) 0.176

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates and winter interaction terms.

[‡] Mortality rates and winter:non-winter ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

NZ's 1.1674 excess winter mortality index (EWMI) is higher than the EWHI of 1.0830. It is to be expected that these indices would be different, since people are hospitalised to preserve quality of life as well as to prevent death, and the distribution of events over different disease categories varies markedly between cases of hospitalisation and death (see Table 4.5).

Unlike the results for EWH, the only variable that shows significant differences in all-cause EWM by category is age-group: like EWH, EWM has a U-shaped distribution by age, with highest rates in the 80+ age group. However, unlike EWH, the 0-4 years peak in EWM is much lower, and there is no summer excess in 5-14 year olds. Instead, the 15-29 year age group has a summer excess, and therefore the lowest EWM.

Table 4.5 shows the different contributions of ICD-10 chapters to total mortality and hospitalisations, with the EWMI and EWHI for the period 1 February 2000 to 31 January 2006.

Sixty-nine percent of deaths are attributed to just two ICD-10 chapters: II, Neoplasms; and IX, Circulatory disease. Hospitalisations, however, have a more even spread: the two most common chapters, XIX – Injury and IX – Circulatory, account for only 35% of hospitalisation; a comparable 69% would include a further three chapters, none of them Neoplasms.

Given the differences between EWH and EWM by both disease and demographic distribution, it would be inappropriate to compare total EWHI directly with NZ or overseas EWMI. However, it is reasonable to compare directions and trends.

The period 1980-2000[78] also shows differences between NZ mortality and hospitalisation patterns. Deaths peak in July and trough in February, rather than in August and January respectively for hospitalisations. Again, this pattern may reflect different disease burdens. As shown in Figure 4.9, however, annual EWHI and EWMI patterns are loosely similar.

Table 4.5 Comparison of EWMIs and EWHIs by ICD-10 chapter, with percentage of total events, 1 February 2000- 31 January 2006.*

ICD-10 Chapter Description		EWMI	95% CI	p-value	% of total Deaths	EWHI	95% CI	p-value	% of total Hosps
I	Infection	1.1020	(0.9648-1.2588)	0.152	0.6%	**1.2146**	**(1.1962-1.2333)**	**0.000**	4.4%
II	Neoplasms	**1.0339**	**(1.0146-1.0535)**	**0.001**	28.8%	**0.9664**	**(0.9482-0.9850)**	**0.000**	3.0%
III	Blood etc	**1.2756**	**(1.0386-1.5668)**	**0.020**	0.2%	**1.0348**	**(1.0014-1.0682)**	**0.041**	1.0%
IV	Endocrine etc	**1.1827**	**(1.1237-1.2448)**	**0.000**	3.8%	1.0167	(0.9936-1.0404)	0.157	2.0%
V	Mental	**1.2631**	**(1.1879-1.3431)**	**0.000**	2.6%	0.9878	(0.9716-1.0042)	0.144	4.0%
VI	Nervous	**1.2293**	**(1.1642-1.2979)**	**0.000**	3.3%	**1.0345**	**(1.0128-1.0567)**	**0.002**	2.4%
VII	Eye	0	-	-	0.0%	0.9731	(0.9199-1.0295)	0.343	0.3%
VIII	Ear	0.7979	(0.1548-4.1126)	0.787	0.0%	**1.2409**	**(1.1873-1.2970)**	**0.000**	0.5%
IX	Circulatory	**1.2168**	**(1.1979-1.2360)**	**0.000**	39.8%	**1.1003**	**(1.0914-1.1093)**	**0.000**	15.7%
X	Respiratory	**1.5804**	**(1.5282-1.6343)**	**0.000**	8.3%	**1.7382**	**(1.7239-1.7525)**	**0.000**	14.2%
XI	Digestive	**1.1424**	**(1.0750-1.2140)**	**0.000**	2.7%	**0.9627**	**(0.9529-0.9727)**	**0.000**	10.3%
XII	Skin	0.9842	(0.7849-1.2342)	0.890	0.2%	**0.8836**	**(0.8695-0.8978)**	**0.000**	4.4%
XIII	Musculoskeletal	1.0527	(0.9420-1.1763)	0.365	0.8%	0.9887	(0.9706-1.0071)	0.228	3.2%
XIV	Genitourinary	**1.1453**	**(1.0505-1.2488)**	**0.002**	1.3%	**0.9357**	**(0.9215-0.9501)**	**0.000**	4.7%
XV	Pregnancy etc.	1.0499	(0.4882-2.2578)	0.901	0.0%	-			-
XVI	Perinatal	1.0302	(0.8958-0.1848)	0.676	0.5%	-			-
XVII	Congenital	**1.1324**	**(1.0001-1.2822)**	**0.050**	0.6%	0.9421	(0.8662-1.0247)	0.164	0.2%
XVIII	Symptoms	**1.2276**	**(1.0423-1.4457)**	**0.014**	0.4%	0.9959	(0.9865-1.0053)	0.393	12.1%
XIX	Injury	-	-	-	-	**0.9127**	**(0.9054-0.9201)**	**0.000**	17.1%
XX	External causes	**0.9591**	**(0.9201-0.9997)**	**0.048**	6.1%	-	-	-	-
XXI	Health status					1.0077	(0.9593-1.0586)	0.759	0.0%
	TOTAL	**1.1649**	**(1.1534-1.1766)**	**0.000**	100%	**1.0830**	**(1.0795-1.0866)**	**0.000**	100%

Looking at demographic modifiers, EWMIs, like EWHIs, were higher in the eldest and youngest (see Figure 4.10), but whereas hospitalisation indices were highest for the very young, mortality indices were highest for the old. Forgender, both the EWHI and the EWMI were higher for females, but the difference was more pronounced for mortality (see Table 4.2 and Table 4.4). There was no significant difference in EWMI between NZ Europeans and any other individual ethnicity, but NZ Europeans had a 5.00% (RRR 1.0500, 95% CI 1.0236–1.0770, p=0.000) higher

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[*] Only includes the 1 February 2000 – 31 January 2004 time period as death data by ICD-10 chapter was not available for subsequent years.

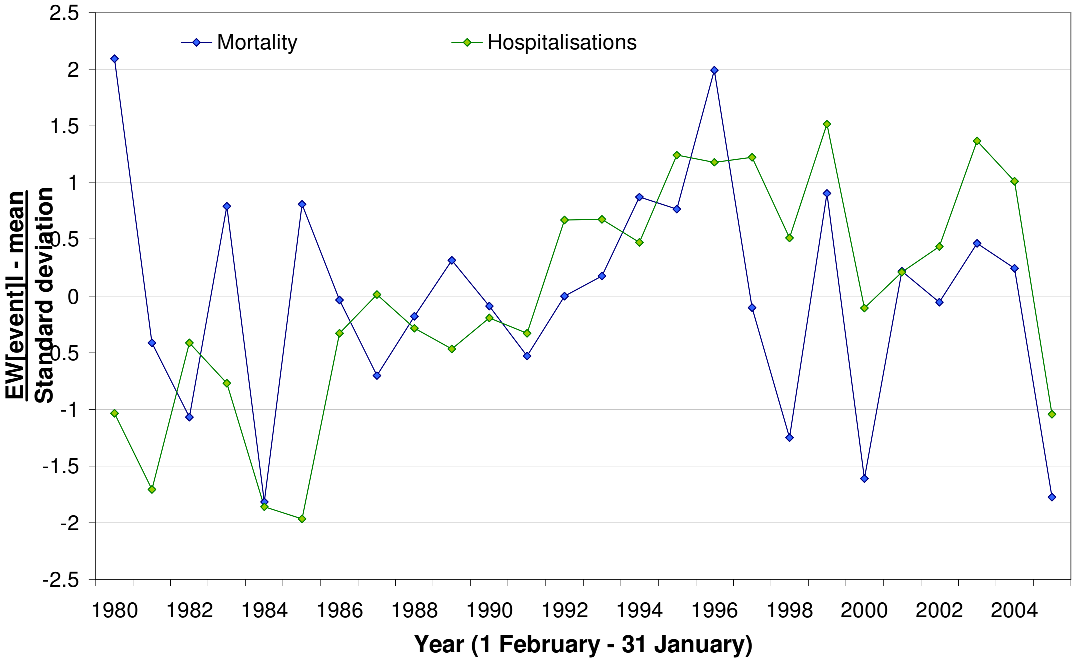

Figure 4.9 **EWMI and EWHI compared: standard deviations from mean excess winter event index for the period 1 February 1980 to 31 January 2006.**

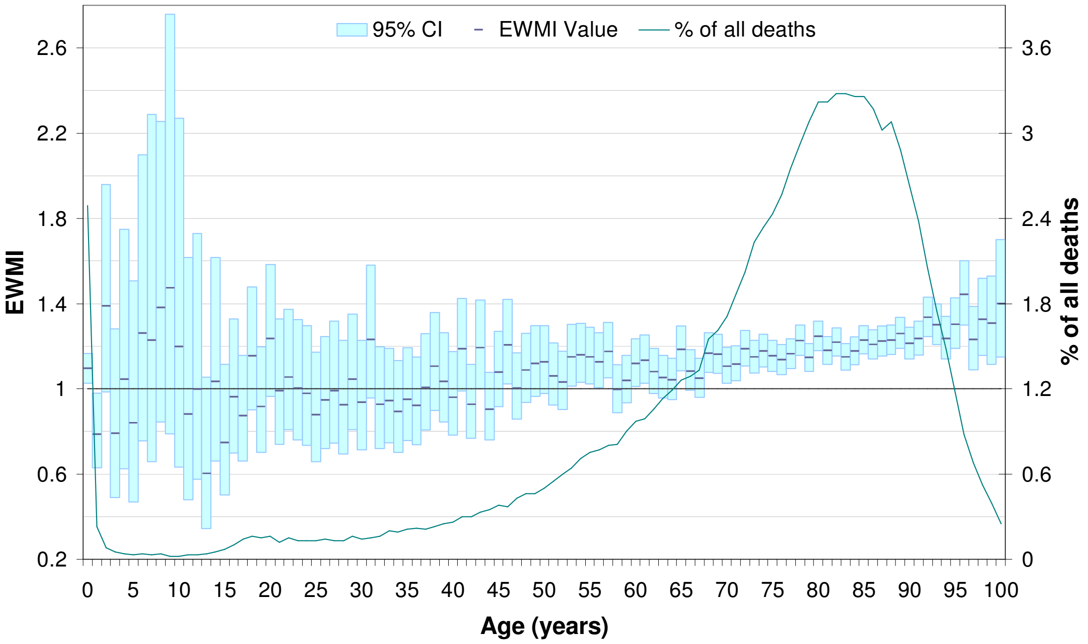

Figure 4.10 **Winter:non-winter all-cause death rate ratios by year of age, 2000-2006 (adjusted for sex, ethnicity, NZDep decile, rurality and annual average minimum temperature), with percentage of total deaths by year of age.**

EWMI when compared to all other ethnicities combined. However, this difference was not constant through different age groups. In the under-five years age group, the differences between ethnicities lie in the same direction as for EWHIs, with RRRs of 1.2033 (95% CI 1.0275-1.4093, p=0.022) for Māori, and 1.4863 (95% CI 1.1957-1.8475, p=0.000) for Pacific children.

However, in this dataset, 64% of deaths in the under-five years age group are deaths on day of birth, so their occurrence is more a representation of maternal health than an indicator of the baby's environmental exposures.[*] The EWMI for deaths on day of birth was 1.4814 (1.2082 – 1.8163) for Pacific babies, which was RRR 1.6105 (95% CI 1.2339-2.1022, p=0.000) higher than NZ European after controlling for sex, NZDep decile, rurality and annual average minimum temperature. There were no other significant differences by ethnicity. As noted above, the direction of these main results are similar to the few other EWM ethnicity analyses which include ethnicity as a variable, but opposite to the direction of EWH results. EWH also differs from EWM in showing a deprivation effect.

By disease category, there were similarities and differences between EWH and EWM. ICD-10 Chapters I (Infection), IX (Circulatory) and X (Respiratory) all showed a marked winter excess in both hospitalisation and mortality.

However, diseases of the ear, which showed a high EWHI, were too rare a cause of death to show any significant excess in the EWMI.

Chapters II, XI and XIV showed significant winter excess for mortality, but non-winter excess for hospitalisation. No chapters had a non-winter excess for mortality, but not hospitalisation. Only the comparable ICD-10 Chapters XIX (Injury, for hospitalisations) and XX (External cause of death) had a non-winter excess for both health events.

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[*] These include all babies born after 20 full weeks of gestation, or weighing 400g or more, whether death occurred before or after birth.

Finally, a comparison of EWM and EWH indicates that caution may be needed in extrapolating causal results from one to the other: as their disease distribution is different, factors which contribute to EWH may play a different role in EWM, and vice versa.

4.5 CONCLUSION

Excess winter hospitalisation in New Zealand shows both similarities to and differences from previous work on EWM, and the few studies of EWH. Trends for age, sex and rurality lie in the same direction as the bulk of EWM study, but results showing significantly higher EWHIs for more deprived groups do not. The differences shown here in EWHI by ethnicity (with higher EWHI for Māori and Pacific Peoples) have not previously been found in any study of excess winter illness and clearly require further attention. Findings from this chapter also emphasise the need for caution when considering total EWH which is inevitably the summation of multiple diverse disease processes and their sometimes opposing effects on EWM. This theme is picked up in the next chapter which looks at the separate contributions that different disease groups make to EWH.

CHAPTER 5 EXCESS WINTER HOSPITALISATION BY ICD-10 CHAPTER

5.1 INTRODUCTION

This chapter provides a break down of EWH by ICD-10 chapter. Full results are provided for ICD-10 Chapters I (Infectious and parasitic disease), IX (Circulatory disease), and X (Respiratory disease). As there were few significant results for other ICD-10 chapters, the focus here is on these three disease categories.

As the results show, a break down of EWH by ICD-10 chapter is important, as differences by disease group or variables of interest may help illuminate the aetiology of EWH and any potential areas for intervention.

Table 5.1 below lists winter: non-winter ratios by disease code, and the contribution of each ICD-10 Chapter to absolute EWH, as a percentage. Excess was calculated in two ways: first, as a percentage of total excess hospitalisations; and second, as a percentage of excess hospitalisations for those diseases with an EWHI above 1.0000, i.e. "positive excess".

The bulk of seasonal illness comes from just two chapters: X (Respiratory) and IX (Circulatory). EWHIs are higher for Chapters I (Infection) and VIII (Ear) than for IX, but their contribution to winter hospital load is less, as their incidence is much lower. Other chapters' contributions to EWH were small to negligible.

Within chapters, the contribution of specific diseases to EWH varied markedly (Appendix 3). Several individual diseases were intensely seasonal with EWHI > 2, notably influenza (EWHI = 13.06 for identified virus, 5.36 with unidentified virus), viral pneumonia (EWHI = 4.09), and acute bronchiolitis (EWHI=3.47). All but hypothermia were respiratory infections.

It is also worth noting that all disease chapters contained diseases that showed divergent seasonal effects, with both positive and negative EWHI (see EWHI for all 3-digit level disease codes, Appendix 3)

Table 5.1 Rates of hospitalisation in winter and non-winter months, ratio of rates and relative change in winter:non-winter ratios for all causes of hospitalisation, 2000-2006.

ICD Chapter		Rate per 1000 person years (No of hospitalisations)				% of total EWH[*]	% of + EWH	Winter: non-winter ratio	
	Description	Winter		Non-winter					(95% CI)[†]
I	Infection	2.52	(26474)	2.08	(43480)	10.9	7.87	1.2146	(1.1962-1.2333)
II	Neoplasms	1.51	(15819)	1.56	(32651)	-1.30	-	0.9664	(0.9483-0.9850)
III	Blood etc	0.52	(6521)	0.50	(12631)	0.42	0.30	1.0348	(1.0014-1.0692)
IV	Endocrine etc	1.05	(13395)	1.03	(26180)	0.41	0.30	1.0167	(0.9936-1.0404)
V	Mental	2.01	(26438)	2.04	(53645)	-0.63	-	0.9878	(0.9716-1.0042)
VI	Nervous	1.24	(15361)	1.20	(29839)	0.99	0.72	1.0345	(1.0128-1.0567)
VII	Eye	0.17	(2170)	0.18	(4457)	-0.12	-	0.9731	(0.9199-1.0295)
VIII	Ear	0.30	(3775)	0.25	(6173)	1.44	1.04	1.2409	(1.1873-1.2970)
IX	Circulatory	8.55	(105875)	7.77	(193068)	18.96	13.72	1.1003	(1.0914-1.1093)
X	Respiratory	10.13	(125962)	5.83	(144395)	105.02	76.01	1.7382	(1.7239-1.7525)
XI	Digestive	5.14	(64753)	5.34	(134053)	-4.92	-	0.9627	(0.9529-0.9727)
XII	Skin	2.07	(25899)	2.34	(58798)	-6.69	-	0.8836	(0.8695-0.8978)
XIII	Musculoskeletal	1.61	(20082)	1.63	(40624)	-0.47	-	0.9887	(0.9706-1.0071)
XIV	Genitourinary	2.31	(29252)	2.47	(62203)	-3.91	-	0.9357	(0.9215-0.9501)
XVII	Congenital	0.08	(951)	0.08	(2060)	-0.12	-	0.9421	(0.8662-1.0247)
XVIII	Symptoms	6.14	(77339)	6.17	(155335)	-0.69	-	0.9959	(0.9865-1.0053)
XIX	Injury	8.22	(103222)	9.01	(225419)	-19.32	-	0.9127	(0.9054-0.9201)
XXI	Health services	0.23	(2836)	0.23	(5671)	0.04	0.03	1.0077	(0.9593-1.0586)

5.1.1 Disease category and ethnicity

ICD-10 disease distribution of EWHI varied by ethnicity. The major ICD-10 3-letter disease codes contributing to Māori and Pacific EWHIs are listed in Appendix 3

Figure 5.1 shows monthly hospitalisation rates for the three largest EWH chapters, over the 2000 to 2006 study period. For respiratory illness, it demonstrates the year-to-year variation in date of peak hospitalisations. It also shows that while they are moderately similar, the peaks for circulatory illness and respiratory illness do not necessarily coincide. Peak months for the two chapters did match in 2003 and 2004. However, the respiratory peak fell in the month prior to the circulatory peak in 2000 and 2005, was one month after the circulatory peak in 2002, and two months after in 2001 and 2006. If temperature were the main driver for both chapters, we would expect the peak dates to be closer than they are. The differences in peak dates

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[*] Negative percentages occur for diseases that have a non-winter rather than a winter excess, e.g. more injuries occur in summer than in winter.

[†] Cohort analysis

suggest the chapters may have different aetiology, or at least a different lag response to temperature.

Meier et al. previously found acute respiratory-tract infections to be associated with an increased risk of first-time acute myocardial infarction in the following two weeks.[79] If circulatory events are associated with respiratory events, the association is not strong enough to show an exact relationship between peak periods for the overall chapters.

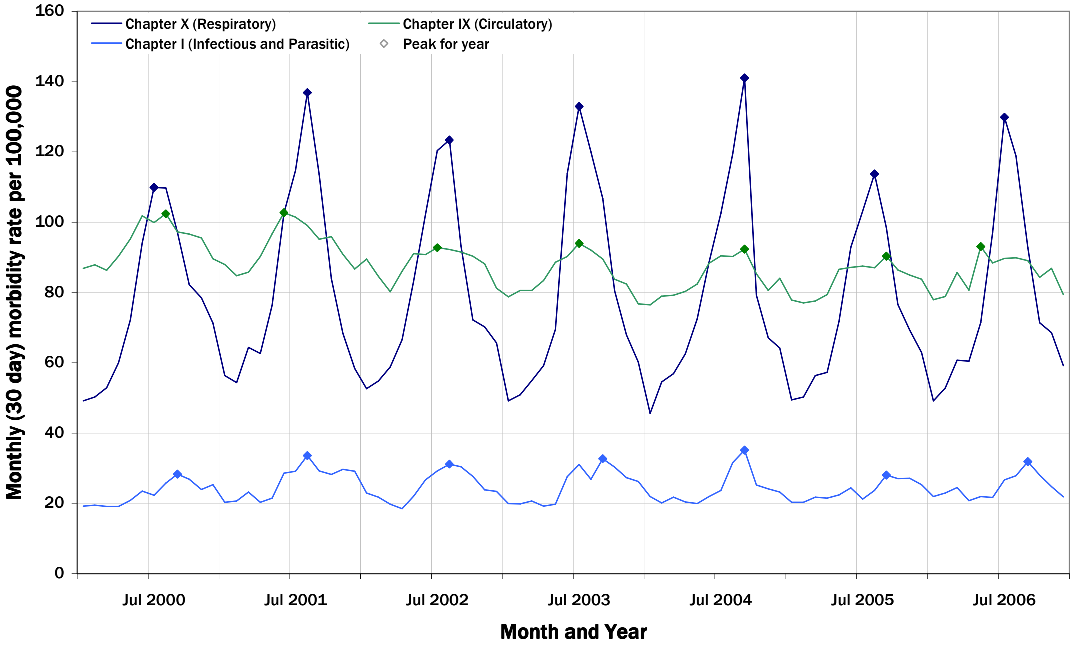

Figure 5.1 **Monthly (30-day) hospitalisation rate per 100,000, 2000-2006 for ICD-10 Chapters I, IX, and X.**

The infectious and parasitic chapter regularly shows a smaller secondary peak in late summer/early autumn, indicating a likely intra-chapter variation in seasonal patterns by disease (enteric infections for example have a well-established association with warm summer months).

5.2 ICD-10 CHAPTER X - RESPIRATORY ILLNESS

Respiratory illness accounts for 14% of all hospitalisations, and 76% of positive EWH. Given this large contribution to all-cause EWH, it is unsurprising that respiratory EWHI patterns, as shown in Table 5.2, mirror, or magnify, many of the patterns of all-cause EWHIs.

The respiratory EWHI was highest in the 0 to 4 years age group, peaking in under-1-year olds (see Figure 5.2) and dropping exponentially ($y = 3.0978x^{-0.3837}$, R2 = 0.9843) for each year of age until nine. It then gradually increased through each age group, to reach a secondary peak in the 80+ age-group.

For ethnicity, the greatest difference from the NZ European baseline was for Pacific Peoples, who had a 9.90% higher EWHI (RRR 1.0990, 95% CI 1.0645-1.1345, p=0.001).

Socio-economic deprivation showed a larger gradient in respiratory illness than in all-cause hospitalisation, with the NZDep 8-10 tertile 3.96% (RRR 1.0396, 95% CI 1.0129-1.0669, p=0.003) higher than NZDep 1-3 tertile, and a continuous increase of 1.0058 (95% CI 1.0023-1.0092, p=0.001) across NZDep deciles.

5.2.1 Annual distribution

Figure 5.3 shows the daily variation in respiratory hospitalisations over the study period, with lowess smoothing[80], using a 14-day-span locally weighted running regression. The figure shows a double peak for respiratory illness, with the first in early July, and the second in mid-August. This is a real double peak, rather than a result of, for example, variation in influenza outbreak dates. While year-to-year distribution does vary, each year shows this double peak, and it appears to be the result of variation in distribution by disease type within the ICD-10 respiratory chapter. In general, upper respiratory infections peak earlier and lower respiratory infections later.

This double peak is important, as it may offer some clues to the difference in EWH for ICD-10 Chapter 10 ($EWH_{10)}$ by ethnicity. Figure 5.4 suggests that higher Māori respiratory hospitalisation, compared to European, is spread across both peaks; while among Pacific Peoples the difference appears in the second peak but not in the first. In contrast, the differences in weekly variation in respiratory hospitalisation are more evenly spread throughout the year (Figure 5.5).

There are some other useful observations that can be made from the daily distribution (Figure 5.3). First, there is an approximately three-week period of optimal respiratory health in late January and early February; and second, the four month June to September 'winter' period only captures the very worst of the winter excess: the smoothed regression line crosses the average 1.00 on 22 May on the way up, and 11 October on the way down. An analysis by temperature, not included in this study, might suggest an alternative winter: non-winter distribution for analytical purposes.

Table 5.2 Rates of hospitalisation for ICD Chapter 10 (Respiratory Disease), in winter and non-winter months; ratio of rates; and relative change in winter:non-winter ratios for potential modifying factors; 1 Feb 2000 – 31 Jan 2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				**Winter: non-winter ratio (95% CI), unadjusted (cohort analysis)**		**Winter: non-winter ratio relative to baseline Category (95% CI), p-value**		
	Winter		**Non-winter**						
All					1.74	(1.72-1.75)			
Age (years)									
0-4	56.8	(33141)	24.0	(28019)	2.3645	(2.3272-2.4024)	**1.4914**	**(1.4561-1.5276)**	**0.000**
5-14	4.3	(6672)	3.0	(9302)	1.4306	(1.3863-1.4763)	**0.9015**	**(0.8686-0.9356)**	**0.000**
15-29	3.2	(6919)	2.2	(9705)	1.4220	(1.3788-1.4665)	**0.8957**	**(0.8638-0.9287)**	**0.000**
30-59	3.9	(17106)	2.5	(22316)	1.5288	(1.4987-1.5596)	**0.9613**	**(0.9364-0.9869)**	**0.000**
60-79	21.7	(27392)	13.7	(34548)	1.5814	(1.5565-1.6066)	**1**	**Baseline**	
80+	37.4	(14904)	22.5	(17899)	1.6608	(1.6251-1.6973)	**1.0417**	**(1.0132-1.0710)**	**0.000**
Gender									
Male	10.5	(53638)	6.2	(63730)	1.6789	(1.6597-1.6983)	1	Baseline	
Female	9.8	(52529)	5.4	(58108)	1.8032	(1.7821-1.8246)	**1.0917**	**(1.0733-1.1105)**	**0.000**
Ethnicity[†]									
NZ European	10.1	(73989)	6.1	(61948)	1.6681	(1.6544-1.6818)	1	Baseline	
Māori	26.9	(28618)	16.4	(26161)	1.6381	(1.6300-1.6464)	0.9877	(0.9647-1.0112)	0.303
Pacific	20.4	(12031)	11.0	(12089)	1.8449	(1.8340-1.8559)	**1.0990**	**(1.0645-1.1345)**	**0.000**
Asian	6.0	(2925)	3.7	(2427)	1.6483	(1.6311-1.6657)	0.9462	(0.8933-1.0023)	0.060
Other	2.6	(2479)	1.4	(2096)	1.8561	(1.8258-1.8871)	1.0633	(0.9998-1.1310)	0.051
Unknown	1.9	(1796)	1.0	(1446)	1.7972	(1.7626-1.8325)	1.0153	(0.9446-1.0912)	0.681
NZDep01/06									
1-3	6.7	(16447)	4.0	(19658)	1.6689	(1.6347-1.7039)	1	Baseline	
4-7	9.2	(36744)	5.4	(43236)	1.6952	(1.6718-1.7189)	1.0161	(0.9903-1.0425)	0.224
8-10	13.5	(51011)	7.5	(56635)	1.7967	(1.7753-1.8183)	**1.0396**	**(1.0129-1.0669)**	**0.003**
1-10 (continuous)							**1.0058**	**(1.0023-1.0092)**	**0.001**
Rurality									
Main Urban	10.0	(73290)	5.7	(84216)	1.7360	(1.7189-1.7532)	1	Baseline	
Secondary	11.4	(7931)	6.7	(9240)	1.7122	(1.6616-1.7643)	0.9982	(0.9656-1.0321)	0.918
Minor	12.9	(11408)	7.2	(12666)	1.7966	(1.7517-1.8427)	**1.0458**	**(1.0167-1.0757)**	**0.002**
Rural Centre	9.0	(2273)	5.6	(2791)	1.6245	(1.5369-1.7169)	0.9517	(0.8992-1.0073)	0.088
Other rural	8.0	(5878)	4.6	(6835)	1.7155	(1.6567-1.7764)	1.0073	(0.9705-1.0456)	0.701
Other	7.2	(17)	2.3	(14)	2.4221	(1.1939-4.9134)	3.8551	(0.4009-37.0671)	0.243
Mean min. temp.							0.9961	(0.9916-1.0006)	0.089

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate).

[†] Morbidity rates and ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

5.2.1.1 Respiratory EWH in the 0-4 age group.

The 0 to 4 years age group had the highest EWHI$_{10}$. The EWHI$_{10}$ was significantly higher in girls than boys (RRR 1.1507, 95% CI 1.1129-1.1898, p=0.000). RRRs lay in the same direction by ethnicity as for all age groups, but the differences were not significant. Differences in EWHI$_{10}$ by NZDep tertile were more pronounced than in all ages, with the EWHI$_{10}$ for the NZDep 8-10 tertile 7.74% higher than for NZDep 1-3 (RRR 1.0774, 95% CI 1.0207-1.1373, p=0.007), and a continuous trend of 1.0096 (95% CI 1.0025-1.0167, p=0.000). Minor Urban areas showed a higher EWHI$_{10}$ than Main Urban areas (RRR 1.0598, 95% CI 1.0014-1.1216, p=0.044), which was similar to all age groups. There was no significant gradient by annual average minimum temperature.

5.2.1.2 Respiratory EWH in ages 65+

In those aged 65+, the EWHI$_{10}$ was higher for women than for men (RRR 1.1110 (95% CI 1.0801-1.1428, p=0.000). Differences in EWHI$_{10}$ by NZDep tertile were more pronounced, with the EWHI$_{10}$ for the NZDep 8-10 tertile 6% higher than for NZDep 1-3 (RRR 1.0604, 95% CI 1.0178-1.1048, p=0.005). Māori had a significantly lower EWHI$_{10}$ than NZ European (RRR 0.9119, 95% CI 0.8673-0.9588, p=0.000) and the slightly elevated RRR for Pacific Peoples was non-significant (1.0190, 95% CI 0.9453-1.0985, p=0.622). There was no difference in EWHI$_{10}$ by rurality, or annual average minimum temperature.

5.2.2 Non-respiratory admissions

Given the large contribution of respiratory illness to overall EWH, I was interested to see what EWH remained without it. Without respiratory illness, all other chapters combined show no excess winter hospitalisation; the winter effect and non-winter effect chapters, and age-groups, cancel each other out.

It should also be noted that although the Māori EWHI$_{10}$ was not significantly different from NZ European, respiratory illness was the driver for the significant difference between Māori and NZ European all-cause EWHIs, due to respiratory

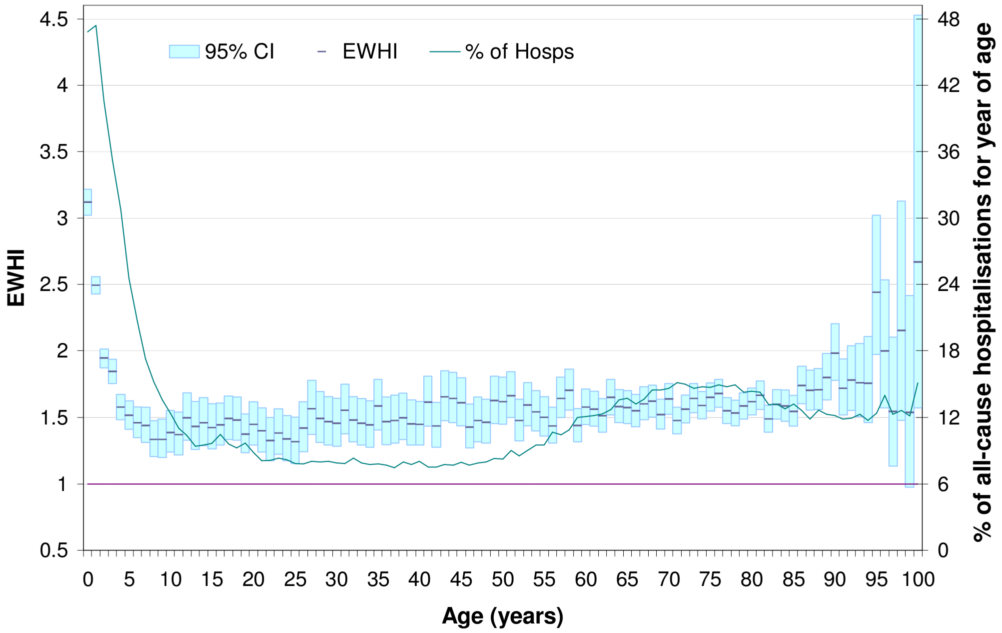

Figure 5.2 ICD-10 Chapter X (Respiratory) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, annual average minimum temperature, and rurality), and percentage of all-cause hospitalisations, 2000-2006, by year of age.

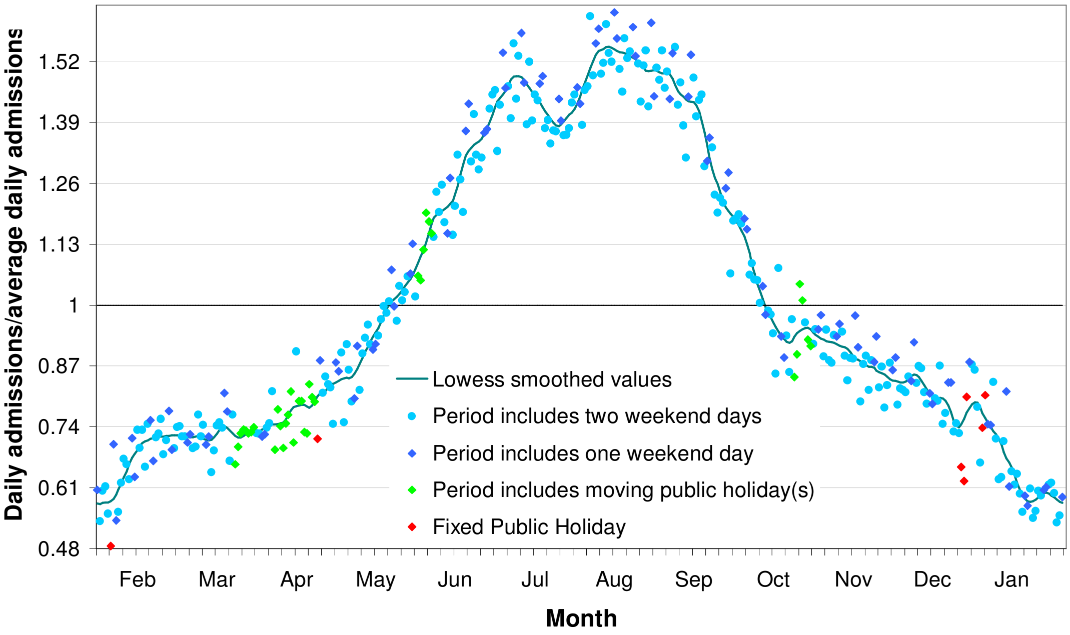

Figure 5.3 Daily variation in respiratory admission rates with 14-day lowess smoothing, for the period 1 February 2000 – 31 January 2006.*

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* N.B. Shows 1 February – 31 January year to clarify Christmas/New Year distribution; 29 February excluded.

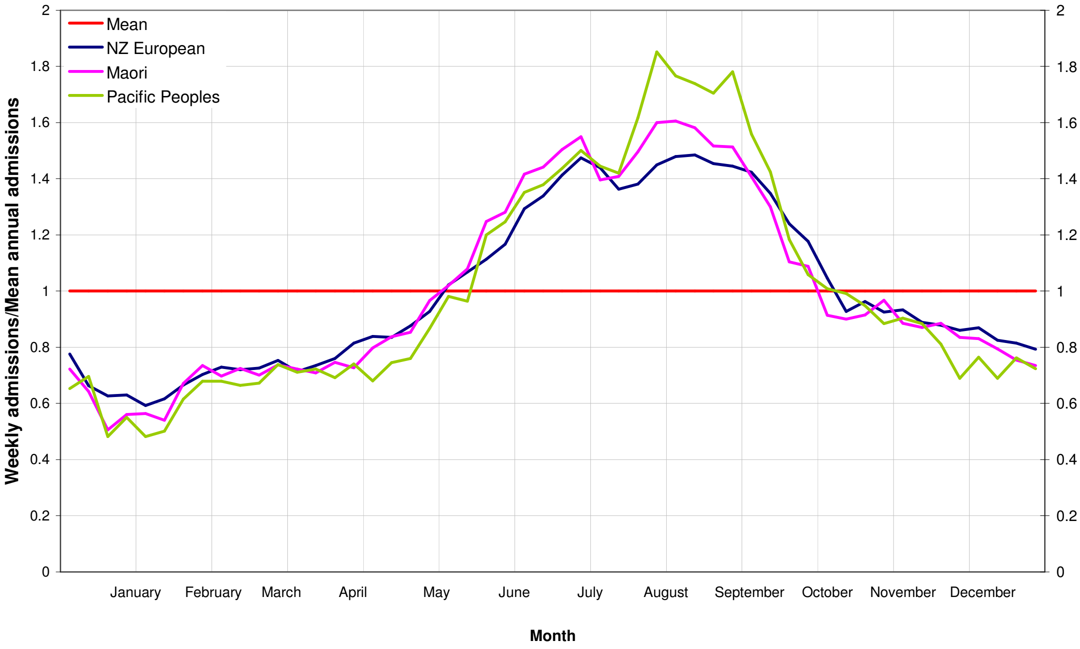

Figure 5.4 Weekly variation in respiratory admission rates by ethnicity, for the period 1 February 2000 – 31 January 2006.*

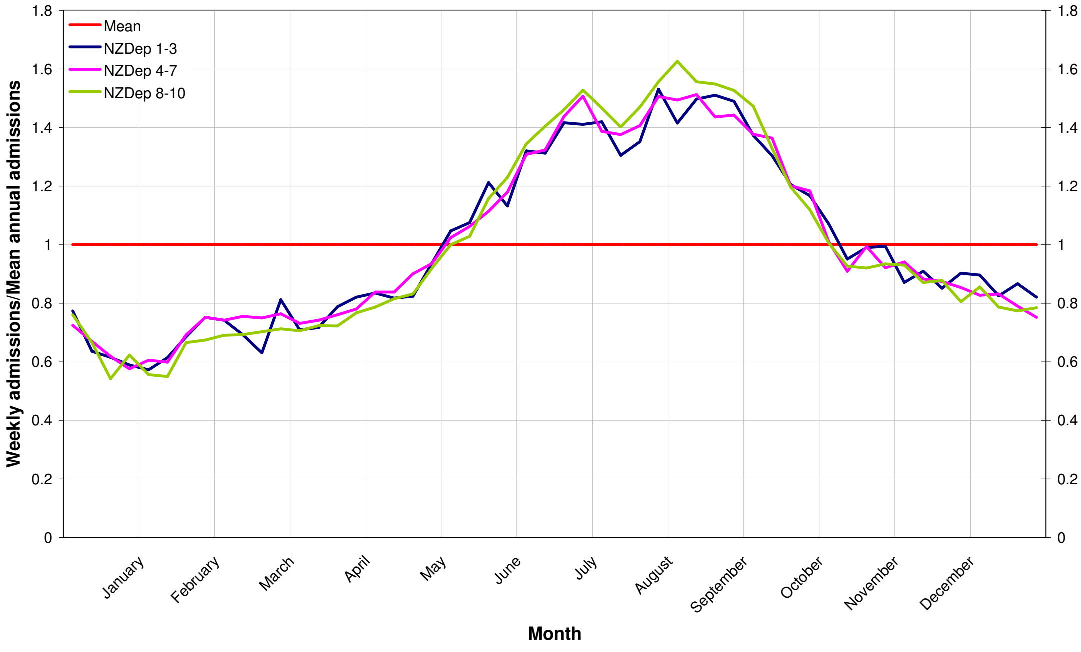

Figure 5.5 Weekly variation in respiratory admission rates by NZDep tertile, for the period 1 February 2000 – 31 January 2006.†

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* 29 February and 30 December excluded, 31 December included in first week.

† 29 February and 30 December excluded, 31 December included in first week

Table 5.3 Rates of hospitalisation for ICD Chapter 9, in winter and non-winter months; ratio of rates; and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006.

	Rate per 1000 person years[*] (No of hospitalisations)		Winter:non-winter ratio (95% CI)	Winter:non-winter ratio relative to baseline category (95% CI)[†], p-value	
	Winter	Non-winter	Unadjusted (cohort analysis)		
All			1.1003 (1.0914-1.1093)		
Age (years)					
0-4	0.4 (211)	0.4 (443)	0.9522 (0.8082-1.1219)	0.8680 (0.7314-1.0302)	0.105
5-14	0.5 (710)	0.4 (1209)	1.1713 (1.0676-1.2851)	1.0893 (0.9888-1.1999)	0.083
15-29	0.5 (1147)	0.5 (2014)	1.1359 (1.0565-1.2213)	1.0399 (0.9642-1.1215)	0.310
30-59	4.1 (18013)	3.9 (34627)	1.0375 (1.0190-1.0564)	**0.9556 (0.9345-0.9771)**	**0.000**
60-79	33.1 (41823)	30.6 (76999)	1.0833 (1.0705-1.0963)	1 Baseline[‡]	
80+	69.4 (27674)	59.2 (47110)	1.1717 (1.1544-1.1892)	**1.0815 (1.0605-1.1028)**	**0.000**
Gender					
Male	9.2 (47415)	8.4 (86425)	1.0944 (1.0822-1.1067)	1 Baseline	
Female	7.9 (42203)	7.1 (76042)	1.1071 (1.0940-1.1203)	1.0040 (0.9873-1.0209)	0.640
Ethnicity[§]					
NZ European	10.9 (71813)	9.9 (129782)	1.1012 (1.0932-1.1092)	1 Baseline	
Māori	18.2 (9011)	16.3 (16456)	1.1126 (1.1064-1.1189)	1.0167 (0.9872-1.0470)	0.271
Pacific	9.6 (2959)	9.0 (5569)	1.0722 (1.0640-1.0805)	0.9816 (0.9350-1.0305)	0.454
Asian	6.9 (1718)	6.0 (3139)	1.1407 (1.1303-1.1513)	1.0216 (0.9605-1.0865)	0.497
Other	1.4 (2309)	1.3 (4218)	1.0902 (1.0686-1.1123)	0.9928 (0.9411-1.0472)	0.790
Unknown	1.6 (1808)	1.5 (3303)	1.0999 (1.0792-1.1209)	0.9903 (0.9328-1.0513)	0.749
NZDep01/06					
1-3	7.2 (17574)	6.5 (31793)	1.1026 (1.0825-1.1231)	1 Baseline	
4-7	9.1 (36454)	8.3 (66230)	1.0979 (1.0840-1.1120)	0.9938 (0.9711-1.0171)	0.599
8-10	9.0 (34149)	8.2 (61762)	1.1029 (1.0885-1.1176)	1.0007 (0.9769-1.0251)	0.955
1-10 (continuous)				0.9995 (0.9963-1.0028)	0.781
Rurality					
Main Urban	8.2 (60709)	7.5 (109560)	1.1053 (1.0944-1.1164)	1 Baseline	
Secondary	11.9 (8230)	10.8 (14931)	1.0995 (1.0704-1.1295)	1.0057 (0.9756-1.0368)	0.713
Minor	11.1 (9877)	10.2 (18081)	1.0897 (1.0634-1.1167)	0.9932 (0.9663-1.0208)	0.627
Rural Centre	8.0 (2016)	7.3 (3665)	1.0972 (1.0392-1.1585)	1.0050 (0.9505-1.0628)	0.860
Other rural	6.5 (4821)	6.1 (8988)	1.0700 (1.0332-1.1081)	0.9865 (0.9503-1.0240)	0.475
Other	9.8 (23)	11.3 (53)	0.8656 (0.5306-1.4121)	0.9080 (0.2734-3.0156)	0.875
Mean min. temp.				1.0041 0.9999-1.0083	0.057

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate).

[†] Adjusted for covariates including winter interaction terms. Covariates grouped for reporting purposes (NZDep tertiles, age groups) were expanded (NZDep deciles, year of age) for other regressions.

[‡] The 60-79 years age group was selected as the baseline because its EWHI was closest to the Chapter mean, and it had largest number of cases.

[§] Morbidity rates and ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

hospitalisations accounting for 21% of Māori hospitalisations, but only 12% of NZ European.

5.3 ICD-10 CHAPTER IX: DISEASES OF THE CIRCULATORY SYSTEM

Diseases of the circulatory system account for 15.8% of all hospitalisation, and 13.7% of positive EWH. The overall EWHI for Chapter IX was 1.10 (1.09-1.11, 0.000). The only variable to show significant differences in RRRs was age group, but given the large contribution of circulatory disease to overall EWH, full results have been included in Table 5.3.

The most obvious implication of Figure 5.6 is that circulatory hospitalisation rates are low in the first third of the age range, making analysis by age-year less useful than analysis by age-group for this disease chapter.

Looking at age groups, therefore, we see that the EWHI for the baseline 60 to 79 year age group, which at 1.0833 (95% CI 1.0705-1.0963) is closest to the overall mean circulatory EWHI of 1.1003 (95% CI 1.0914-1.1093), is significantly higher than the EWHI for the younger 30-59 year age group (RRR 0.9556, 95% CI 0.9345-0.9771, p=0.000) and lower than the EWHI for the older 80+ age group (RRR 1.0815, 95% CI 1.0605-1.1028, p=0.000).

There were no significant intra-age group differences by demographic sub-group.

5.3.1 ICD-10 Chapter I: Certain infectious and parasitic diseases.

ICD-10 Chapter I made up 4.4% of all hospitalisations, and accounted for 7.9% of positive excess winter hospitalisations. The overall EWHI for Chapter I was 1.2146 (95% CI 1.1962-1.2333, p=0.000). Women experienced greater EWH than men (RRR 1.0457, 95% CI 1.0132-1.0793, p=0.006). EWHIs reduced with increasing age and were greater in rural centres (RRR 1.1261, 95% CI 1.0150-1.2494, p=0.025) than in urban centres. Although there was strong variation in this chapter by age group and sex, there was none by deprivation or ethnicity.

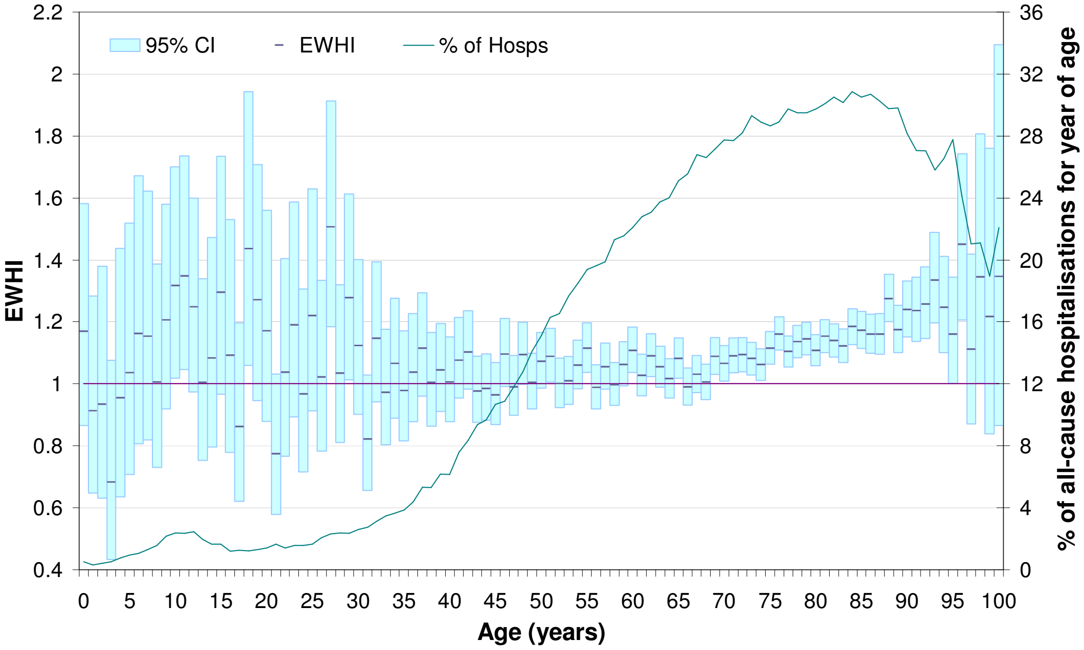

Figure 5.6 ICD-10 Chapter IX (Circulatory) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, mintemp, and rurality), and percentage of all-cause hospitalisations, 2000-2006, by year of age.

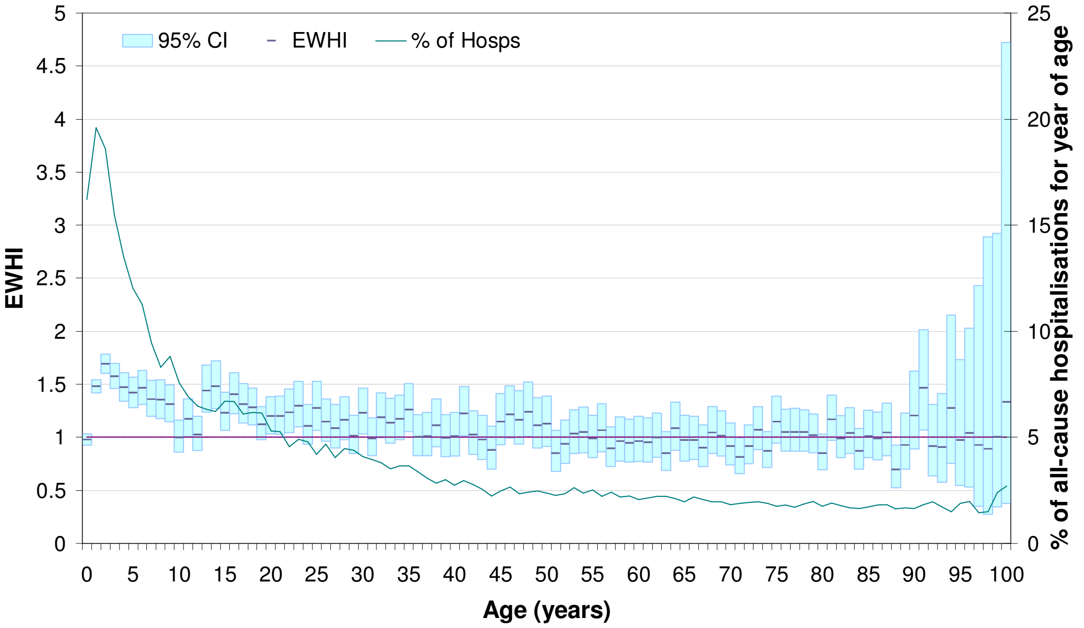

Figure 5.7 Infectious and parasitic (ICD-10 Chapter I) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, minimum temp, and rurality), and percentage of all-cause hospitalisations, 2000-2006, by year of age.

Table 5.4 Rates of hospitalisation for ICD Chapter 1, in winter and non-winter months; ratio of rates; and relative change in winter:non-winter ratios for potential modifying factors, 2000-2006.

	Rate per 1000 person years[*] (No of hospitalisations)		Winter:non winter ratio (95% CI)		Winter:non-winter ratio relative to baseline		
	Winter	Non-winter	Unadjusted (cohort analysis)		category (95% CI)[†], p-value		
All			1.2146	(1.1962-1.2333)			
Age (years)							
0-4	17.7 (10317)	12.6 (14703)	1.4029	(1.3681-1.4387)	**1.1560**	**(1.1004-1.2144)**	**0.000**
5-14	2.4 (3653)	1.8 (5545)	1.3140	(1.2602-1.3700)	**1.0868**	**(1.0237-1.1534)**	**0.006**
15-29	1.7 (3793)	1.4 (6257)	1.2091	(1.1613-1.2589)	1	Baseline[‡]	
30-59	1.0 (4434)	0.9 (8301)	1.0654	(1.0272-1.1049)	**0.8816**	**(0.8333-0.9327)**	**0.000**
60-79	2.2 (2812)	2.3 (5717)	0.9810	(0.9377-1.0263)	**0.8079**	**(0.7585-0.8605)**	**0.000**
80+	3.7 (1463)	3.7 (2948)	0.9899	(0.9298-1.0539)	**0.8110**	**(0.7503-0.8766)**	**0.000**
Gender							
Male	2.6 (13343)	2.2 (22203)	1.1988	(1.1733-1.2248)	1	Baseline	
Female	2.5 (13132)	2.0 (21277)	1.2311	(1.2047-1.2582)	**1.0457**	**(1.0132-1.0793)**	**0.006**
Ethnicity[§]							
NZ European	10.9 (16074)	9.9 (27025)	1.1951	(1.1779-1.2124)	1		
Māori	18.2 (5564)	16.3 (8653)	1.1626	(1.1489-1.1765)	0.9909	(0.9480-1.0358)	0.686
Pacific	9.6 (2662)	9.0 (4131)	1.2202	(1.2047-1.2358)	0.9680	(0.9113-1.0282)	0.290
Asian	6.9 (1137)	6.0 (1832)	1.1679	(1.1478-1.3637)	0.9731	(0.8980-1.0545)	0.505
Other	1.4 (651)	1.3 (1115)	1.3322	(1.3015-1.3637)	1.0580	(0.9540-1.1734)	0.285
Unknown	1.6 (387)	1.5 (724)	1.1121	(1.0765-1.1490)	0.9413	(0.8275-1.0706)	0.357
NZDep01/06							
1-3	2.1 (5064)	1.7 (8486)	1.1904	(1.1497-1.2325)	1		
4-7	2.3 (9382)	2.0 (15663)	1.1948	(1.1646-1.2258)	1.0138	(0.9696-1.0601)	0.546
8-10	3.0 (11489)	2.4 (18460)	1.2415	(1.2129-1.2708)	1.0336	(0.9871-1.0824)	0.160
1-10 (continuous)					1.0042	(0.9980-1.0105)	0.187
Rurality							
Main Urban	2.5 (18529)	2.1 (30301)	1.2198	(1.1977-1.2423)	1		
Secondary	2.6 (1804)	2.2 (3092)	1.1639	(1.0982-1.2334)	0.9722	(0.9119-1.0364)	0.387
Minor	2.6 (2278)	2.2 (3934)	1.1551	(1.0970-1.2163)	0.9548	(0.9022-1.0104)	0.109
Rural Centre	2.5 (631)	1.8 (926)	1.3592	(1.2284-1.5039)	**1.1261**	**(1.0150-1.2494)**	**0.025**
Other rural	2.3 (1718)	2.0 (2897)	1.1830	(1.1144-1.2557)	0.9755	(0.9143-1.0409)	0.455
Other	2.1 (5)	1.7 (8)	1.2466	(0.4078-3.8106)	-	-	-
Mean min. temp.					1.0042	(0.9959-1.0125)	0.327

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate).

[†] Adjusted for covariates including winter interaction terms. Covariates grouped for reporting purposes (NZDep tertiles, age groups) were expanded (NZDep deciles, year of age) for other regressions.

[‡] The 15-29 years age group was selected as the baseline because its EWHI was closest to the Chapter mean.

[§] Morbidity rates and ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

5.4 Other ICD-10 Disease Chapters.

ICD-10 chapters V, XI, XII, XIII, XIV and XVII showed a non-winter rather than a winter excess, so it would be perverse to talk about EWH being higher or lower in any particular group.

As there were fewer trends or results of interest or significance in other winter excess chapters, full results tables have been forgone, and only results of interest have been summarised in the following sections. As age is the strongest indicator of differences in EWH, full graphs of results by year of age have been included for each winter excess chapter.

5.4.1 ICD-10 Chapter III: Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism

The overall EWHI for Chapter III was 1.0348 (95% CI 1.0014-1.0692, p=0.041). EWHIs were higher among the young, and plateaued for age groups over 14. It was significantly lower among Māori than NZ European (RRR 0.8884, 95%CI 0.7962-0.9913, p=0.034).

5.4.2 ICD-10 Chapter VIII: Diseases of the ear and mastoid process

The overall EWHI for Chapter VIII was 1.2409 (95% CI 1.1873-1.2970, p=0.000). EWH$_8$ was most prominent among the young: the EWHI$_8$ for the 5 to 14 year age group was closest to the overall EWHI$_8$ at 1.2098 (95% CI 1.0240-1.4293, p=0.025); compared to that baseline, the 0 to 4 year age group had an RRR of 1.6678 (95% CI 1.3778-2.0188, p=0.000). Older age-groups RRRs were all below 1.0000, ranging from 0.8208 to 0.8562, but none were significantly different from the baseline.

The EWHI$_8$ also decreased with increasing annual average minimum temperature, with a trend of 0.9539 (95% CI 0.9313-0.9772, p=0.000) by 0.5^{o}C increase.

There was no difference in EWHI$_8$ by ethnicity.

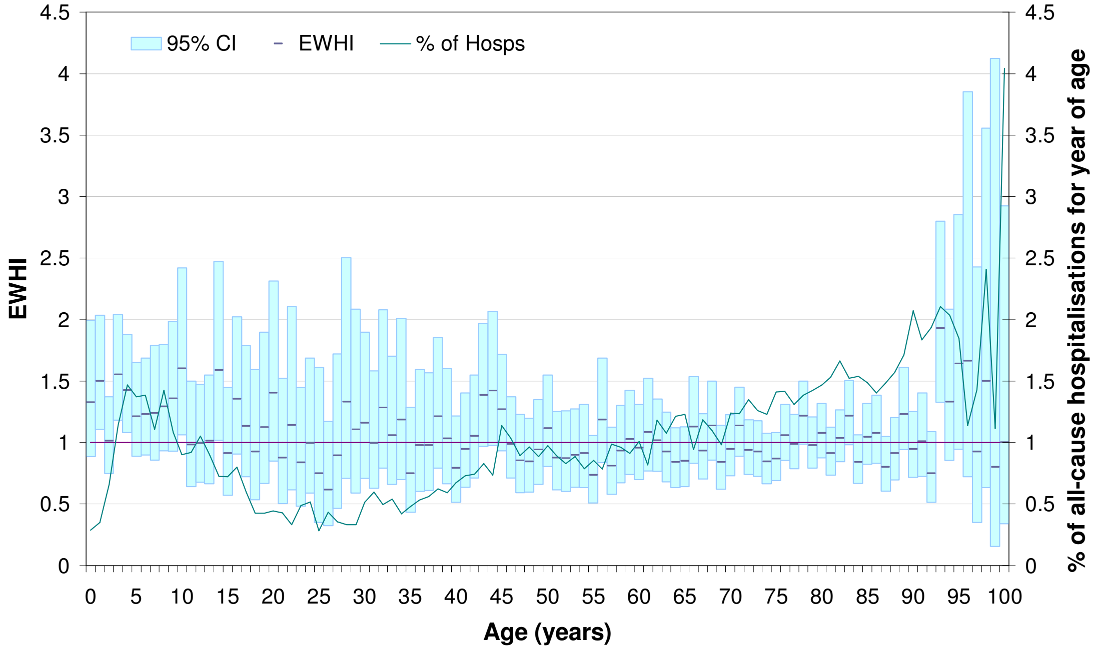

Figure 5.8 Blood disorder (ICD-10 Chapter III) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, minimum temperature, and rurality), and percentage of all-cause hospitalisations, 2000-2006, by year of age.

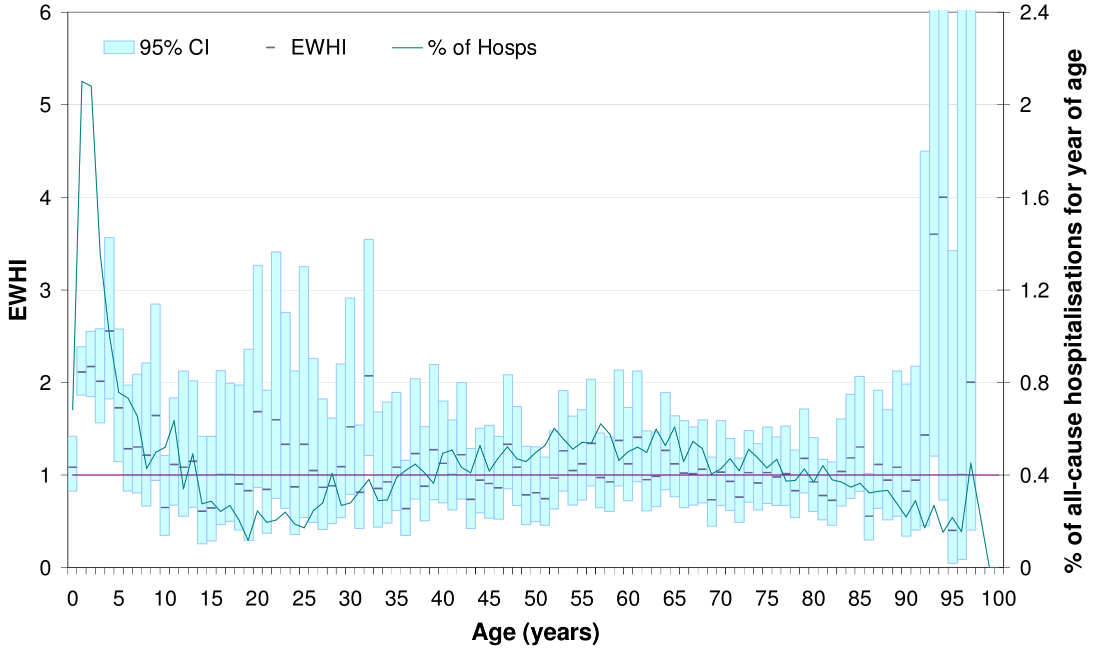

Figure 5.9 Ear and mastoid (ICD-10 Chapter VIII) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, minimum temperature, and rurality),* and percentage of all-cause hospitalisations, 2000-2006, by year of age.

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* No results calculable for ages 98-100.

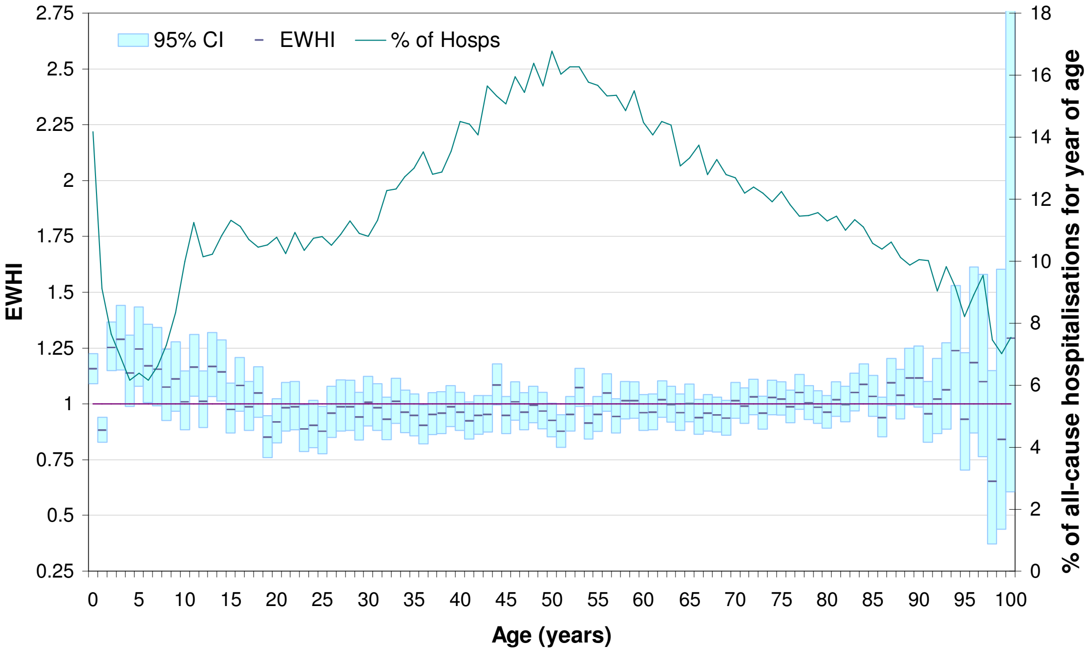

Figure 5.10 Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD-10 Chapter XVIII) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, minimum temperature, and rurality), and percentage of all-cause hospitalisations, 2000-2006, by year of age.

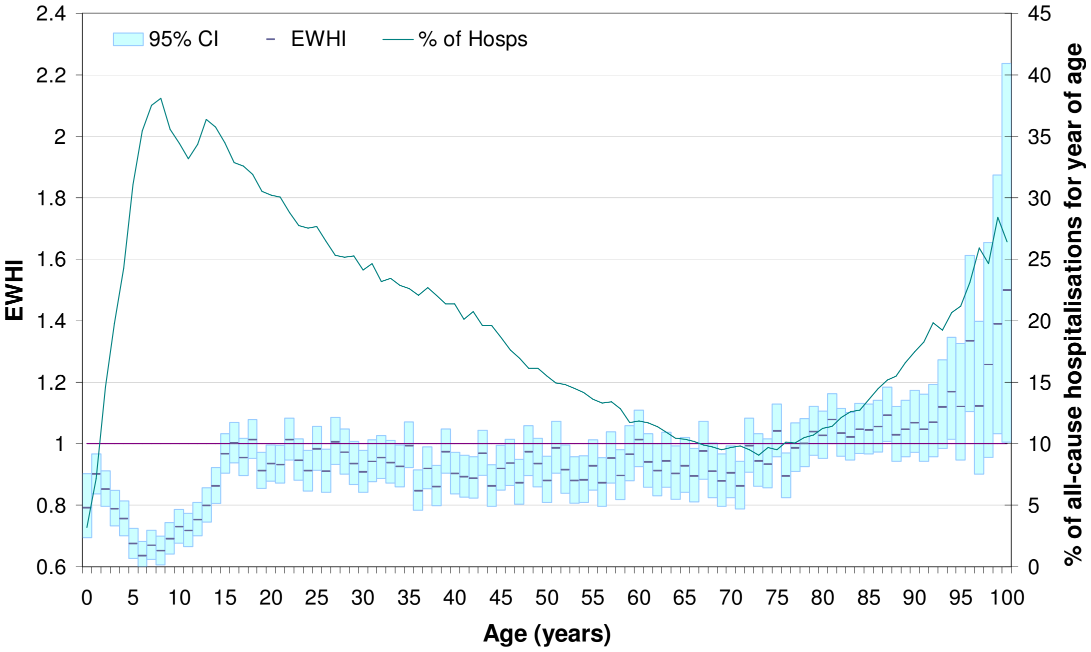

Figure 5.11 Injury, poisoning and other external cause (ICD-10 Chapter XIX) hospitalisations: winter:non-winter incidence rate ratios (standardised for sex, ethnicity, NZDep decile, minimum temperature, and rurality), and percentage of all-cause hospitalisations, 2000-2006, by year of age.

5.4.3 ICD-10 Chapter XVIII: Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified

The overall EWHI for Chapter XVIII was non significant (RRR 0.9959, 95% CI 0.9865-1.0053, p=0.393). However, this was a result of different seasonal patterns for different age-groups, as illustrated in Figure 5.1: children and over-80s experienced winter excess for Chapter XVIII, with EWHI$_{18}$s of 1.0848 (95% CI 1.0472-1.1237) for the 0 to 4 years age group, 1.1192 (95% CI 1.0731-1.1672) for the 5-14 year age group, and 1.0280 (95% CI 1.0024-1.0543) for the 80+ age group, while age groups in between had a non-winter excess or no significant winter: non-winter difference.

5.4.4 Chapter XIX: Injury, poisoning and certain other consequences of external causes

Chapter 19 showed a non-winter excess for all age-groups except over-80s, who experienced an EWHI$_{19}$ of 1.0611 (95% CI 1.0384-1.0844, p=0.000). Of particular interest are the results for 1 to 15 year olds, which show a strong U-shape, all with non-winter excesses, as illustrated in Figure 5.11. This pattern is particularly important because it is the driver for the all-cause non-winter excess in the 5-14 year age group.

5.5 CONCLUSION

Analysis by ICD-10 chapter provides some useful insight into excess winter hospitalisation. In particular, there are differences in patterns between the two main contributing chapters, circulatory and respiratory illness. Second, the dip in all-cause EWHI for ages 6 to 13 is likely to reflect the larger proportion of hospitalisations in this age group resulting from injury (ICD-10 Chapter XIX), and the particular EWHI-age pattern associated with that chapter. ICD-10 disease chapter analysis has shown respiratory disease (by ratio) and circulatory disease (by numbers) to be the largest contributors to EWH. Given the role of respiratory disease in so many of the EWH pathways hypothesised in the literature review, it is a clear candidate for disease-specific consideration in housing trait analysis.

Findings in this chapter are an important reminder of the limitations of global measures such as total EWH or EWM. Such measures are inevitably the sum of multiple, and sometimes contradictory, seasonal patterns. Even at the level of ICD-10 chapters, we are still looking at diverse aetiological pathways. A good example is infectious diseases, which are distributed across all chapters in addition to ICD-10 Chapter I (certain infectious and parasitic diseases). Previous analysis of New Zealand data has shown that the infectious disease chapter included only 17% of infectious disease hospitalisations and 11% of infectious disease deaths, with the rest in other ICD chapters, notably respiratory diseases.[81] Analysis below the chapter level (for the 3-digit level disease codes shown in Appendix 3) also showed the very wide divergences of seasonal effects, with both positive and negative EWHI within each chapter.

CHAPTER 6 NEW ZEALAND DWELLINGS

6.1 INTRODUCTION

This chapter describes New Zealand dwellings, with particular emphasis on description by QV dwelling type. The purpose of this description is to highlight distribution of dwelling features and differences between the different dwelling types, in order to shed light on any differences in health outcomes by dwelling attributes.

6.2 BACKGROUND

One architectural historian notes that "New Zealand architectural discourse and history has few major texts. Indeed, aside from a small handful of books, most of the country's published accounts of architecture might be categorised as [hard to find] ephemera—pamphlets, exhibition catalogues, and the odd short-lived journal."[82]

A brief sojourn through these texts would leave the reader under the impression that most of us live in pre-war houses, particularly villas (Figure 6.1); and pre-war

Figure 6.1 1910s Villa, Waiatarua, Waitakere City.

Figure 6.2 **1920s Bungalow, Mt Eden, Auckland.**

Figure 6.3 **1940s State House, Three Kings, Auckland.**

Figure 6.4 1950s Vernon Brown-designed house, Remuera.

Figure 6.5 1950s Bach, Papamoa Beach.

Figure 6.6 2000s Holiday home, Omaha.

Figure 6.7 1960s post-war bungalow, Wellington

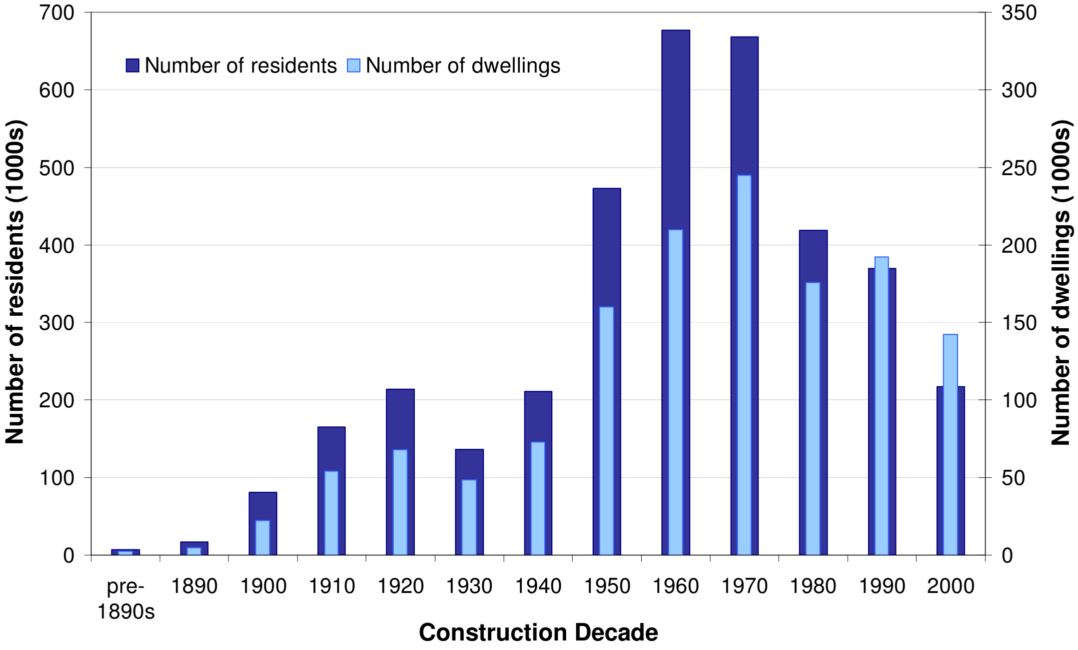

Figure 6.8 Distribution of New Zealand residents and dwellings by construction decade, where known (QV data)

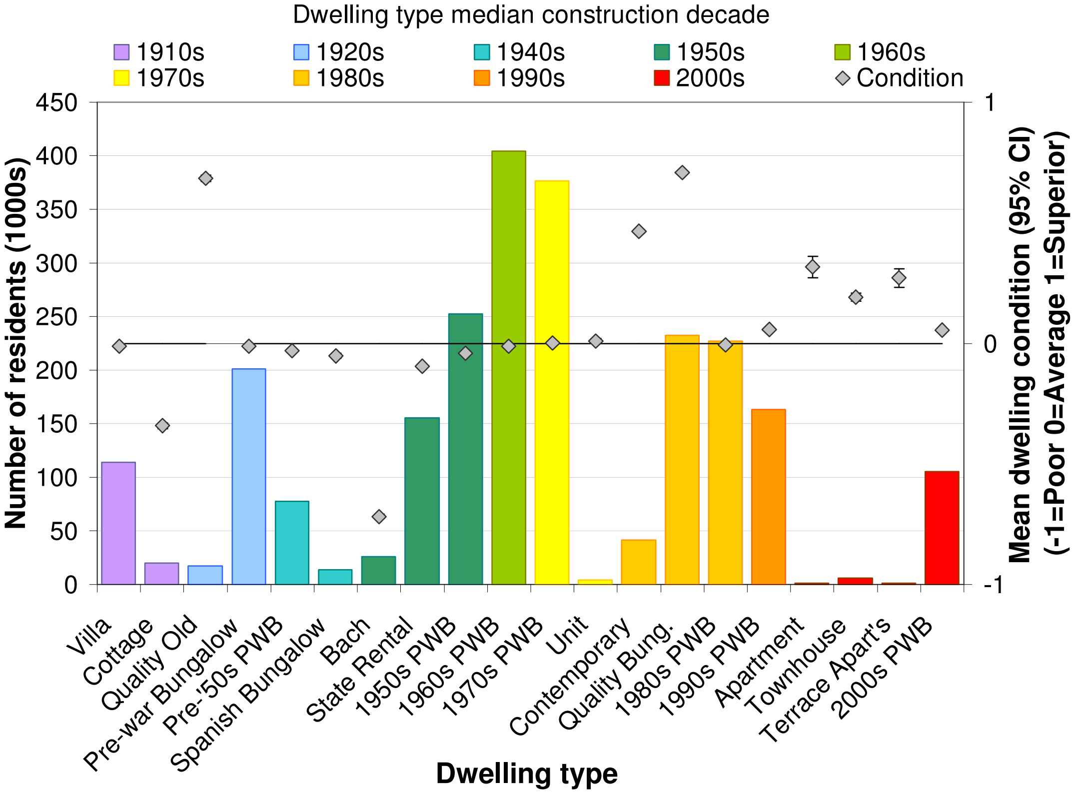

Figure 6.9 Distribution of New Zealand residents by dwelling type, where known, with median age and mean condition of dwelling type (QV data).*

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* PWB=Post-war Bungalow

bungalows (Figure 6.2); with the rest of us inhabiting either a state house (Figure 6.3);or perhaps a 1950s or '60s house designed by one of a small coterie of "modern" architects (Figure 6.4); and with many of us taking our holidays in a bach, that is either quaint (Figure 6.5); or not (Figure 6.6).

In reality, of course, we don't. The distribution of known construction decades and styles for New Zealand dwellings is shown in the graphs following (Figure 6.8, Figure 6.9).

Thus, as the population-weighted distributions in Figure 6.8 and Figure 6.9 demonstrate, most of us live in a post-war bungalow, which may look something like the 1960s classic in Figure 6.7; the 1970s brick example in Figure 6.10; or the 1980s standard in Figure 6.11.

6.3 NEW ZEALAND HOUSING LITERATURE REVIEW

6.3.1 Style, characteristics and features

The small body of work on New Zealand housing styles is most comprehensive for pre-war houses. My main reference for this period has been Jeremy Salmond's *Old New Zealand Houses 1800-1940*[83], which describes not only the many variations in stylistic features of those houses, but also their materials and social context. While there are other works on older houses, they are largely pictorial, and/or concerned with external detail[84] [85], rather than with aspects of the house which might make a difference to its inhabitants' lifestyle, the way the house is used, or, most importantly for this study, its thermal properties.

An additional difficulty with all these works is that they are intended to document pre-war houses as they were, rather than as they are today. Salmond's section on planning and form, for example, shows the original 4-6 room Villa layout with a parlour at the front, kitchen at the back, and lean-to scullery, pantry, wash-house and bath. My observation is that the front parlour may now more commonly be used as a bedroom; and the pantry and scullery may be integrated into an open-plan kitchen,

Figure 6.10 1970s post-war bungalow, New Plymouth

Figure 6.11 1980s post-war bungalow, Wellington

living and dining area, preferably with double-width or wider glazed doors allowing access to a back deck. However, there are no data on how widespread this observed arrangement may be; it may be peculiar to my social sphere. This is by no means a criticism of Salmond's work, but meant as an illustration of the limitations of using architectural history-focussed texts as a guide to current residential dwelling use.

Toomath argues that in order to "learn about ourselves", "we need to cancel the familiarity of our houses, to defamiliarise their appearance". He notes that "It is often stated that a nation's architecture provides a true picture of its culture at any particular time", and then goes on to "a reading of our more common types of houses for the historical light they throw on the shaping of ourselves as New Zealanders. … [focussing on] our main formative period, … from the 1800s to the start of the 1940s."[85]

As the previous section of this chapter has demonstrated, most New Zealand houses were built after 1950. Therefore, while descriptions of older houses may well be "helpful tools in the search for an understanding of our cultural roots", in that they do a good job of telling us where we came from, they tell us little about where we are now.

Texts on post-war houses are more limited. What literature there is for this later era of dwellings tends to focus on "canonic ideals"[82] - buildings designed by architects, rather than on the far more common and presumably architecturally mundane builder or owner-designed houses. While these ideals apparently impacted on the evolution of mundane houses, they are not mundane houses, and, by my observation, cannot be viewed as representative of them. As Douglas Lloyd Jenkins has noted,

> "[P]ostwar builders disguised their timber behind wallboard or veneers of brick and seldom innovated much at all. Architects, on the other hand, inclined to the experimental, while exploring exposed timber as cladding, floorboards, wall-linings and ceilings."[86]

Knowledge of these canonic ideals therefore tells us little about post-war houses in general.

In "The Elegant Shed: New Zealand Architecture since 1945", Mitchell and Chaplin begin to deliver a description of the New Zealand post-war bungalow, but then veer off to the architecture of the bach, viewing it as "common ground between the high architecture of the professional designer and the folk building of the amateur". It may well be that, but it is not where most of us live day to day. Once again, the authors have been diverted by the picturesque.

In *A History of New Zealand Architecture*[87], Peter Shaw provides the most comprehensive overview of New Zealand building, but he also takes an architect's view, describing the general house-building public as suffering from "timidity, not to say a pronounced taste for the mediocre". Still, among the usual list of works of architects, there are some comments on builder-designed houses. Unfortunately, his comments are not always supported by QV data, so while I have incorporated them in the dwelling type descriptions provided later in this Chapter, they are not necessarily reliable.

There is, then, a gap in the architectural literature: there is no broad description of the houses New Zealanders live in; what they are made of, how they were constructed (including additions and alterations over time); and most importantly for public health, how they are used. Until that gap is filled, the Building Research Association of New Zealand (BRANZ) House Condition Survey is the best alternative source of information on current New Zealand housing.

6.3.2 Housing Condition: BRANZ House Condition Surveys

BRANZ's most recent House Condition Study was conducted in 2005, making it up to date for this research study period. Apart from the fact that BRANZ records only the housing construction decade, and not its style, the main limitations to using the house condition survey as an indicator of actual New Zealand housing conditions are that it covers only stand-alone, owner-occupied dwellings, in the three highest population centres. Based on 2006 Census area unit populations by household tenure, the houses BRANZ surveyed are directly representative of dwellings for only 21% of households.

Research overseas has found rental properties more likely to be sub-standard than owner-occupied dwellings[88]. However, no comparable New Zealand research has been done, so it is not clear whether owner-occupied dwellings are representative of rental housing quality. Owner-occupiers may have greater incentive to improve their houses, because they live in them, but perhaps less capacity, if they are paying a mortgage; while rental-owners may have more capacity to improve their houses, as they have sufficient capital to own an investment property, and can claim repairs and maintenance costs against tax, but less incentive to do so unless they can improve their rent return. However, a short analysis of Census tenure and QV housing quality data (see Chapter Seven) suggests that rental dwellings in New Zealand are likely to be in poorer condition than owner-occupier dwellings.

However, while BRANZ recognises that its survey may also "under-estimate the extent of deterioration in the housing stock", it is still a useful starting point. In the summary of relevant BRANZ results below, QV data have been included as a comparison where available.

6.3.2.1 Overall health-related housing conditions.

The BRANZ 2005 survey[*] shows the overall lowest condition-rated exterior components of houses to be window fasteners, insulation, cladding clearance, and sub-floor ventilation. Of the exterior components surveyed, these four would appear to be the most pivotal to the 'healthiness' of the house, as their poor condition is most likely to contribute to a cold, damp house.[3] Along with foundations, they were also

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[*] BRANZ inspectors surveyed owner-occupied dwellings in the main centres Auckland, Wellington, and Christchurch, assessing individual components, and also making an overall judgement on the maintenance condition of the property. Homeowners were also surveyed by telephone and asked to rank the condition of their dwelling.

the exterior components for which the largest percentage of houses had serious or poor condition.

Subfloor dampness was a particular problem, with more than a third of houses having less than half the currently required ventilation area, and 17% less than a quarter.

6.3.2.2 Winter effects on housing conditions

The 2005 survey inspections were all completed in summer, which prevented seasonal comparison, but the previous 1999 survey had found notable differences between houses assessed in summer and houses assessed in winter; 70% more houses were assessed as damp in winter than in summer. BRANZ viewed this as a conservative estimate, and estimated winter moisture problems could be up to 10% higher if Christchurch properties had been properly represented in the winter surveys. However, BRANZ found that adjusting for dehumidifier use increased the potential proportion of houses with year-round dampness by 10%.

Inspections carried out in 2005 found that once an increase in use of dehumidifiers had been adjusted for, levels of dampness were little changed from 1999.

6.3.2.3 Insulation

Overall levels of insulation were variable. Two-thirds of dwellings (69%) had all ceilings insulated, but this did not mean adequately insulated; defects in insulation were common, particularly gaps (36%); settling (34%); and poor fitting (29%).

In addition, there was variation in insulation levels by dwelling age, both in coverage and thickness. Figure 6.12 shows that while ceiling coverage increased quite steadily with building age, the standard of the coverage was unreliable: insulation in the most populous construction decade, the 1960s, was least likely to meet 1996 standards; and while 96% of post-1980s construction had full insulation coverage, that coverage was not of a reliable standard either. It is unclear why insulation in so many dwellings constructed post-1978 fails to meet relevant building code standards, but could be any or all of; inadequate initial inspection, meaning the building was signed off as meeting the building code even though the insulation installed was too thin or not properly fitted; deterioration of insulation, particularly settling (identified by BRANZ as particularly common in macerated paper); or insulation being moved post-construction (for example to install new light fittings), leaving gaps.

These results are of particular concern because people may assume from the fact that they have ceiling insulation that their ceiling is thermally insulated: BRANZ results suggest otherwise for many dwellings.

Wall and floor insulation were of sufficiently uniform low coverage and quality to be discounted in this study.

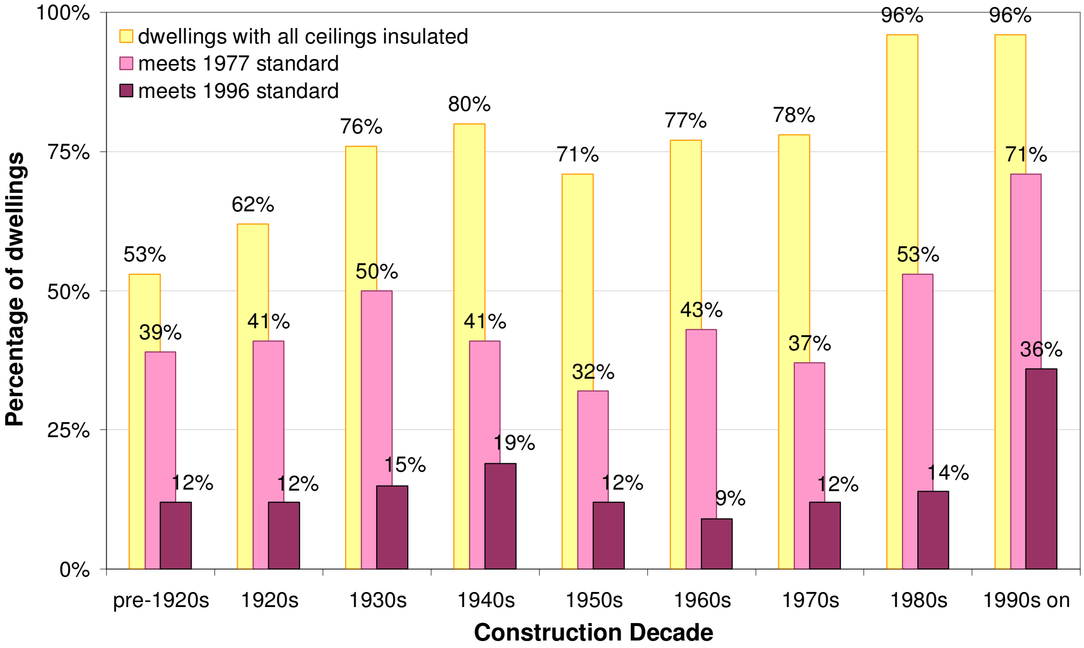

Figure 6.12 Percentage of BRANZ-inspected dwellings meeting 1977 and 1996 ceiling insulation standards by construction decade (BRANZ data).[68]

6.3.2.4 *The Inverse Housing Law*

The last point from the BRANZ surveys worth noting in relation to insulation was that the "inverse housing law" noted by Blane et al.[89], whereby dwellings in the coldest areas are of the lowest quality, does not seem to apply in relation to New Zealand insulation levels: Christchurch had greater insulation coverage than Wellington, which in turn had greater coverage than Auckland.

However, while insulation may not follow the inverse housing law, overall dwelling quality does show some features of it. Figure 6.13 demonstrates an inverted U-shaped relationship between QV dwelling condition and annual average minimum temperature: houses in colder areas are generally in poorer condition (except in the very coldest locations, where small dwelling numbers meant wide confidence intervals); dwelling condition improves as annual average temperature increases, until 6°C, then declines with increasing temperature. Adjusting for demographic factors (age, sex, ethnicity, NZDep and rurality) did not change the direction of these results, but did reduce the severity of the decline in mean dwelling condition at the warmer end of the temperature axis, meaning that poorer mean dwelling condition at the warmer end of the temperature axis is partly related to the greater representation of lower socio-economic groups in the warmest parts of the country.

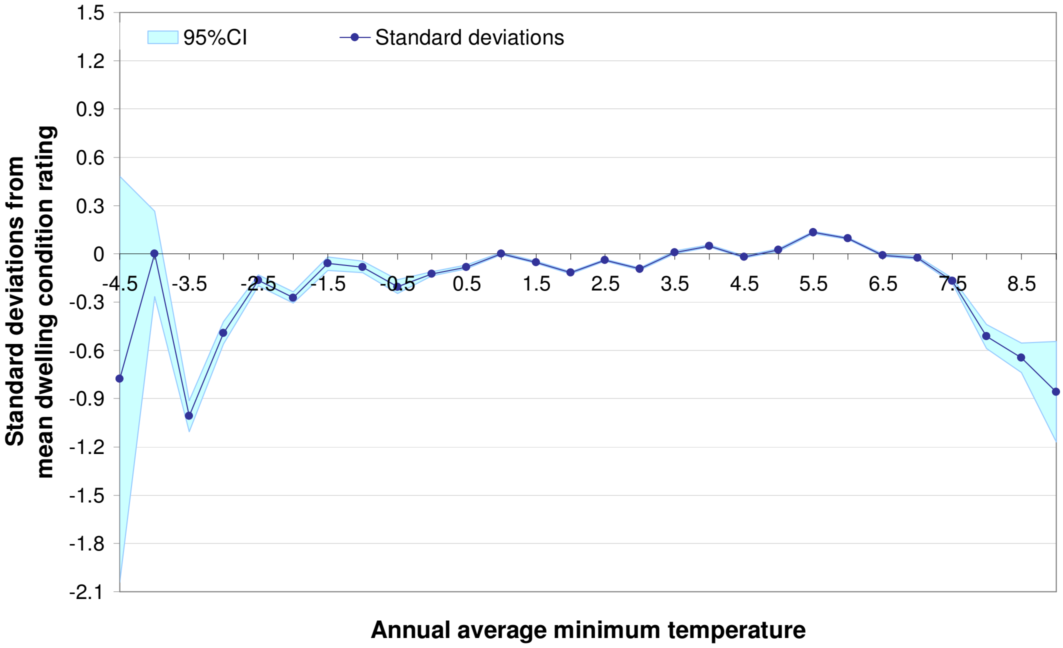

Figure 6.13 Mean QV dwelling condition by census area unit-level annual average minimum temperature (QV and Landcare Research data).

Dwelling-weighted linear regression shows a significant trend of improving dwelling condition with increasing temperature, but this result reflects the fact that the vast majority (93%) of dwellings are in areas with annual average minimum temperatures between 1 and 7 degrees C inclusive.

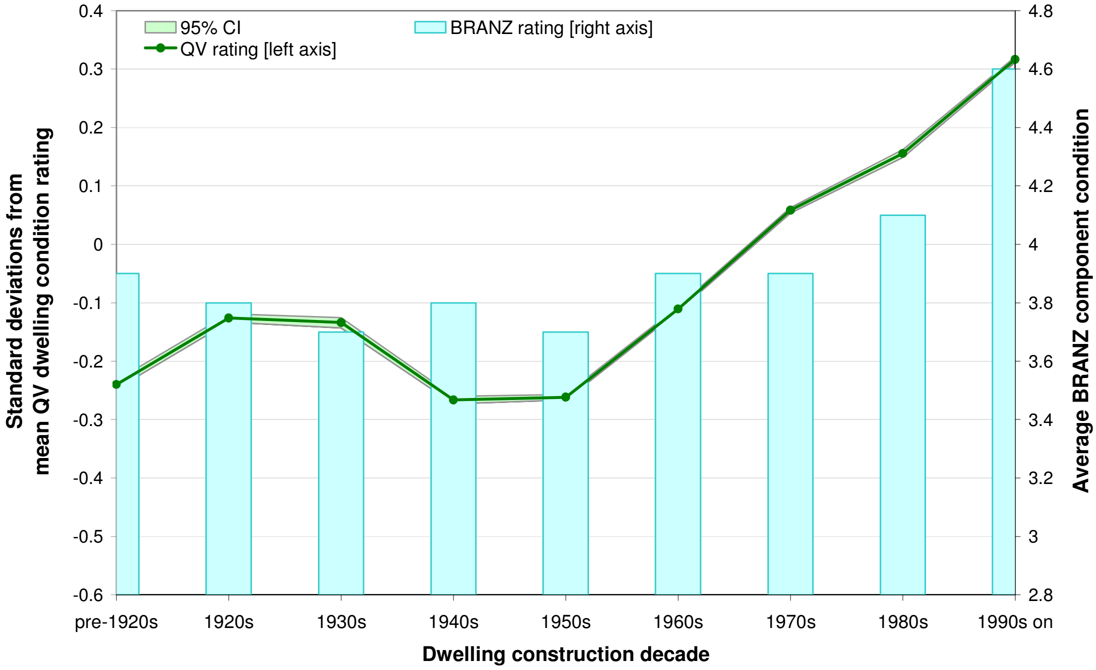

Figure 6.14 Standard deviations from mean QV dwelling condition rating, (QV data) and average BRANZ component condition (BRANZ data[68]), by dwelling construction decade.

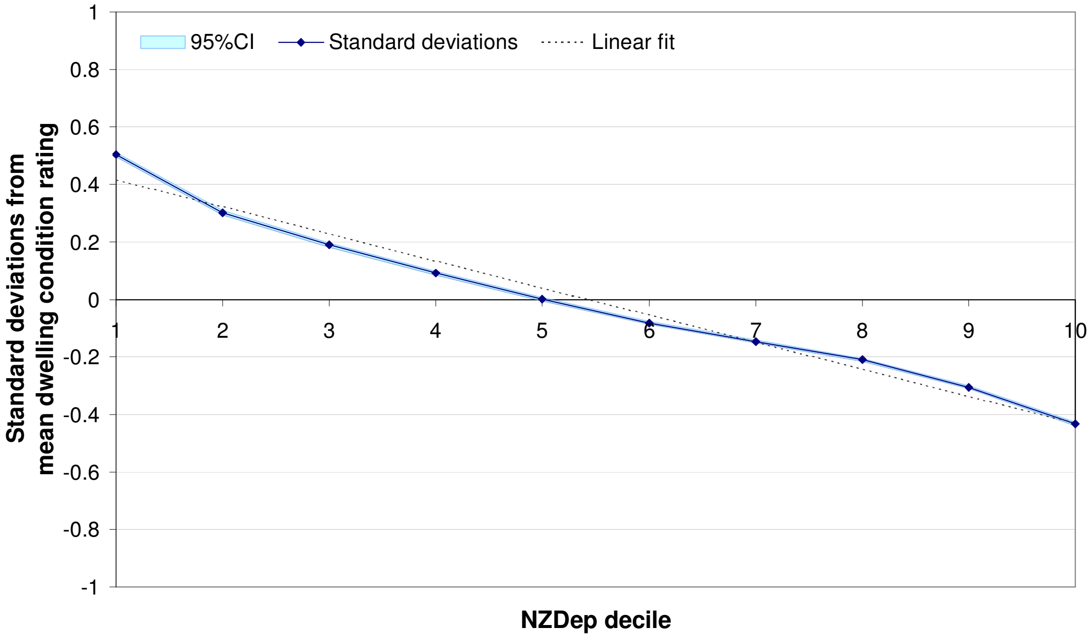

Figure 6.15 Standard deviations from mean dwelling condition rating by NZDep decile, weighted by number of dwellings. (QV data)

It could be assumed from the BRANZ 2005 report that their survey data did not support this assessment. Using the same method of assessing mean dwelling condition (where "Superior" (QV) or "Good" (BRANZ) is counted as 1, "Average" (QV) or "Moderate" (BRANZ) is counted as 0, and "Poor" (both) is counted as -1), the BRANZ mean dwelling condition was highest in the Wellington area (0.45), and equal in Auckland and Christchurch (0.32), while the dwelling-weighted median annual average minimum temperatures for each centre were 5, 6, and 2 degrees Celsius respectively. However, it is the distribution of dwellings *across* New Zealand that gives the curve in Figure 6.13 its shape. The relationship between mean QV dwelling conditions across the same sets of territorial authorities was similar to those of BRANZ, with Wellington having the highest mean dwelling condition (0.12, which was 0.175 standard deviations from the mean), while Auckland (0.06, 0.014 standard deviations) and Christchurch (0.05, 0.002 standard deviations) were much closer to the overall mean.

6.3.2.5 Condition by dwelling age

Overall, the House Condition Survey shows pre-1920s dwellings to be in slightly better condition than those between the 1920s and 1950s. In subsequent decades condition improves with decreasing age, with the newest dwellings being of highest quality. QV condition distribution by age loosely matches BRANZ results (Figure 6.14) if, as BRANZ has done, pre-1920s houses are aggregated into a single category. The main difference is in pre-1920s dwellings, which are of poorer condition relative to other building eras in QV data than in BRANZ data.

6.3.2.6 Condition by household characteristics.

The House Condition Survey found that the best standard houses were more likely to be inhabited by families with higher incomes, but incomes were more evenly distributed among the worst condition houses.

QV/NZHIS data do not include household income information, but the association

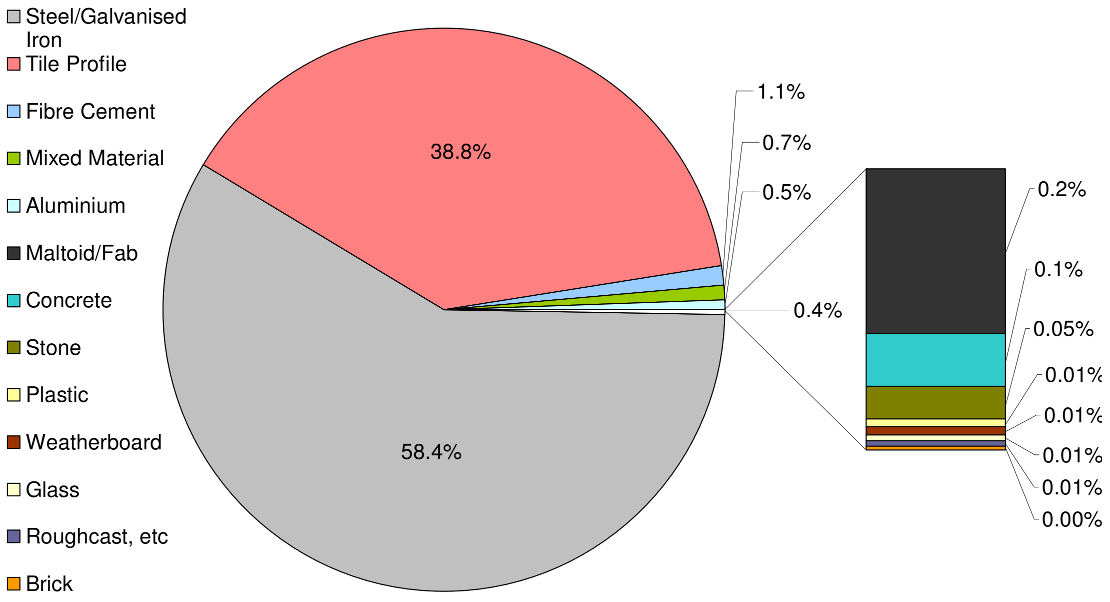

Figure 6.16 **Roof construction materials of New Zealand houses, by percentage of residents in matched dwellings (Matched QV/NHI data).**

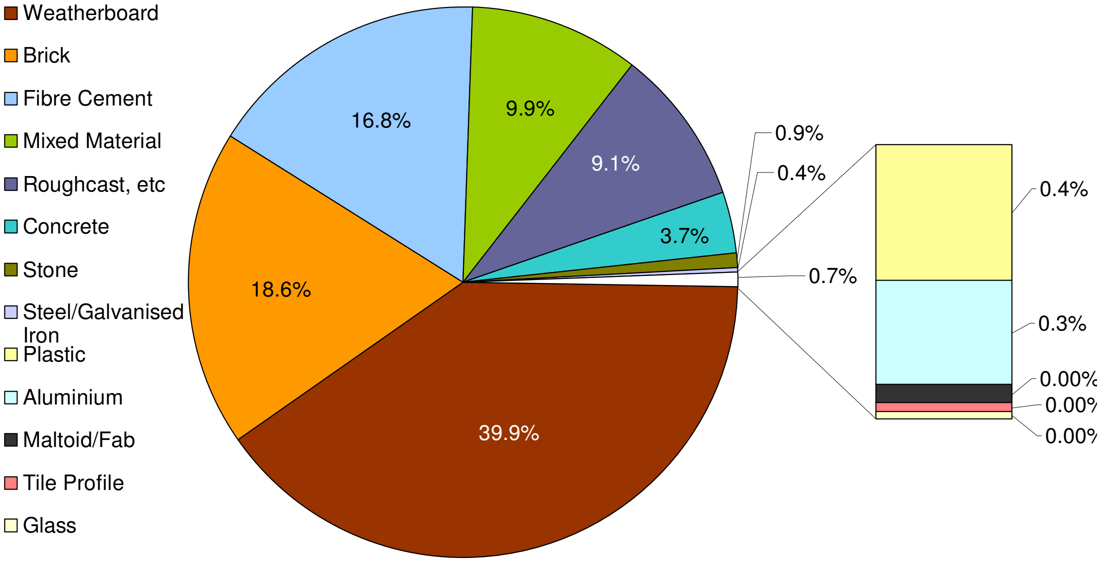

Figure 6.17 **Wall construction materials of New Zealand houses, by percentage of residents in matched dwellings (Matched QV/NHI data).**

between the NZDep decile of the dwelling's census meshblock, and the dwelling's condition, is illustrated in Figure 6.15. It shows a more directly linear relationship between higher meshblock deprivation score and poorer dwelling condition than does the BRANZ survey; a linear regression provides a coefficient of -0.0942 (95% CI -0.0942 - -0.0941, p=0.000) with a constant of 0.5102 (95% CI 0.5100-0.5102, p=0.000) and an R2 value of 0.9778.

6.3.2.7 Dwelling cladding materials

New Zealand houses most commonly have weatherboard walls, painted corrugated roofs, and timber windows (Figure 6.16, Figure 6.17). These 'traditional' materials were generally in worse condition. Other houses predominantly feature masonry veneer, masonry tiles, and aluminium windows; and their condition was generally better.

6.3.3 Beacon's House Typologies

In 2008, Beacon Pathway Limited released a report on "New Zealand House Typologies to Inform Energy Retrofits"[90]. The main difficulty with using the information provided in Beacon's House Typology report[90] is that it is based on expert opinion rather than any housing stock survey. The previous literature review has highlighted some discrepancies between what some experts believe about New Zealand housing, and what the data show, highlighting the risk in relying on experts' opinion alone. For example, the report which formulated Beacon typologies stated that "since the 1980s it is thought most [QV House Types] are listed as Contemporary"[91], which QV data do not support (only 3.6% of matched 1980s+ houses are listed as Contemporary). Statements in the report regarding ventilation and heating, which might otherwise be useful to this study, include no indication of the source of that information, which might be used to judge its reliability.

A comparison between the house types identified by Beacon, and those used in this report (and their overlaps) is provided in Figure 6.18.

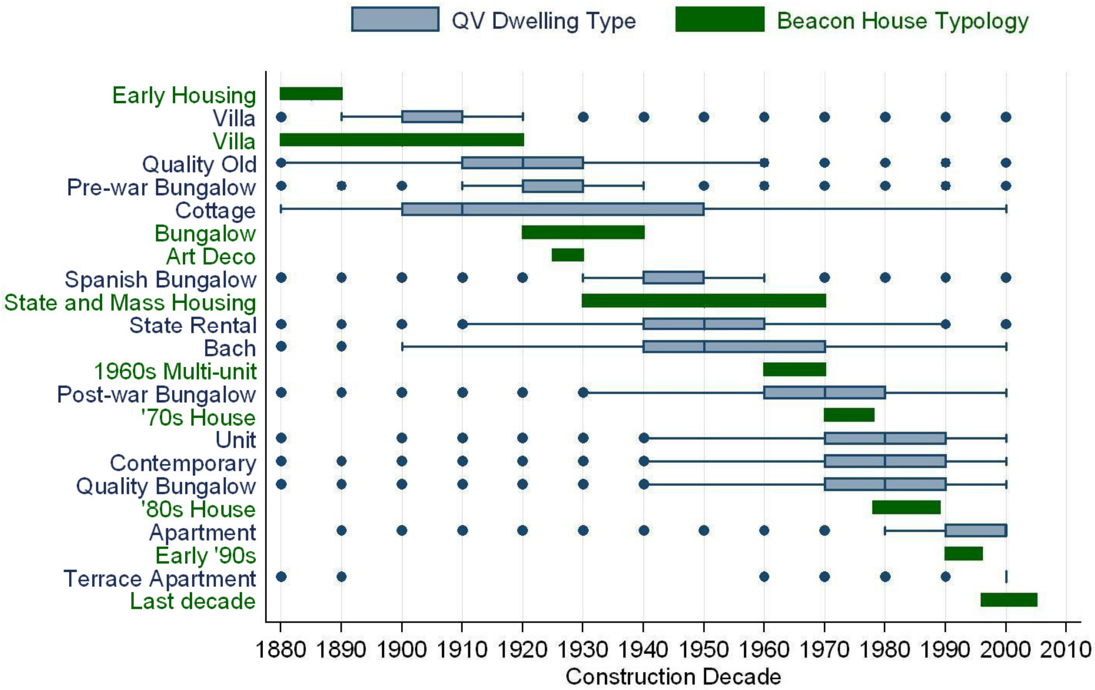

Figure 6.18 **Comparison of construction decade distribution of Beacon House Typologies and QV Dwelling Types.**

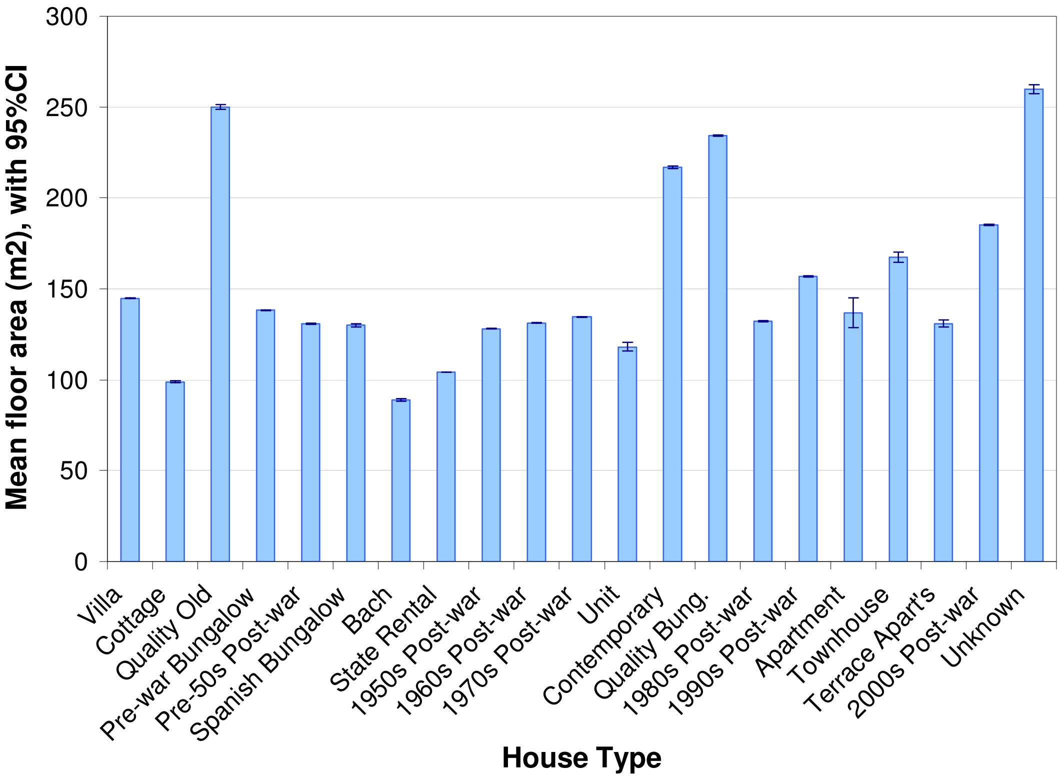

Figure 6.19 **Mean floor area for NZ dwellings, by dwelling type (QV data).**

6.4 DWELLING TYPES

Different dwelling types have different features. These features include: external ornamentation, which is less relevant to this study; layout; construction materials; ceiling heights; and floor area. The next section of this chapter provides a description of each QV dwelling type, with a particular focus on factors which may impact on the occupants' experiences of the seasons. However, the descriptions should not be understood as prescriptive; individual houses may include aspects of other types. In some cases it may have been difficult for QV valuers to ascribe a dwelling type; "transitional" villas, for example, which incorporate aspect of both Villas and Pre-war Bungalows, could be difficult to categorize.

Dwelling types are described in order of mean decade of construction, from oldest to newest. Descriptions for some dwelling types are more complete than others, according to available information. It was not possible, for example, to comment on heating and ventilation for all types, but these have been included where possible.

6.4.1 Villas

QV description: "generally built 1900 - 1920s - door faces street, weatherboard, high stud, can be one or two storey, iron roof with four sides and single point, eaves, brackets, finial, fretwork common."

The Villa style became popular at the turn of the 19th Century. They are generally a New Zealand interpretation of "broadly American-based styles"[85], and were overwhelmingly built of wood, with corrugated iron roofs. The focus of most literature on Villas is the great variety of ornamental features, but these are not fundamental to the structure of the dwelling, so it would not be relevant to describe them here.

6.4.1.1 Construction

Salmond describes Villas as "a timber skeleton propped up on piles and covered with boards, and its roof covered with slates, tiles or iron. It's openings were … factory-made standard windows and doors." He notes that the piles "were the weak spot in these otherwise well-built houses, because in time they invariably settled into the ground". This tendency to sink will have contributed to the prevalence of poor sub-floor ventilation.

Interior lining was originally boards, sometimes finished with lime plaster, or tongued and grooved boards, though few examples of original lining remain.

The few masonry buildings of this type succumbed to rising damp unless a damp proof course was installed.

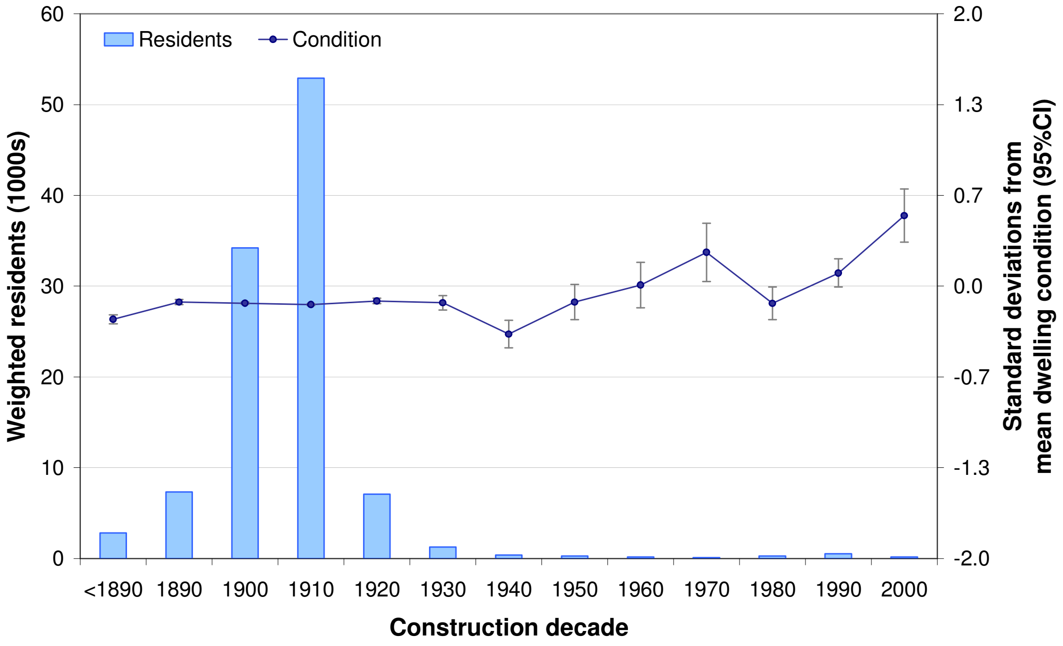

Figure 6.20 **Number of Villa residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Villa construction (Matched QV/NHI data).**

6.4.1.2 *Heating and ventilation.*

The most notable difference between Villas and subsequent housing types is their higher ceilings, generally 3 - 3.5 metres, which in theory makes them more difficult to heat than lower-ceilinged dwellings.

The kitchen's main source of heating was a cast-iron cooking range; open fireplaces provided heating in the parlour and dining room (if there was one). North Island villas sometimes had a fireplace in the main bedroom; in the South Island most bedrooms had one.[85] Toomath notes that

> "the brick chimneys were normally "internal" in the plan, with the fireplaces back-to-back in the cross partitions to retain maximum heat

within the building. Given the lack of insulation in the walls and iron roof, in typical New Zealand manner the closed cellular plan enabled one or two rooms to be heated economically while the rest of the house froze."

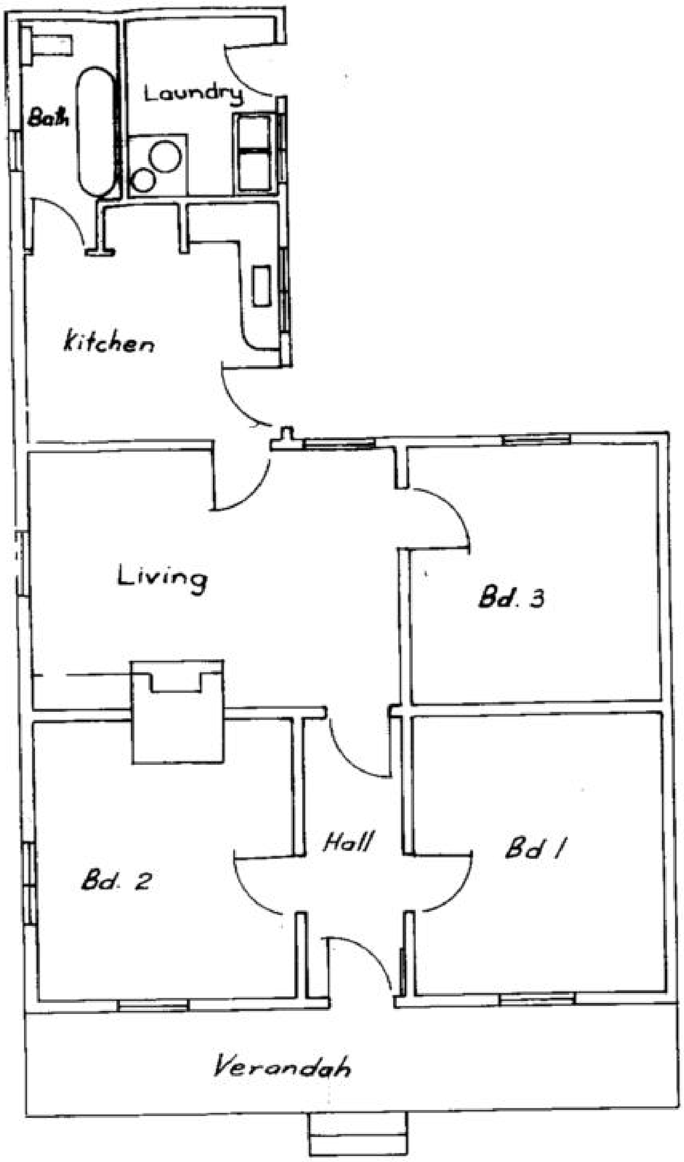

Figure 6.21 Layout of a 1905 villa, as drafted in 1961.[*]

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[*] The 1905 original would likely have had Bedroom 2 (Bd.2) designated a "Parlour"; and the door from the kitchen to the bathroom is also likely to be a post-1905 addition. In relation to my earlier point about changes in dwelling layout, the current layout of this dwelling is quite different to this illustration: two smaller bedrooms have been added at the front, extending past where the verandah once was; the bathroom and laundry are now at the side of the house in part of the old Bd.1; the kitchen is in part of Bd.1 and Bd.3; and a verandah and French doors have been added at the back.

Villas were generally built to a basic plan (Figure 6.21): two rooms with a central corridor wide, and two to three rooms deep, with a lean-to kitchen and washroom at the back. They often featured front verandahs.

Toomath, arguing that the Villa and Cottage styles derived from a cottage plan developed in the Virginia and the Carolinas, noted that this plan type "was regarded in later 19th-century America … as … suited to a hot climate because of its corridor, which enabled easy cross-ventilation of rooms through the whole house." Unfortunately, New Zealand's climate is not as warm as these US former British colonies, and summer cross-ventilation easily becomes winter draughtiness. This draughtiness may be added to by their tendency to have gaps in window joinery and, particularly in earlier versions, holes and cracks in floorboards.[90]

It is unclear to what extent the original features of villas are extant in surviving dwellings: chimneys may have been removed, and solid fuel cooking ranges may no longer be in use. On the other hand, sarking wall lining may have been replaced by plasterboard or other more thermal lining; and if the living area has had French or sliding doors, more passive solar heating may be available.

6.4.2 Cottages

QV description: "generally built 1890-1900, door facing street, gable roof, veranda along front, single storey, weather clad, iron roof with two sloping slides."

Cottages were an earlier proto-type for Villas, but are included later in the time-line because their style has a wider age-spread than Villas (see Figure 6.22) and they have continued to be built since their initial period of popularity.

The main differences between the two styles are that Cottages have a broader age distribution; were generally smaller (averaging 99m^2 rather than 145m^2); and always single story (where Villas are sometimes two-storied), with a gabled (two sloping sides) rather than hipped (four sloping sides) roof. From a heating standpoint, they may be easier to heat than Villas, because they are smaller, but otherwise they share the same characteristics.

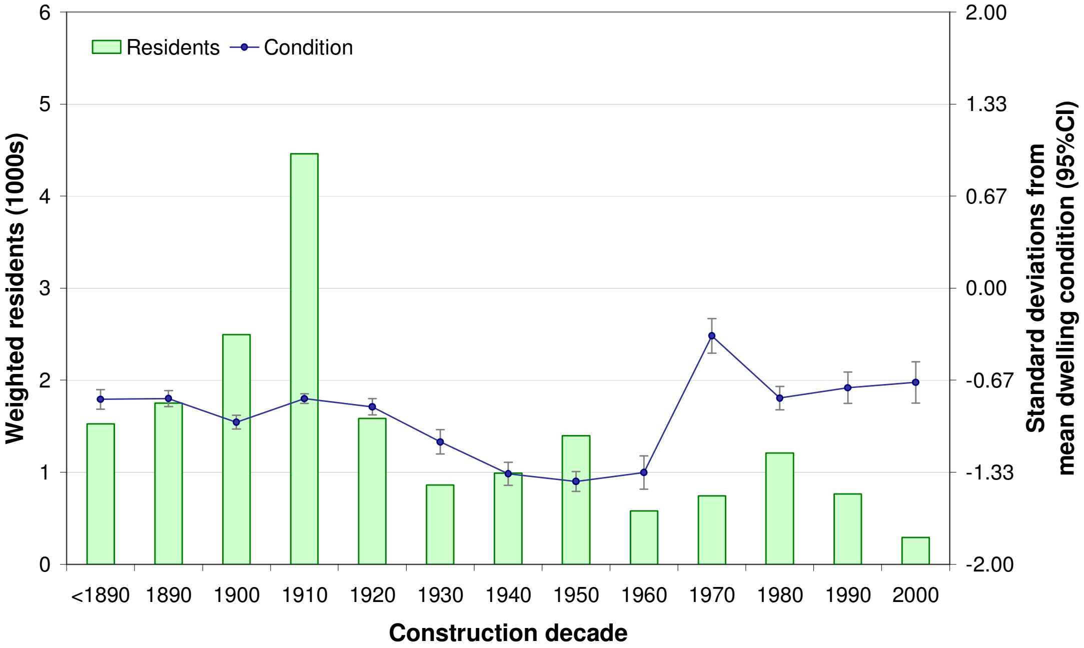

Figure 6.22 Number of cottage residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of cottage construction (Matched QV/NHI data).

Figure 6.23 1900s Cottage, Aro Valley, Wellington.

Figure 6.24 **1930s Quality Old dwelling, Mt Eden, Auckland.**

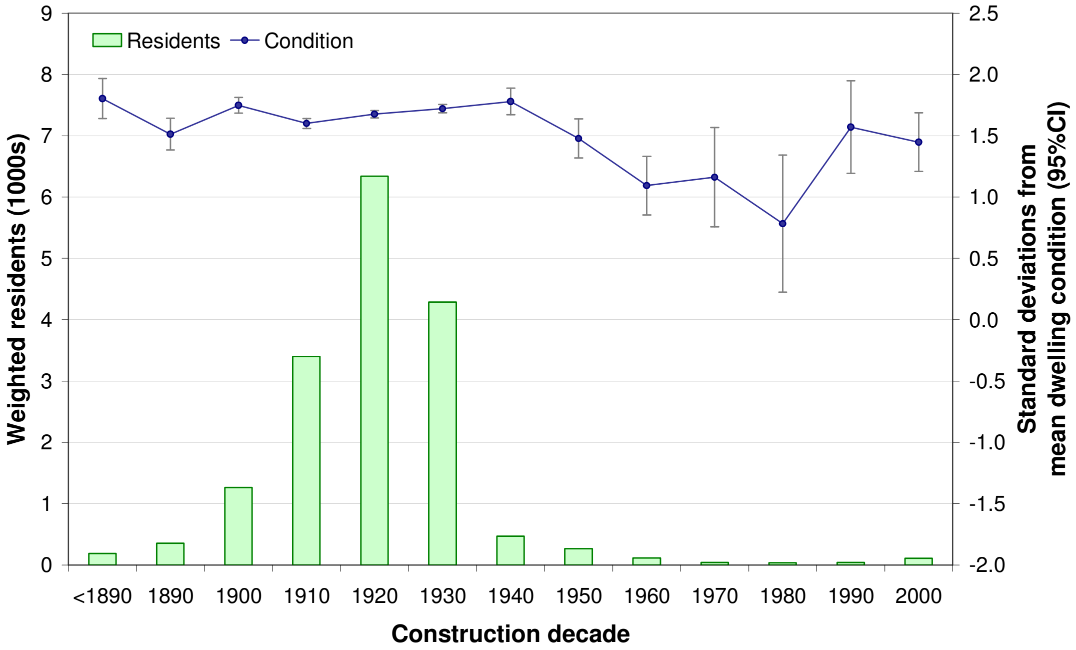

Figure 6.25 **Number of Quality Old dwelling residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Quality Old dwelling construction (Matched QV/NHI data).**

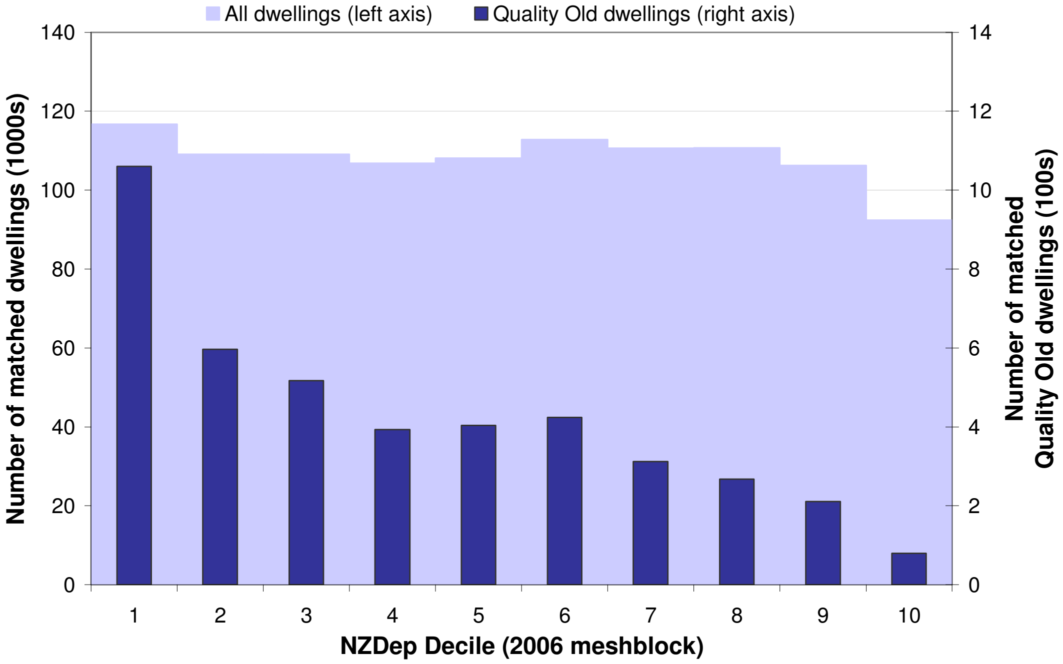

Figure 6.26 Distribution of Quality Old dwellings by NZDep decile, compared with distribution of all dwellings (Matched QV/NHI data).

6.4.3 Quality Old

QV Description: "generally built 1920-1940s - Tudor and Georgian influences, English styles, large and grand, good quality materials, fixtures and fittings, usually 2 storey, weatherboards, stucco, brick and shingles, often in combination. Timber joinery. Sometimes referred to as `Arts and Crafts'."

Quality Old dwellings are also referred to in architectural parlance as "Arts and Crafts", "English-style", or "English Cottage Style", or a sub-set "Swiss Cottage". The `cottage' label may make them sound small, but they are generally grander dwellings, with a large floor area (mean 250m^2), having originally been built for the affluent. Otherwise, in materials and planning, they are much like a two-storied version of a pre-war Bungalow[83], though perhaps built with better quality materials and craftsmanship.

Quality Old dwellings are the only pre-war dwelling category to show a greater prevalence with lesser deprivation; 25% of this style of dwelling are sited in NZDep decile 1 areas (Figure 6.26).

6.4.4 Pre-war Bungalow

QV Description: "generally built 1920-1940s - House faces street - greater utility and less ostentatious, narrow weatherboard, iron roof, lower stud and gable, bay and boxed windows, verandas part of main roof. Timber joinery inside. Timber shingles."

Bungalows overtook Villas as the predominant housing type in the 1920s, when they reached the height of their popularity (Figure 6.27). Though not mentioned in the QV description, exterior cladding often includes stucco or plastered areas.

6.4.4.1 *Heating and ventilation*

As noted by QV, Bungalows have a lower ceiling height than villas, making them easier to heat. Living rooms were more likely to face the sun, but had less window area and deeper eaves, so total sunlight penetration may not be much improved. Bungalow windows were predominantly side-hinged casements, with fanlights above for ventilation[85], and there was usually a ventilation panel in the roof space of the main gable. Fireplaces were generally on an outer wall, rather than internal, meaning (where these fireplaces are still in use) that more heat is lost to the outside.

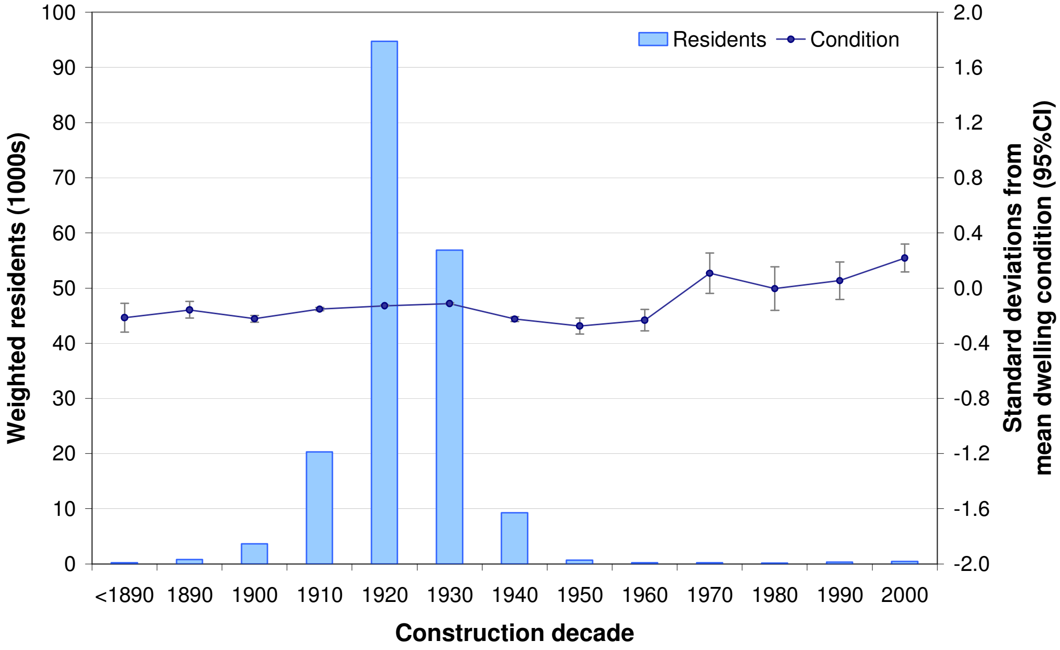

Figure 6.27 **Number of pre-war bungalow residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of pre-war bungalow construction (Matched QV/NHI data).**

The floor plan is less formal than the villa, but usually still includes a hall or passageway; open planning, found in the American Bungalows from which the New Zealand models derived, was not widely adopted. Salmond notes that "the climate was not cold enough to justify central heating, nor was it so warm that the entire house could be heated from the living room fireplace."[83]

Ryan et al. assert that open fires are likely to have been converted to inset wood burners or (in urban areas) unflued wall gas heaters.[90] However, the extent of such changes is unmeasured.

Otherwise, Pre-war Bungalow construction and basic materials are much the same as Villas, though original piles are more likely to be glazed or concrete than timber, and some houses include concrete foundation walls, potentially reducing the incidence of sinking and sub-floor ventilation issues.

6.4.5 Spanish Bungalow

QV description: generally built 1930-1950 - Art Deco and Spanish styles, predominantly 30s and 40s built, horizontal lines feature in design, often curved walls, low pitched roofs, always stucco clad, and parapets around roof line.

The "Spanish Bungalow" type as categorized by QV includes two related housing styles: the "Spanish Mission" style; and "Moderne" or "Deco" style houses. While Toomath and Salmond both describe this style as ceasing construction in the 1940s, QV data would suggest that the style continued into the 1950s (Figure 6.28).

Layouts were much the same as the concurrent Pre-war Bungalows. The primary differences between Spanish and other Pre-war Bungalows, apart from a slightly newer average age, are in cladding and roofline. The majority of Spanish Bungalows are clad in stucco (Figure 6.29) rather than the bungalow's weatherboard, or in a stucco effect achieved with plastered concrete or "Konka board" (a type of concrete sheeting).

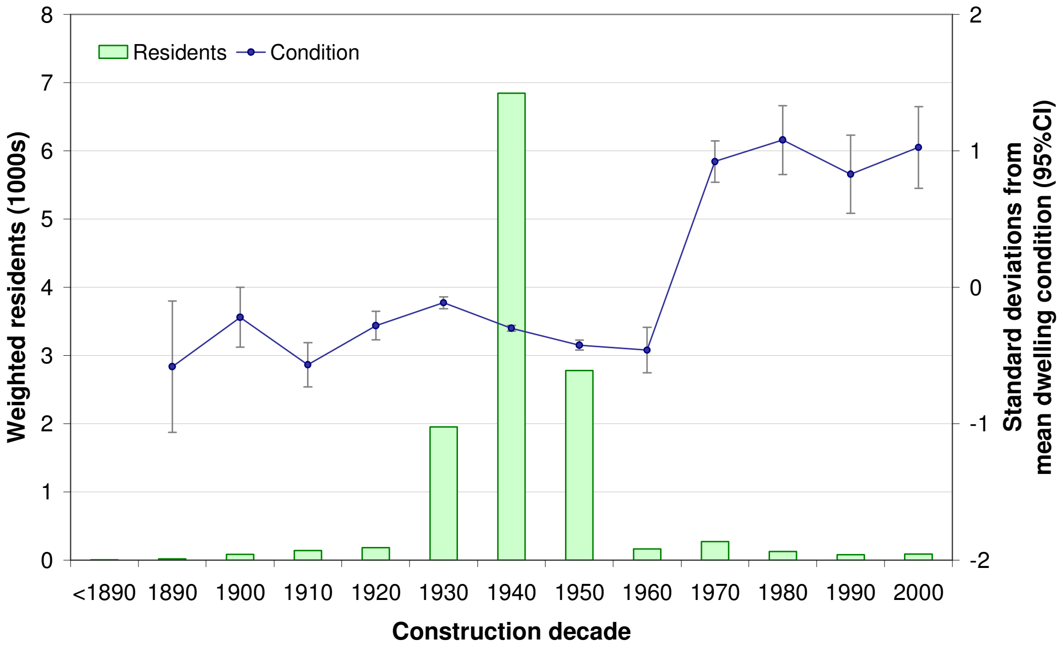

Figure 6.28 Number of Spanish bungalow residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Spanish bungalow construction (Matched QV/NHI data).

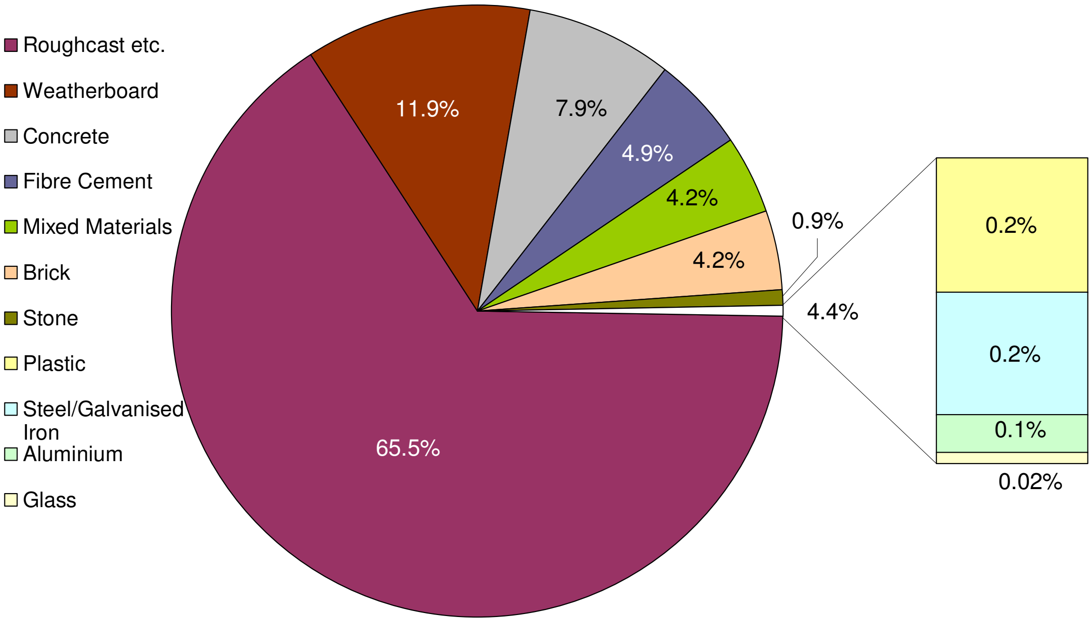

Figure 6.29 Spanish Bungalow wall materials, by percentage of residents (Matched QV/NHI data).


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Figure 6.30 1940s Spanish Bungalow, Hastings.

6.4.5.1 Heating and ventilation

Data or literature on heating and ventilation-related features of Spanish Bungalows are scant. One group of experts I spoke with asserted that their roughcast cladding is a poor insulator, their construction aesthetics put them at high risk of poor subfloor insulation, and their flat or near-flat roofs make them prone to leaks. At the same time, Ryan et al. describe them as generally having 500mm or greater under-floor clearance. There is no way of telling which is more accurate.

Roofs were ideally flat, but practicality sometimes saw low slopes built instead, hidden behind a parapet.

6.4.6 Bach

QV description: "any age - basic design, materials, layout, often small floor size, two bedrooms, and open plan, frequently extended in different styles and materials. Also called a crib in Southland."

The diverse range of building materials used in Baches is shown in Figure 6.31. Given that they can be built of any material and in any decade, they are defined primarily by: their location, usually near a water body; their haphazardness and poor condition; and their size (at an average of 89m^2, they are the smallest housing type).

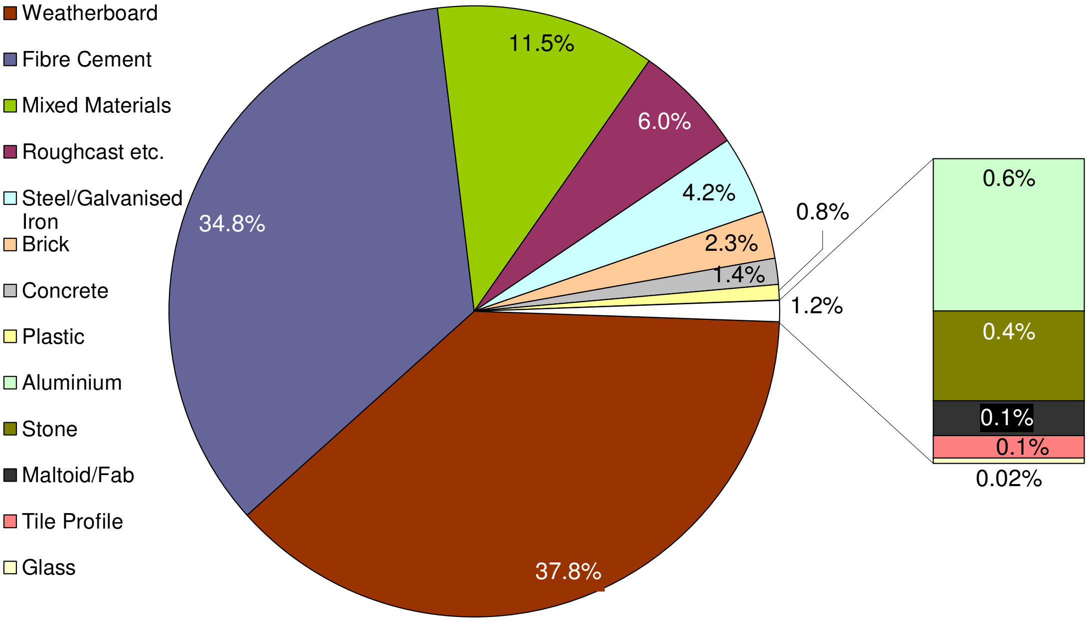

Figure 6.31 Bach wall materials, by percentage of residents (Matched QV/NHI data).

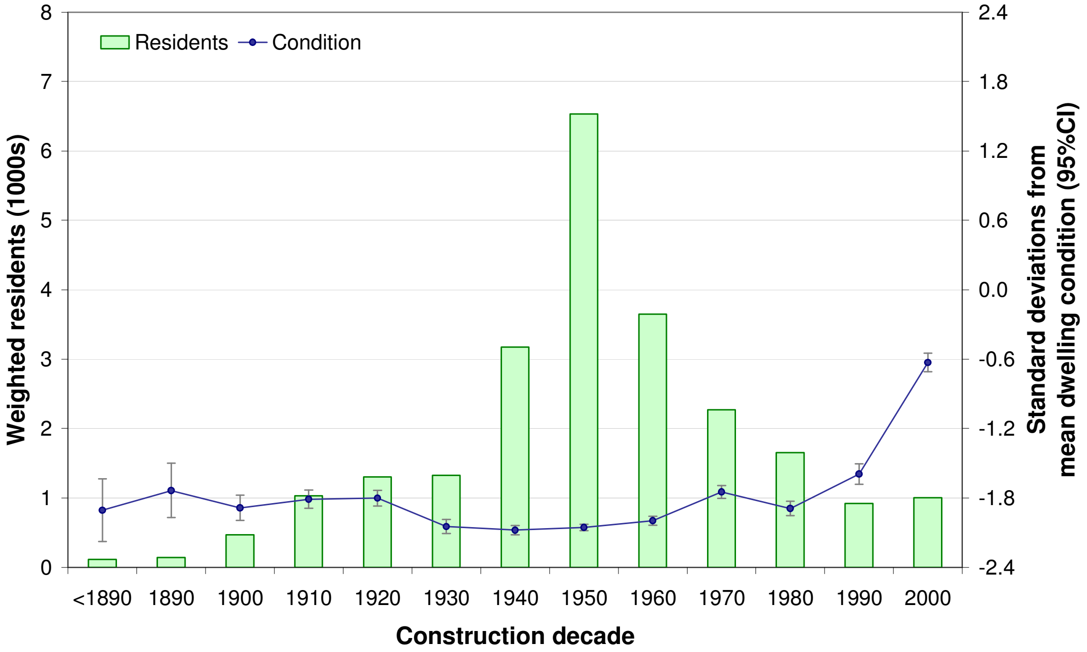

Figure 6.32 Number of Bach residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Bach construction (Matched QV/NHI data).

The most occupied Baches are those built in the 1950s (Figure 6.32). Unlike other dwelling types, the distribution of residents by construction decade may be less representative of the spread of actual numbers of dwellings. One would not expect Baches to be nominated as an NHI address, unless they are the primary residence, so there will likely be a large number of unoccupied Baches, which do not appear in this dataset because they were not matched with an NHI address. These uninhabited dwellings are unimportant to this study, but should be borne in mind by anyone consulting this chapter for other purposes.

Mitchell and Chaplin have identified three basic Bach types: the dunetopper, a lean-to style common in the 1950s, most commonly built of fibrolite; and the "lantern-jaw" and "buck-tooth" of the 1960s and '70s, where the main part of the dwelling sat above a concrete block garage/games room/extra sleeping space – the name reflecting whether the upper story sat forward or back from the top of the garage.[92]

6.4.6.1 *Heating and insulation*

Baches are primarily constructed as temporary residences. Their mean condition is the lowest of all dwelling types. While there are no data on the subject, one would expect them to be under-insulated, if insulated at all. On the other hand, their small size may make them easier to heat than larger dwellings.

6.4.7 State Rental

QV description: "generally built late 1930s onwards - purpose build by the government for social housing, often simple materials and basic design but constructed well, often multiunit, weatherboard cladding, clay or concrete tile roofs."

QV's description identifies ones of the main differences between State Rental and other dwellings; 75% of state rentals are tiled, more than double the rate of other dwellings. However, other differences between State Rentals and other post-war bungalows may vary by decade – Schrader reports Toomath's assessment that by the late 1940s, post-war bungalows had copied the state house style[93], meaning 1940s State Rentals are likely to be little different in construction from 1940s post-war bungalows.

Location of State Rental dwellings is strongly associated with higher deprivation areas (Figure 6.34).

6.4.7.1 *External features*

State Houses were primarily based on the English cottage[83 85 87 93], though where Shaw states that "the Californian Bungalow did not feature at all", Salmond views them as having "developed from the late bungalows of mixed American and English origins."

Roofs were of clay or concrete tiles, steep-pitched, mostly hipped but sometimes gabled, with small eaves.

Salmond and Shaw again differ in their description of wall materials, with Salmond arguing that "walls were brick veneer for permanence and low maintenance, or weatherboard for economy", while Shaw states that "[m]ost of the houses were clad in weatherboard, except in Dunedin where bricks were plentiful." QV data show 52% of State Rental dwellings to be clad in weatherboard and 15% in brick. Use of brick cladding increased with increasing latitude.

Shaw, Salmond, and Toomath's descriptions focus on the first tranche of state houses built in the late 1930s and through the 1940s. However, dwellings in the State Rentals category feature a larger number of post-1940s constructions (Figure 6.33), on which less literature is available. Schrader and Shaw note that this period introduced open plan living areas and more multi-unit dwellings. Multi-units cannot be separated from other dwellings in QV data, but may include many of the dwellings clad in fibre-cement, which after 1940 became more common on State houses than brick.

6.4.7.2 *Heating and ventilation*

Toomath describes the state house interior as featuring "small cellular rooms off a narrow hallway, and no verandahs or sitting porches – only minute recesses sheltering front and back doors."

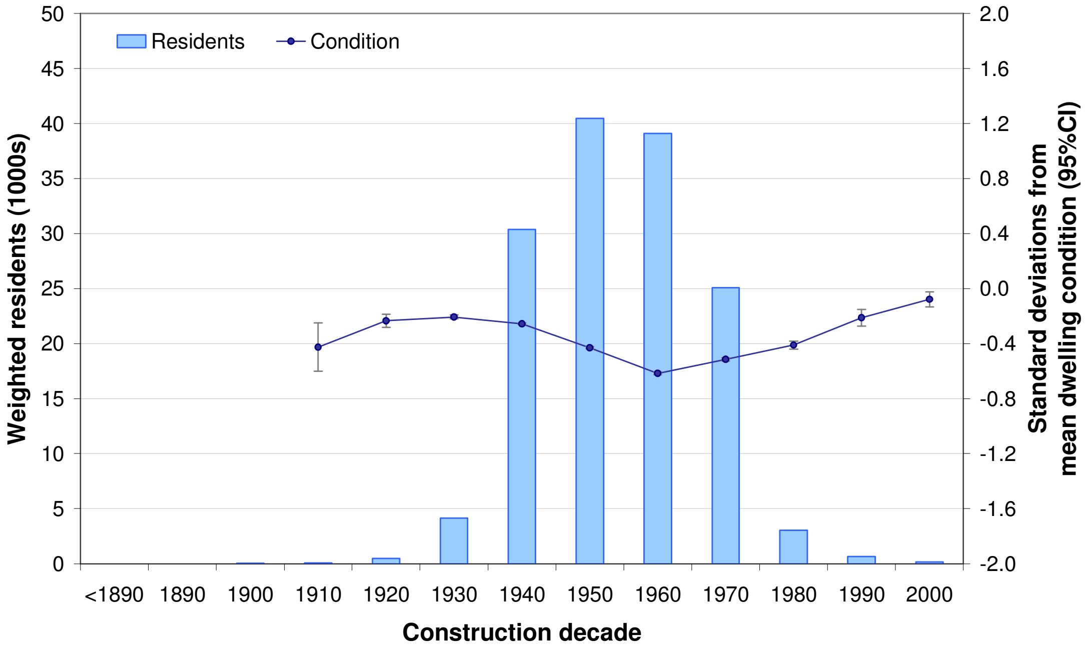

Figure 6.33 Number of State Rental residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of State Rental construction (Matched QV/NHI data).

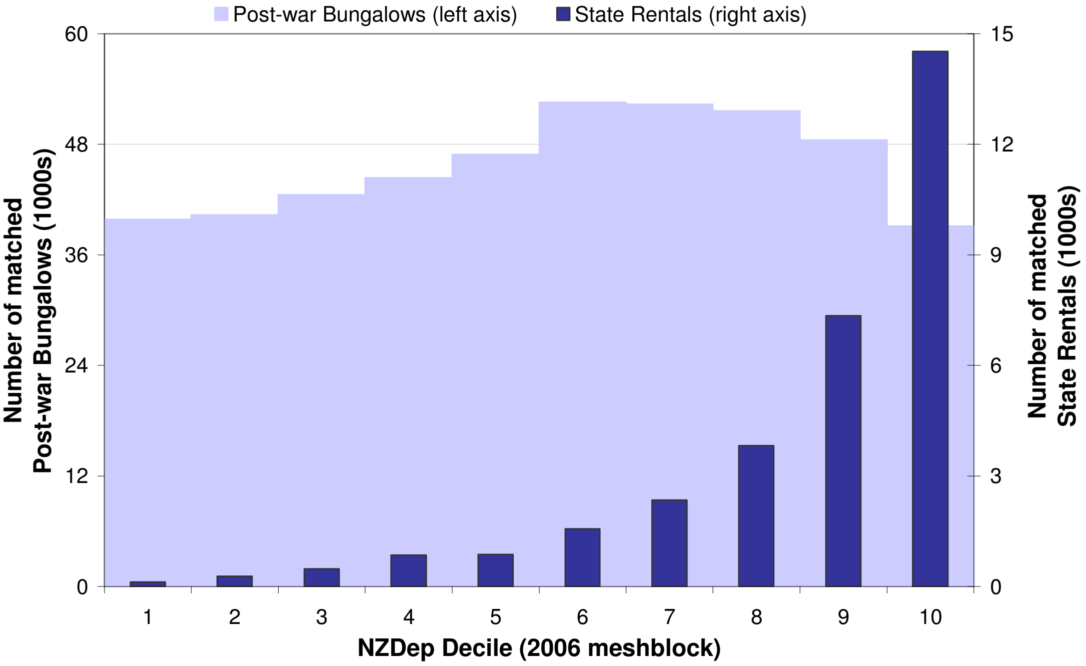

Figure 6.34 Distribution of State Rentals over NZDep deciles, compared with Post-war Bungalows (Matched QV/NHI data).

Window areas were small with high-sills, “more appropriate to the climate of England than New Zealand”[87] and no fanlights[83], reducing opportunities for ventilation.

Living areas were oriented towards the sun, with morning sun in the kitchen and afternoon sun in the living room. As the kitchen was no longer intended to be the centre of family life, the only fireplace was in the living room.[93]

Despite the new orientation, a 1940s thesis on Auckland State housing[94] found mildew and dampness to be common, which the author attributed to construction defects, and Schrader to both construction and the climate.

Schrader also reported a 1946 complaint that Central Otago state houses “were all built of wood, whereas brick would be more suitable for the extremes of heat and cold experienced”.

Schrader comments that Housing New Zealand is now facing the challenge of modernising its housing, quoting study participants whose housing suffers from chimney cracks; damp; and lack of insulation.

6.4.8 Post-war Bungalow

QV Description: “generally built 1950s onwards - 'standard' dwelling using average quality materials and design. Can have gable, Dutch gable or Hip roof lines. Often located for sunshine, not necessarily facing the street. Normally single storey, but sometime appears a dual storey if built over garage on sloping sections.”

Post-war bungalows are by far the most common housing type, accounting for 66% residents matched dwellings and their dwellings. Mean condition is average, with a slight improvement with decreasing age from the 1950s on (Figure 6.35).

Unfortunately, it is at the Post-war Bungalow point in the housing timeline that lack of architectural description begins to tell. Shaw provides the most extensive description of post-war housing, but unfortunately his assessments may not be reliable. He writes of an overwhelming preponderance of brick- and-tile buildings in the 1950s, followed by a gradual return to timber construction in later decades, whereas QV data (Figure 6.36) demonstrate that of surviving occupied 1950s post-war bungalows, more than half have weatherboard cladding, while only 15% are brick. Data for all dwelling types would appear to indicate that brick cladding was no more common in the 1950s than in the two preceding decades. The slight increase in wood cladding in the 1960s reflects the mid-era reduction in roughcast dwellings. Subsequent decades have seen weatherboard cladding use reduce to only 9% in 2000s dwellings, while brick has enjoyed a resurgence, replacing the 1970s and 1980s popularity of fibre cement.

6.4.8.1 Exterior features

Overall, the shape of the most basic post-war bungalow would appear to have changed little over the decades. Compare, for example, a 1950s version (Figure 6.37) with a 1980s version (Figure 6.38).

The window frames have become aluminium; the wall cladding is fibre cement rather than weather-board, the roof is tile rather corrugated iron (though in either case they could as easily be the other way round) and the doorway details have changed a little, but otherwise the two buildings appear very similar.

Shaw notes that post-war housing included a new set of locally-produced kitset homes, including the timber-lined Lockwoods, and Neil houses, replacing the American prefabricated bungalows of earlier decades. "Neil Housing was [gradually] able to persuade its clients to accept lowered roof pitches, split levels, car ports, ranch-slider doors, [and] aluminium joinery".

By the 1980s, housing companies at "the middle and lower ends of the market, … promoted a wide variety of prefabricated homes, most of them favouring timber construction, aluminium joinery and corrugated-iron roofing". [87]

The 1990s saw housing developers aiming for a more affluent clientele, building

> "two-storeyed timber-framed homes with tiled roofs and walls of texture coated cement board sheeting in pastel shades… . Characterised by double height porticos whose columns are invariably

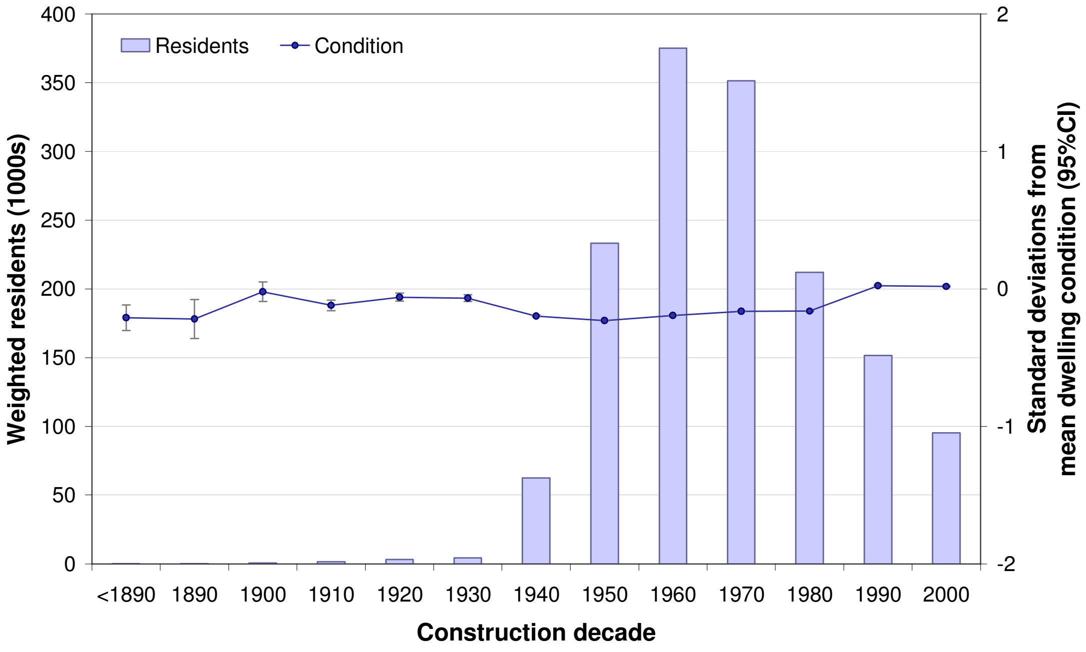

Figure 6.35 Number of Post-war Bungalow residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Post-war Bungalow construction (Matched QV/NHI data).

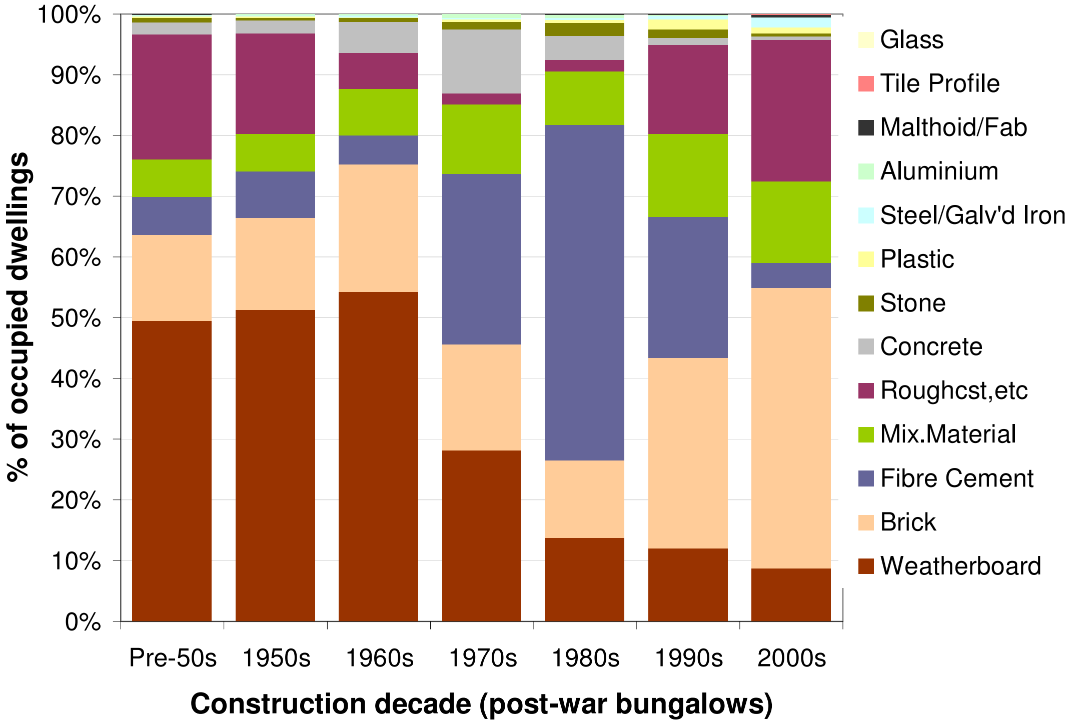

Figure 6.36 Post-war bungalow wall construction materials by decade of construction (QV data).

Figure 6.37 1950s post-war bungalow, New Plymouth

Figure 6.38 1980s post-war bungalow, Lower Hutt

> made of spray-textured plastic or concrete piping with polystyrene detailing … they are rapidly becoming the nineties equivalent of the ubiquitous brick and tile of the sixties.” [87]

6.4.8.2 Interior layout

Shaw’s description of interior layout states that “by the early 1960s … open-plan ideas had begun to influence the way the semi-public, dining/living/ kitchen areas were designed.”

Mitchell and Chaplin describe it as follows:

> “Anyone could recognise the standard plan of the New Zealand house. The front door [and]… back door … connect relatively directly, and on one side of that connection are the ‘living’ quarters of the house, … while on the other are the bedrooms. The kitchen, bathroom and laundry are grouped along one side wall near the back door.”

Shaw notes that the post-war period also coincided with a trend towards fully carpeted floors, gibraltar board wall linings, and plastered ceilings, but other than this neither his nor Mitchell and Chaplin’s works describe features relevant to the warmth or dryness of the dwellings.

The most important point to note about post-war Bungalows, however, is that they represent a definite shift in style and construction from their pre-war counterparts. Materials, orientation-to-sun, and construction all changed post-war, and given their respective contributions to the housing stock, the difference between post-war and pre-war dwellings is the most meaningful difference in dwelling types included in this study.

6.4.9 Unit

QV description: ”generally built 1950s onwards - attached and semi detached, 1-3 bedrooms, small <100m^2, basic design, open plan. Often cross leased.“

There is no literature on Units, possibly because there are not many of them. However, QV data show that they are most commonly built in the 1970s (Figure 6.39); their most common wall material is brick, though there is high diversity in wall materials; and roofing materials are neatly split between Steel/Galvanised Iron, and Tile, with only 5% of Unit roofs built of any other material (Figure 6.40).

Units are also of very uniform quality, with 95% of them listed as being in "Average" condition, compared with 84% of the total dwelling stock.

Although QV describes Units as "small <100m^2", their mean floor area in QV data is 109m^2 (by dwelling numbers) or 118m^2 (population weighted). Most of this difference will be the natural result of multi-person households having larger dwellings than single-person households. However, it is also possible that larger floor areas represent a larger building containing more than one Unit, though this is not how QV prefers to record its data.

6.4.10 Contemporary

QV description: "generally built 1970s onwards - modern, contemporary design, many roof breaks and pitches, high studs, grand entrance halls, often different angles walls, not uniform design. Often stucco, plaster walls. Building features are often associated with Weathertightness issues."

I found the Contemporary type the most difficult to associate with a particular style of building, though presumably it includes much of the work of architects Roger Walker and Ian Athfield, which Miles Warren [in Shaw] had described as a "collection of gables, half gables and slices". The style is most common in the Far North, North Shore City, Wellington and Queenstown, and much less so elsewhere. As there are a number of territorial authorities, most notably Auckland City, which have no matched dwellings classified as "Contemporary", the classification may not be uniformly applied.

Like Quality Bungalows, Contemporary dwellings are more common in less deprived areas. They are more likely to have steel roofs than other dwellings of a similar age, and less likely to be built of brick. They are in good condition, having the third highest mean condition rating after Quality Bungalows and Quality Old dwellings.

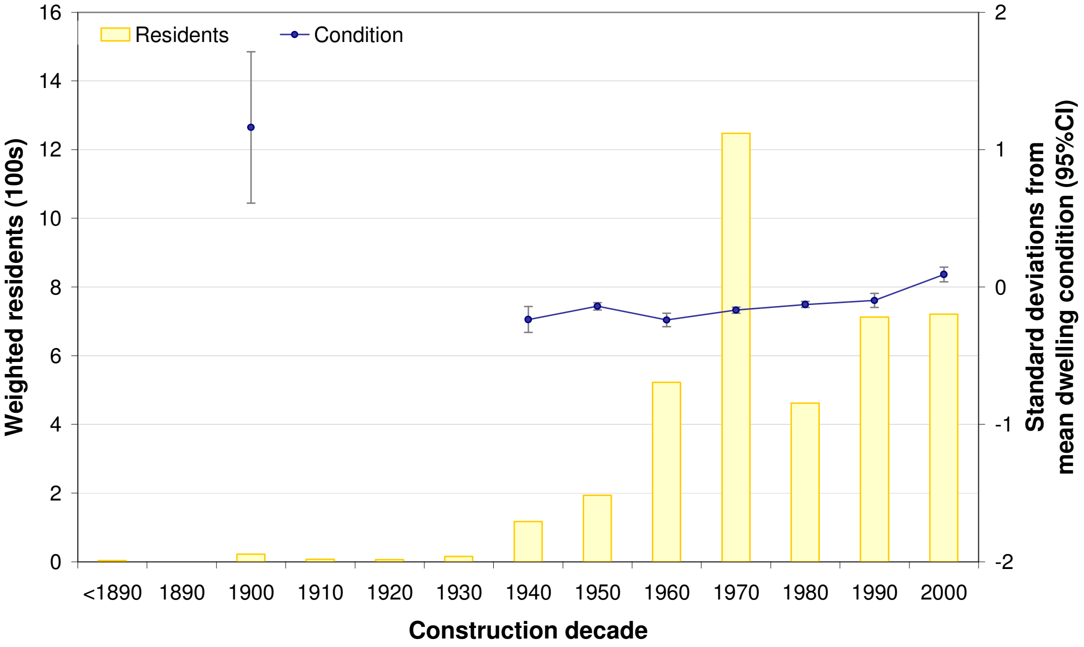

Figure 6.39 Number of Unit residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Unit construction (Matched QV/NHI data).

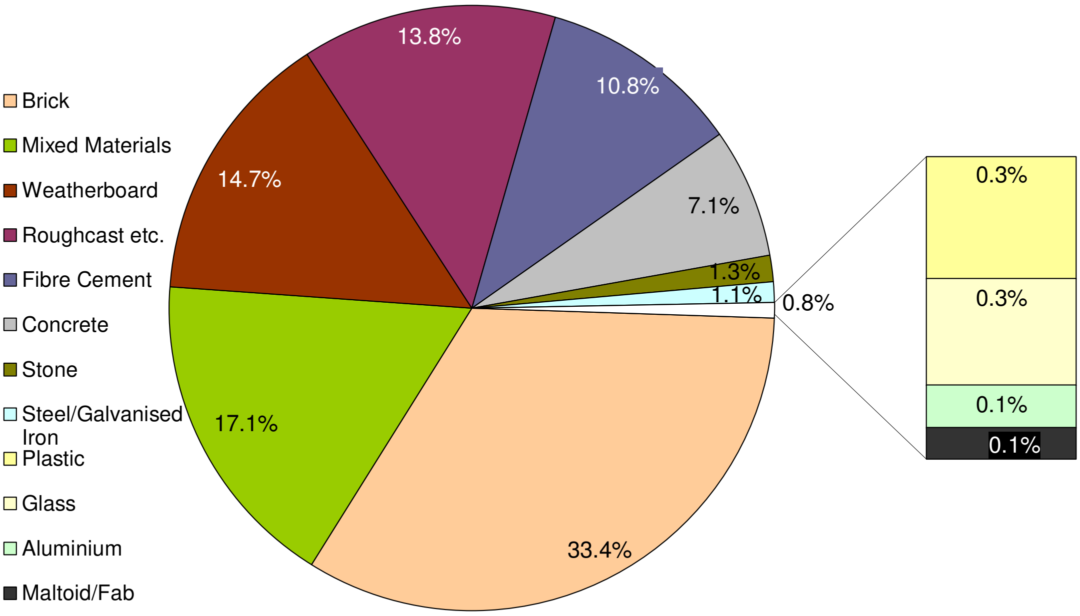

Figure 6.40 Wall materials of Units, by number of residents (Matched QV/NHI data).

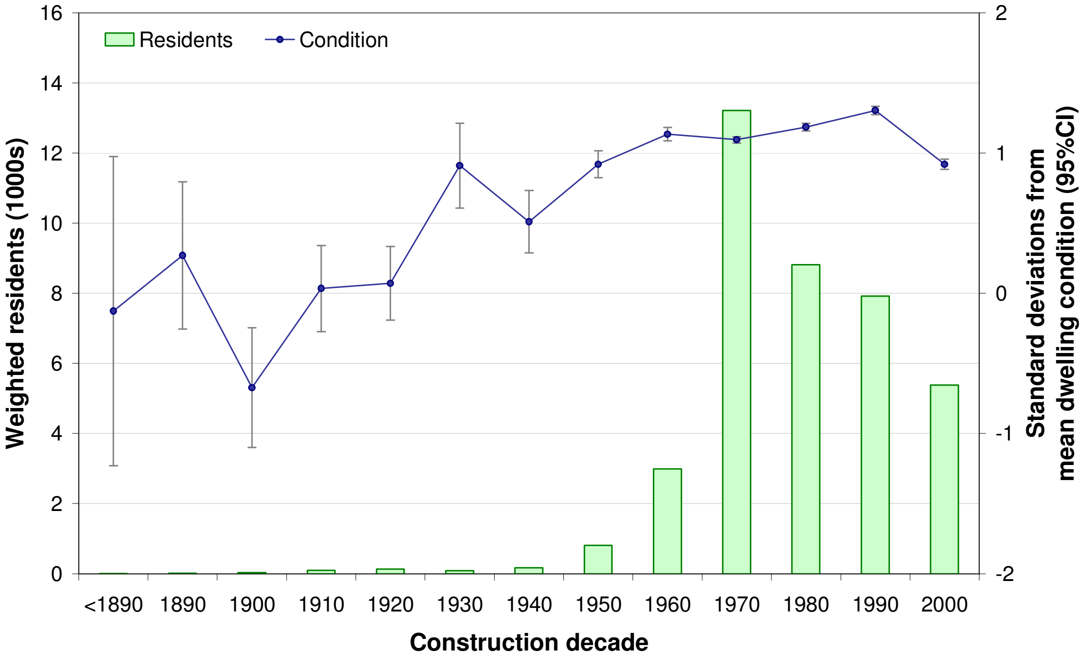

Figure 6.41 Number of Contemporary dwelling residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Contemporary dwelling construction (Matched QV/NHI data).

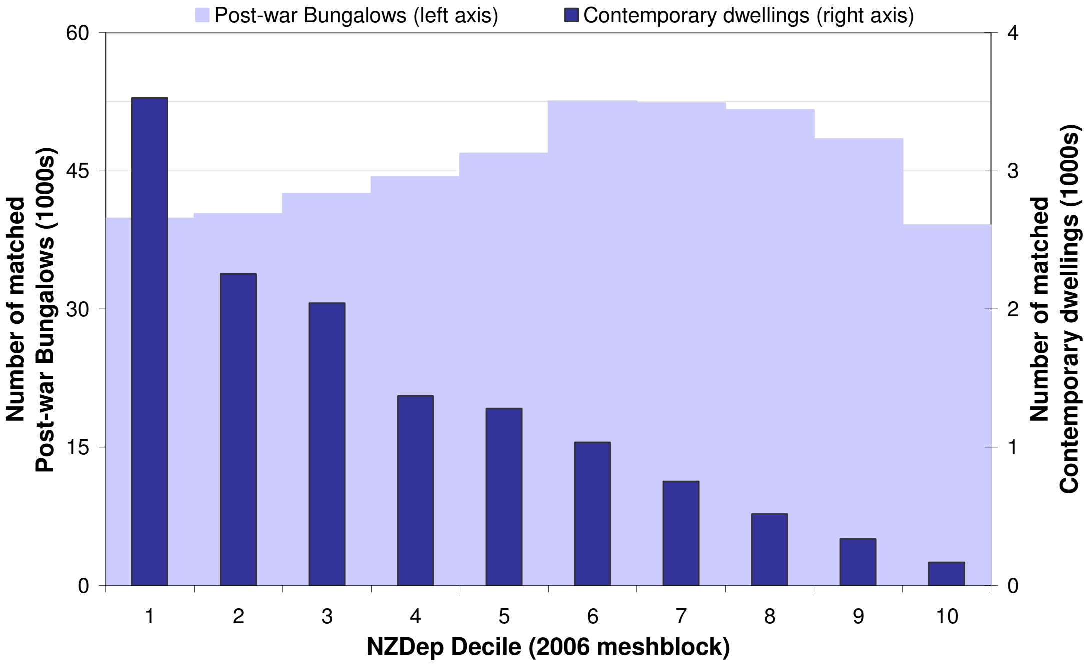

Figure 6.42 Distribution of Contemporary dwellings, by NZDep decile, with Post-war Bungalows as comparison (Matched QV/NHI data).

Figure 6.43 1990s Contemporary dwelling, Wadestown, Wellington.

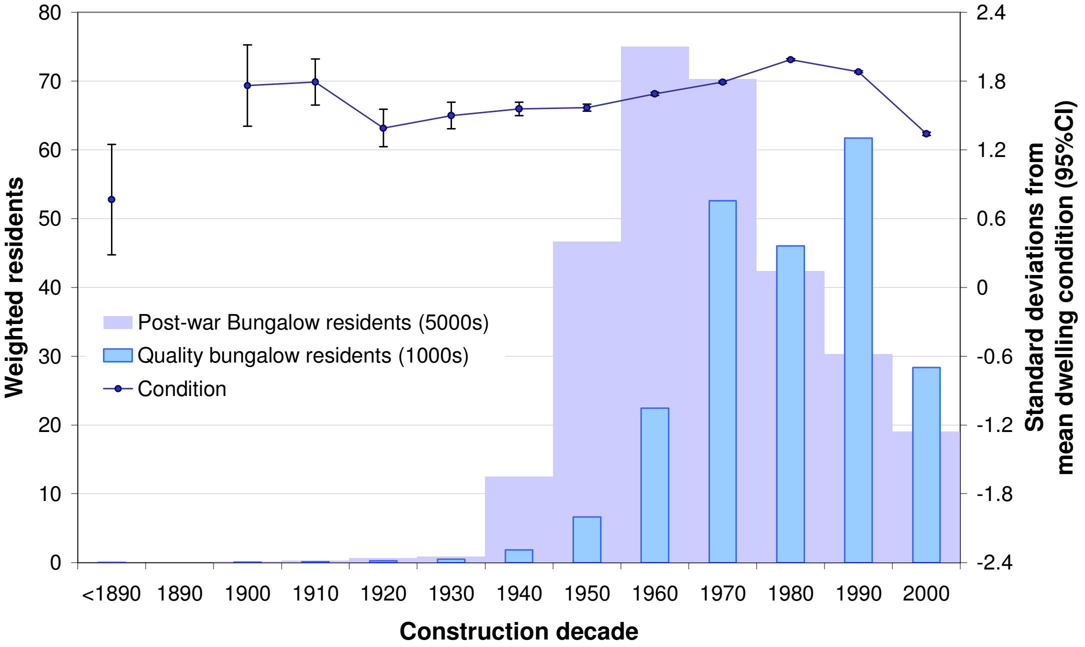

Figure 6.44 Number of Quality Bungalow residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of dwelling construction. Number of Post-war Bungalow residents also shown for comparison purposes (Matched QV/NHI data).

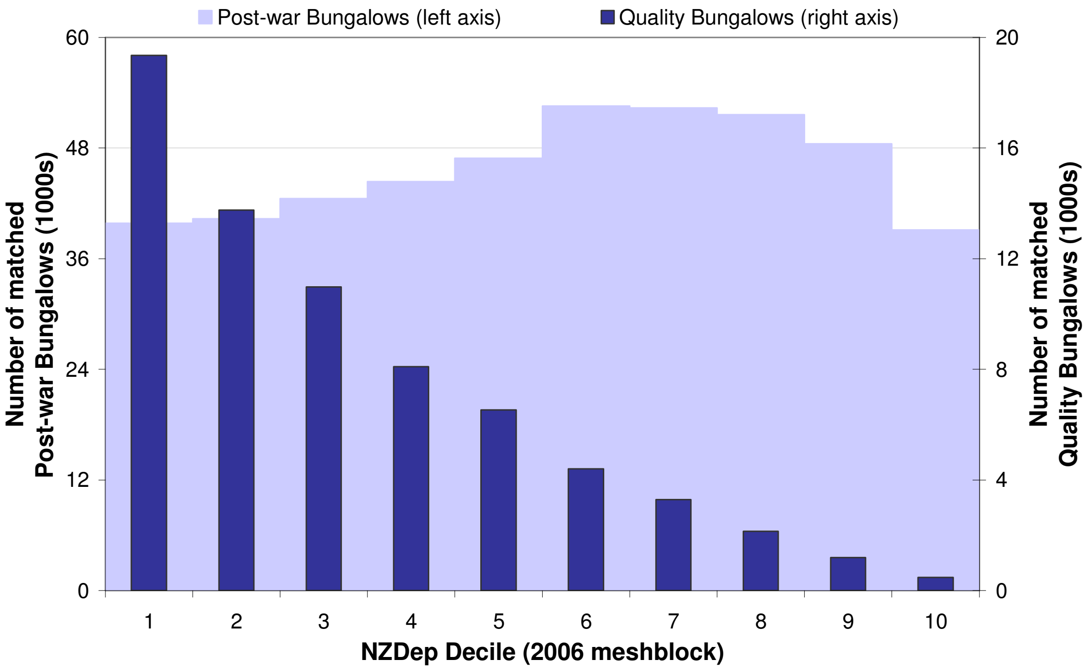

Figure 6.45 Distribution of Quality Bungalows over NZDep deciles, compared with Post-war Bungalows (Matched QV/NHI data).

Figure 6.46 1990s Quality Bungalow, Khandallah, Wellington.

6.4.11 Quality Bungalow

QV description: "generally built 1950s onwards - high quality materials, design, grand designs often with swimming pools, tennis courts etc, can often be two storeys, larger sections."

Architectural literature does not identify "Quality Bungalow" as a housing style, so QV data are the only source of differentiation.

Quality Bungalows are best described in comparison with Post-war Bungalows. As their names would suggest, quality is a good part of what distinguishes the two categories; Quality Bungalows are more likely to be clad in brick or mixed materials than weatherboard; more likely to be tiled than iron-roofed. They are newer, as shown in Figure 6.44; in better condition; and also bigger, with average floor areas 70% higher than Post-war Bungalows. Quality Bungalows have consistently higher capital values than Post-war Bungalows, even when floor and land areas are similar, so their size does not account for the value difference. Last, while Post-war Bungalows show a mid-range bulge in NZDep decile distribution, the number of Quality Bungalows increases with decreasing deprivation (Figure 6.45).

6.4.12 Apartment

QV description: "generally built 1920s onwards - common entrance way, purpose built from the 1960s onwards, multi-storey blocks often with several apartments per floor. 5+ apartments per block. Apartments are normally joined on 2 walls."

There is little information to be had on Apartments. As very few dwellings were matched (Figure 6.47)[*], with only 920 total residents (853 weighted by study person days) over 439 dwellings, it would be hazardous to venture any further assessment of them.

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[*] Apartments usually have two identifying numbers, one for the number of the street, and the other for the number within the complex. However, these numbers can be written in either order in an address, making it very difficult to match the address with any certainty. The likelihood that the matched Apartments are an under-count of dwellings is supported by a 22 October 2008 search of the Real Estate Institute of New Zealand listing site (www.realestate.co.nz), which returned 3951 records of apartments for sale.

6.4.13 Townhouse

QV description: "generally built 1970s onwards - high site coverage, low maintenance sections, better quality than a Unit, can be detached or semi reattached, often separated by a garage. Normally two storey. Stucco plaster wall coverings; can be prone to weather tightness issues. Often cross-leased."

Townhouses have been increasing in number in recent decades as a popular infill housing option, but are still a small proportion of the total housing stock. Mixed materials and stucco make up about 30% each of wall claddings. Dwelling condition is just above average.

6.4.14 Terrace Apartments

QV description: "generally built 1990s onwards - medium to high quality fixtures and fittings, often 2-3 levels, 3-5 units in the complex, party walls between the apartments. These are NOT necessarily `flats'. Often own entrance and garage with dwelling space above."

What QV label a "Terrace Apartment" is generally referred to in Real Estate-speak as a "Townhouse": however, they are different from QV's "Townhouses" in that they are not detached dwellings.

As with Apartments, there are relatively few dwellings classified under this category. It may be that QV has not been using the "Terrace Apartments" category for long, as a check on some obvious Wellington examples, such as the Greta Point development at Evans Bay, have not been classified as such (they are instead listed as Post-war Bungalows). Alternatively, they may have had the same matching issues as Apartments.

6.4.15 "Infill" dwellings

For the purposes of subsequent analysis, I have amalgamated the four least common (and least populous) housing types – Apartments, Terrace Apartments, Townhouses and Units – into the single category "Infill". The distribution of dwelling ages and condition in this combined category are shown in Figure 6.52.

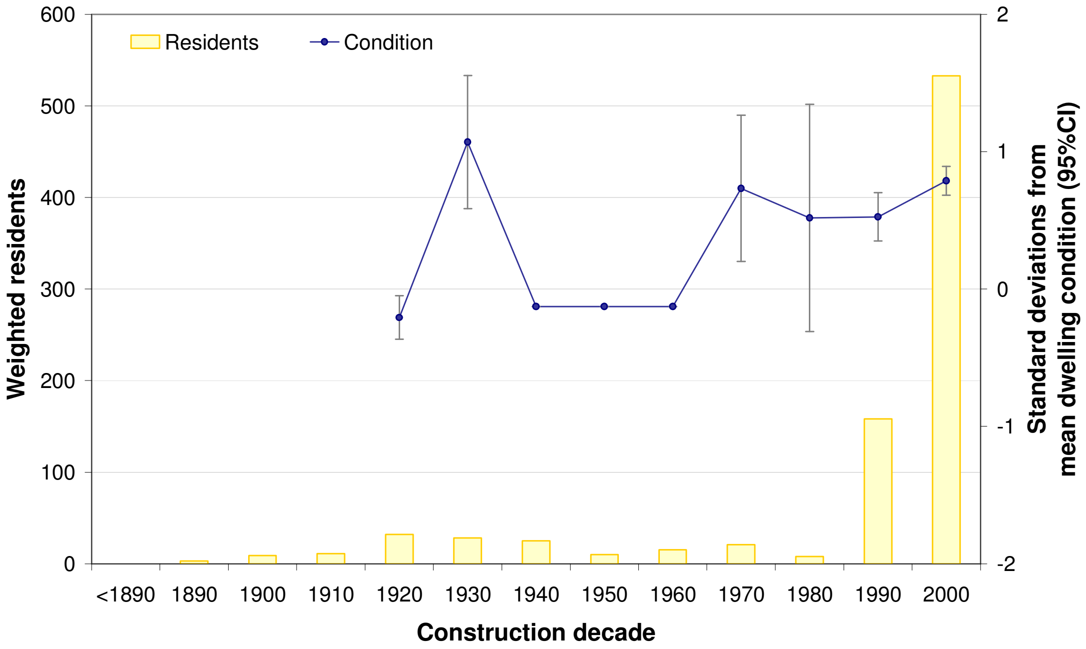

Figure 6.47 Number of Apartment residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Apartment construction (Matched QV/NHI data).

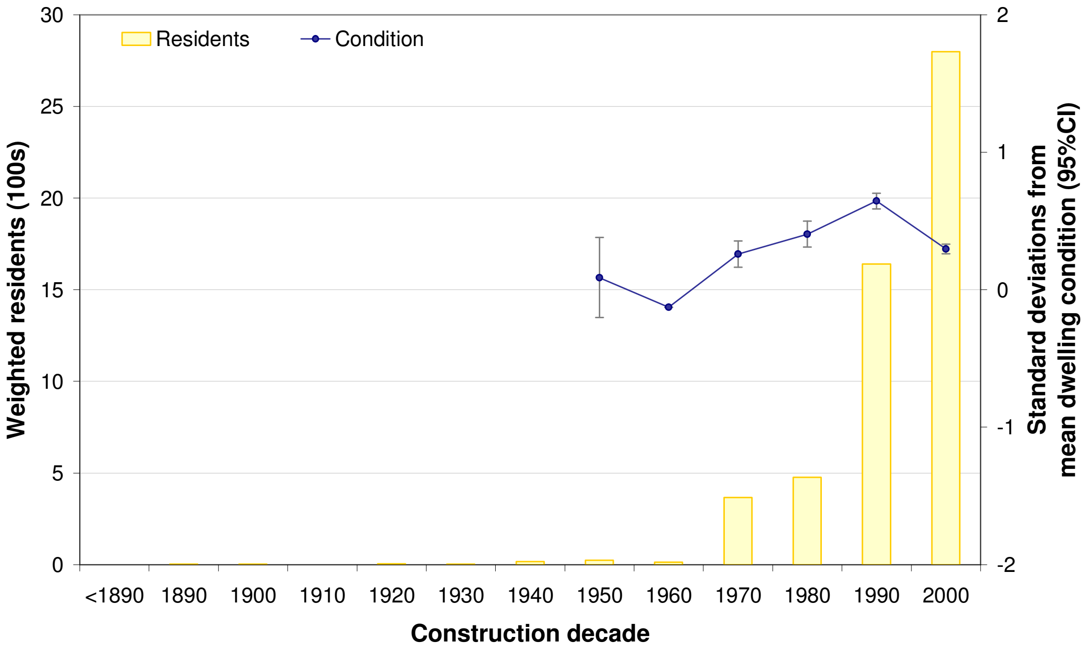

Figure 6.48 Number of Townhouse residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Townhouse construction (Matched QV/NHI data).

Figure 6.49 1990s Semi-detached Townhouses, Karori, Wellington.

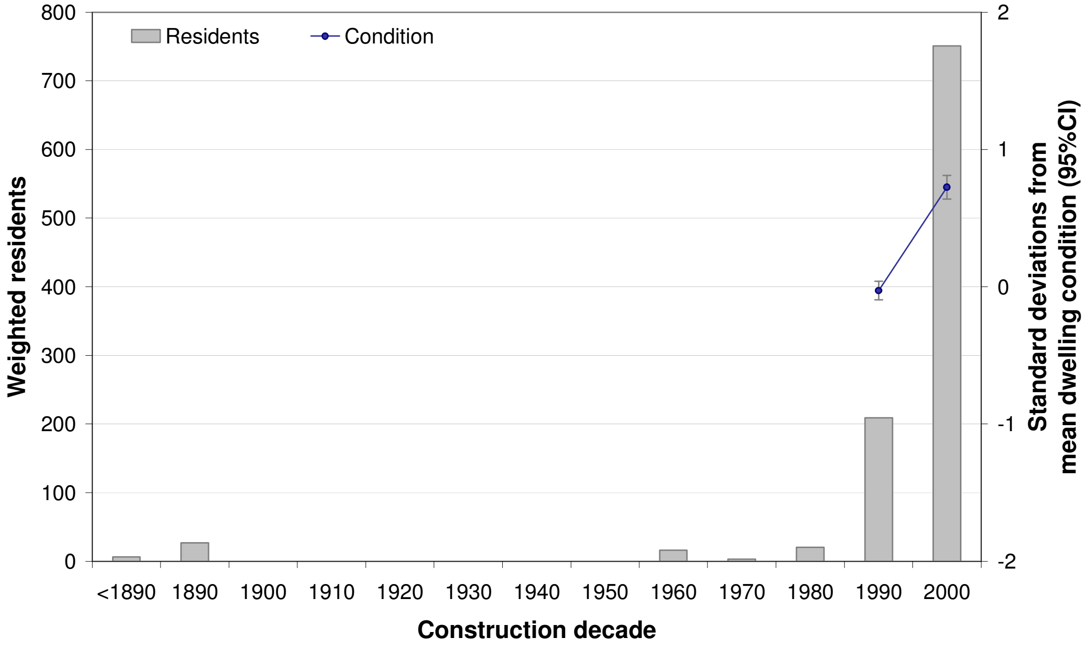

Figure 6.50 Number of Terrace Apartment residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Terrace Apartment construction (Matched QV/NHI data).

Figure 6.51 1990s Terrace Apartments, Birkenhead, Auckland.

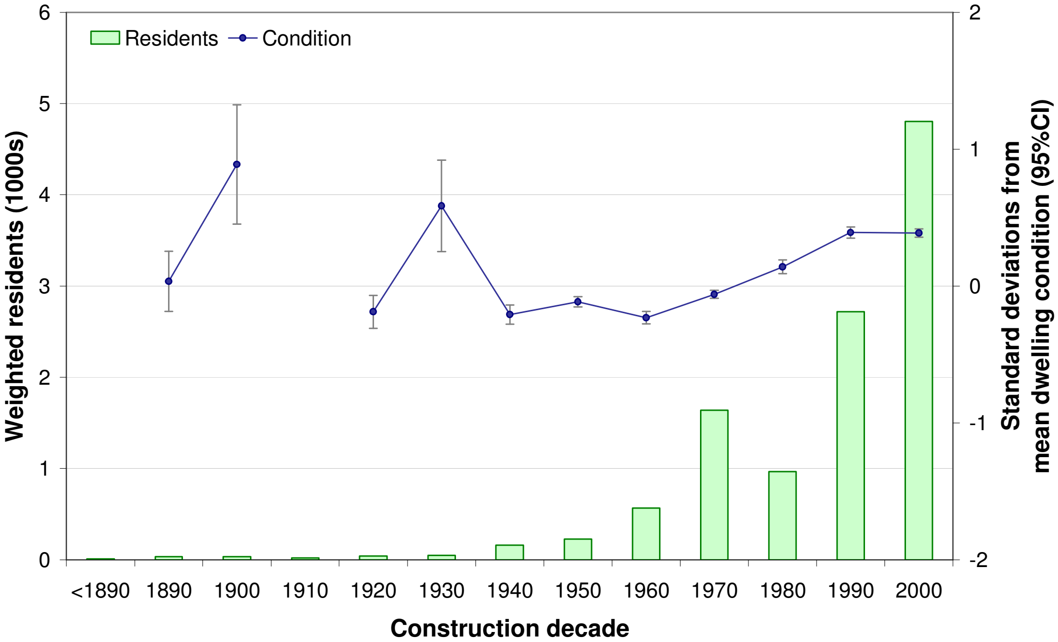

Figure 6.52 Number of Infill dwelling residents (weighted by study person days); and standard deviations from mean dwelling condition for all dwellings, by decade of Infill dwelling construction (Matched QV/NHI data).

6.4.16 "No Date" dwellings.

The hospitalisation rate for "No Date" (as opposed to "No Match") dwellings was higher than the average. An investigation of a small sample of these addresses suggested that "No date" addresses are predominantly occupied by dwellings that have been recently constructed, or by more than one dwelling, conceivably constructed at different times (see Appendix 8 for further details of this investigation).

6.5 LEAKY BUILDINGS

In the 1990s and 2000s a combination of new construction practices and untreated timber resulted in a phenomenon known as "leaky building syndrome" in some dwellings. QV notes Townhouses as being particularly susceptible to the problem.

Weathertight Services, a division of the Department of Building and Housing, notes that there are 5,946 claims registered as seeking adjudication by the Weathertight Homes Tribunal, though some of these represent multi-unit dwellings.[*] It is not possible to tell from QV data how many of the 192,084 QV-listed 1990s dwellings are "leaky buildings", but it would appear to be a small percentage.

Whether a building is 'leaky' or not matters because the syndrome causes indoor damp, and promotes the growth of mould and fungi, all of which are linked to respiratory conditions.[95] [96] [97] `Leakiness' means that houses which might otherwise be assumed to be healthier because they were built after the introduction of more stringent insulation regulations, are not.

6.6 DEPRIVATION BY DWELLING TYPE AND PERIOD

An additional difficulty is that the population is not evenly spread across dwelling types or construction decades. The only measured variable where this is likely to make a difference is deprivation, since NZDep is an ecological-level variable, while

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[*] http://www.dbh.govt.nz/weathertight-services

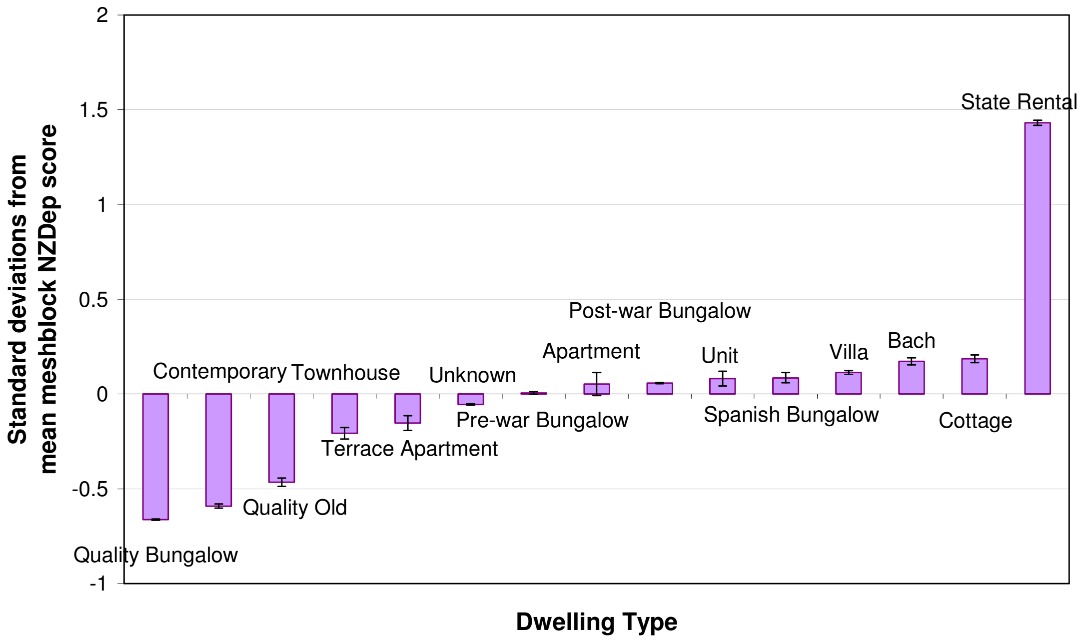

Figure 6.53 Standard deviations from mean dwelling meshblock NZDep (weighted by number of dwellings) by Dwelling Type (QV data).

Figure 6.54 Standard deviations from mean dwelling meshblock NZDep (weighted by number of dwellings) by dwelling construction decade (QV data).

dwelling variables are individual level. As Figure 6.53 and Figure 6.54 and demonstrate, average NZDep varies by dwelling type and age, suggesting that these variables may well be additional, individual markers of deprivation. In particular, as identified earlier in the chapter, living in a Quality Bungalow, Contemporary, or Quality Old dwelling, is likely an additional individual marker for being less deprived, while those living in a "State Rental" are likely to be more deprived than the bulk of the population. At the same time, for dwellings built from 1940 on, increasing age of dwelling is associated with increasing deprivation.

6.7 CONCLUSION

Although dwellings built after the 1940s are more common than those built before, there is less information on the later dwellings, and generally the more recent a dwelling type, the less attention it has received in architectural literature. In other words, there is still a paucity of high quality data on New Zealand dwellings.

Information currently available goes some way towards creating a picture of their likely "healthiness", but there are still plenty of unknowns: Heating and ventilation attributes of many, particularly more recent, housing types remain uncanvassed, and what information there is on these attributes can be largely described as educated guesswork rather than well-documented survey data. Overall, the fairest generalisations to make would be that older, standard dwelling types, i.e. Villas, Cottages, and Pre-war Bungalows (but perhaps not Quality Old or Spanish Bungalows), probably have better ventilation than Post-war Bungalows, but are harder to heat. In recent construction, however, the prevalence of leakiness is yet to be determined.

Last, individual data on dwelling tenure, and rental tenure type (public or private) would be a highly valuable addition to dwelling information, but are not currently available (at least in the QV database).

CHAPTER 7 HOUSING AND EXCESS WINTER MORBIDITY

7.1 INTRODUCTION

As described in the literature review, there is research evidence to support the possibility that housing modifies the effects of outdoor temperature on health[3], and, subsequently and separately, a theoretical basis for hypothesising that housing may modify the effects of winter on health. With excess winter hospitalisation and mortality described in previous chapters, and housing type and quality described in the preceding chapter, this chapter investigates whether the data support that hypothesis.

QV and other data sources include information on a number of housing factors. The factors selected for investigation in this thesis may be loosely divided into two groups:

- static (unchanging) dwelling attributes, being
    - dwelling age;
    - dwelling type, as described in Chapter Six; and
    - floor area, included for completeness and because of its role in CV/m^2 decile, rather than because of any theoretical hypotheses around its role in EWH; and
- dynamic (changeable) dwelling attributes, being
    - dwelling condition,
    - Capital Value (and its derivative, the Capital Value per square metre of dwelling floor area), and
    - tenure index, which is an ecological measure reflecting the proportion of dwellings in rental tenure in a dwelling's surrounding meshblock.

Static dwelling attributes can be described so because they cannot be changed without altering the fundamental nature of the dwelling: if a dwelling is altered sufficiently that its age or type is changed, it is no longer the same dwelling it was before; while a change in floor area will likely result in a change in the way the dwelling is used by its occupants. Changes in condition, capital value and tenure index, however, vary over time with differing levels of volatility, without changing the fundamental nature of the dwelling. Of these factors, dwelling condition is particularly notable as it could encompass some of the modifiable aspects of a house that provide opportunities for public health interventions.

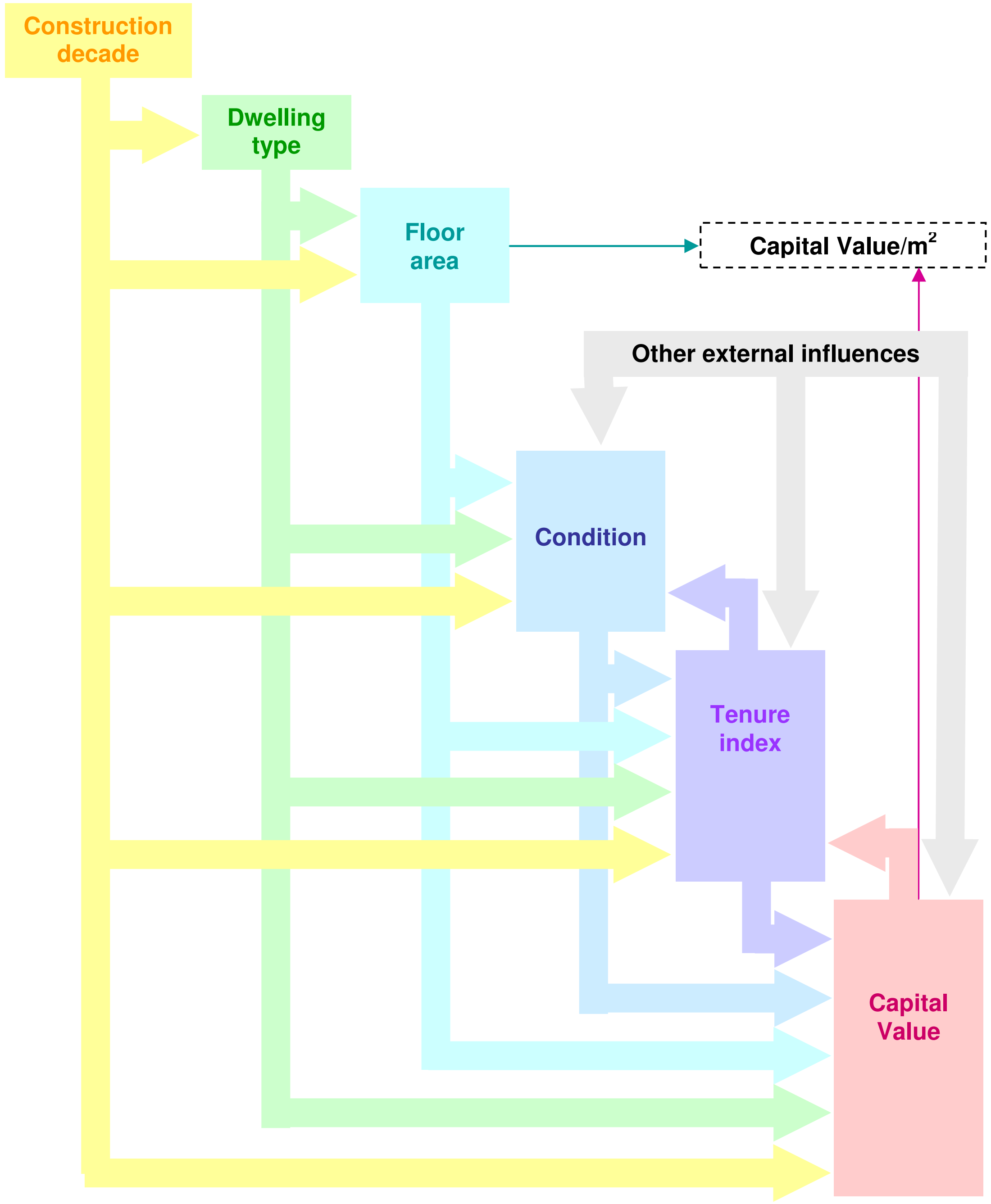

Figure 7.1 Direction of association between housing attributes.

Chapter Six has described some of the association between dwelling type and other variables, but in fact all of the housing variables are related to some degree, as illustrated in Figure 7.1.

Figure 7.1 shows the direction of association between the different housing attributes measured in this study. The primary direction of association between Condition and Tenure index, and between Tenure index and Capital Value, is unknown. Floor area is included in the figure, and in the measured variables, because Capital value/m^2 is derived directly from Capital value and floor area, rather than because of any particular hypotheses about its role in EWH.

This chapter first describes the extent of missing data in QV information and its potential impact. It then provides further background on the different dwelling attributes where these were not pertinent to Chapter Six. Next, all-cause hospitalisation rates for each dwelling factor are briefly described. The main focus of the Chapter then follows; differences in EWHI for each dwelling factor, first for all-cause hospitalisations, then respiratory (ICD-10 Chapter X) and circulatory (ICD-10 Chapter IX).

7.2 MISSING DATA

As noted in Chapter Three, housing data were not available for all National Health Index (NHI) records. Whether or not housing data were missing varied by both demographic and housing variables.

Missing data are described by demographic variables for each housing variable in Table 7.1 and Table 7.2 below.

More data were missing for dwelling type (56%) than for other housing variables, with missing rates between 32% (Capital Value) and 35% (Dwelling age, dwelling condition).

In general, the likelihood of having dwelling data missing was slightly higher for men than for women; increased with increasing age and deprivation; and was much higher in rural than urban areas. Trends for missing dwelling data by demographic variables were in the same direction for all dwelling attributes except by ethnicity, where Pacific People were slightly more likely (IRR 1.0049, 95% CI 1.0048-1.0050) to have dwelling type data missing than NZ Europeans, but less likely (with a range in IRRs from 0.8511 to 0.8884) to have other variables missing; and annual mean minimum temperature, where increasing temperature was associated with less likelihood of missing dwelling type (0.9876, 95% CI 0.9876-0.9876), but greater likelihood of other variables being missing (with a range in trends from 1.0299 to 1.0339).

7.2.1 Likely impact of missing data

Pacific Peoples had an 8% higher all-cause EWHI than NZ Europeans, and make up approximately 5.6% of the NHI population. The EWHI for Pacific Peoples with a missing dwelling type was slightly higher than the EWHI for Pacific Peoples with a matched dwelling type, but not significantly so (RRR 1.0232, 95% CI 0.9973 – 1.0499, p=0.080). Given the distribution of Pacific Peoples over known dwelling types, and the small difference in EWHI between matched and missing dwellings, I consider it unlikely that the missing data would have introduced any meaningful bias to results.

The effect of missing dwelling type data by annual average minimum temperature is harder to gauge, since distribution of matched dwelling types does vary by temperature. Although mean NZDep only increases marginally with decreasing temperature, distribution of dwelling types shows greater variation, with Quality Bungalows more common than Pre-war Bungalows in warmer areas, and vice versa in colder areas. If the "missing" dwelling types in the colder areas were all Quality Bungalows, the EWH in Quality Bungalows would be non significantly higher than in Post-war Bungalows. Conversely, if the "missing" dwelling types in warmer areas were all Pre-war Bungalows, Pre-war Bungalows would still have significantly higher EWH than Post-war Bungalows, though the difference would be less.

Table 7.1 Percentages of missing QV data by demographic variables, for each dwelling variable

	Dwelling Type	**Dwelling age**	**Floor area**	**Dwelling condition**	**Tenure index**	**Capital Value**[*]	**Capital Value/m^2**
Demographic variable	**Unadjusted % missing**	**Unadjusted % missing**	**Unadjusted % missing**	**Unadjusted % missing**	**Unadjusted % missing**	**Unadjusted % missing**	**Unadjusted % missing**
All	56.3%	34.6%	32.7%	34.9%	33.0%	32.2%	33.0%
Sex							
Male	56.6%	35.3%	33.4%	35.6%	33.8%	32.9%	33.7%
Female	56.1%	33.9%	32.0%	34.1%	32.3%	31.5%	32.3%
Age group							
0-4 years	51.6%	29.6%	27.4%	29.8%	27.6%	26.9%	27.6%
5-14 years	52.3%	31.2%	29.2%	31.5%	29.4%	28.7%	29.4%
15-29 years	56.4%	34.0%	32.0%	34.3%	32.3%	31.4%	32.2%
30-59 years	56.5%	34.3%	32.4%	34.6%	32.7%	31.8%	32.6%
60-79 years	56.8%	35.8%	34.2%	35.9%	34.5%	33.7%	34.5%
80+ years	71.8%	53.5%	51.6%	53.0%	51.8%	51.2%	51.9%
Ethnicity							
NZ European	56.2%	34.3%	32.2%	34.3%	32.5%	31.6%	32.5%
Māori	49.5%	32.5%	30.3%	33.0%	30.7%	29.8%	30.7%
Pacific Peoples	51.9%	25.6%	23.8%	26.8%	24.1%	23.5%	24.0%
Asian	61.4%	34.0%	32.4%	34.7%	32.7%	32.0%	32.5%
Other	59.8%	38.3%	36.8%	38.7%	37.1%	36.3%	37.0%
NEI	58.2%	37.7%	36.3%	38.2%	36.6%	35.8%	36.5%
NZDep decile							
1-3	58.1%	34.5%	32.6%	34.5%	32.7%	32.0%	32.8%
4-7	56.3%	34.6%	32.7%	34.8%	33.0%	32.2%	33.0%
8-10	54.9%	34.0%	32.1%	34.5%	32.5%	31.6%	32.4%
Rurality							
Main Urban	55.2%	30.0%	28.5%	30.5%	28.8%	28.1%	28.8%
Secondary	45.1%	35.5%	34.1%	35.5%	34.6%	33.6%	34.3%
Minor	47.4%	34.2%	32.5%	34.2%	33.1%	31.8%	32.9%
Rural Centre	68.2%	56.5%	54.3%	56.4%	54.6%	53.5%	54.7%
Other rural	85.9%	71.9%	64.3%	69.5%	64.9%	63.4%	64.9%
Other	92.6%	80.1%	87.6%	80.4%	78.6%	78.3%	79.0%

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[*] The values for "Capital Value" are all but identical to values for total match, as only 283 of the 3790836 individuals with a matched property record, or 0.007%, had "0" recorded as the property Capital Value.

Table 7.2 Likelihood of dwelling data being missing, relative to baseline.[*]

Demographic variable	Dwelling age		Dwelling Type		Floor area		Dwelling condition		Tenure index		Capital value[†]		Capital Value/m^2	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
Sex														
Male	1.00	Baseline												
Female	0.9696	(0.9696-0.9697)	0.9930	(0.9929-0.9930)	0.9664	(0.9663-0.9664)	0.9678	(0.9678-0.9679)	0.9652	(0.9652-0.9653)	0.9658	(0.9657-0.9658)	0.9667	(0.9666-0.9667)
Age group														
0-4 years	Baseline													
5-14 years	1.0312	(1.0310-1.0313)	1.0054	(1.0053-1.0055)	1.0412	(1.0411-1.0414)	1.0363	(1.0361-1.0364)	1.0421	(1.0419-1.0422)	1.0429	(1.0427-1.0430)	1.0409	(1.0408-1.0411)
15-29 years	1.1382	(1.1380-1.1383)	1.0804	(1.0803-1.0804)	1.1496	(1.1494-1.1497)	1.1412	(1.1410-1.1413)	1.1530	(1.1528-1.1531)	1.1515	(1.1513-1.1517)	1.1488	(1.1487-1.1490)
30-59 years	1.1178	(1.1177-1.1179)	1.0709	(1.0708-1.0710)	1.1346	(1.1345-1.1348)	1.1228	(1.1227-1.1230)	1.1380	(1.1378-1.1381)	1.1371	(1.1369-1.1372)	1.1348	(1.1346-1.1349)
60-79 years	1.1733	(1.1731-1.1735)	1.0885	(1.0884-1.0886)	1.2054	(1.2052-1.2056)	1.1754	(1.1752-1.1755)	1.2057	(1.2055-1.2059)	1.2118	(1.2116-1.2120)	1.2047	(1.2045-1.2049)
80+ years	1.8109	(1.8106-1.8112)	1.3862	(1.3860-1.3863)	1.8695	(1.8692-1.8698)	1.7868	(1.7865-1.7870)	1.8623	(1.8620-1.8626)	1.8892	(1.8889-1.8895)	1.8628	(1.8626-1.8631)
Ethnicity														
NZ European	1.00	Baseline												
Māori	0.9407	(0.9406-0.9408)	0.9139	(0.9138-0.9140)	0.9418	(0.9417-0.9419)	0.9532	(0.9531-0.9533)	0.9406	(0.9405-0.9407)	0.9421	(0.9420-0.9422)	0.9434	(0.9433-0.9435)
Pacific Peoples	0.8638	(0.8637-0.8639)	1.0049	(1.0048-1.0050)	0.8534	(0.8533-0.8536)	0.8884	(0.8883-0.8885)	0.8534	(0.8533-0.8536)	0.8563	(0.8561-0.8564)	0.8511	(0.8510-0.8513)
Asian	1.1513	(1.1511-1.1514)	1.1642	(1.1641-1.1642)	1.1619	(1.1617-1.1620)	1.1578	(1.1577-1.1580)	1.1627	(1.1625-1.1628)	1.1682	(1.1680-1.1683)	1.1582	(1.1581-1.1584)
Other	1.0998	(1.0997-1.0999)	1.0553	(1.0553-1.0554)	1.1227	(1.1226-1.1227)	1.1097	(1.1096-1.1098)	1.1192	(1.1191-1.1193)	1.1258	(1.1257-1.1258)	1.1204	(1.1203-1.1205)
NEI	1.1454	(1.1453-1.1455)	1.0481	(1.0480-1.0481)	1.1730	(1.1729-1.1730)	1.1538	(1.1537-1.1539)	1.1691	(1.1690-1.1692)	1.1778	(1.1776-1.1778)	1.1700	(1.1699-1.1700)
NZDep tertile														
1-3	1.00	Baseline												
4-7	1.0347	(1.0346-1.0347)	1.0167	(1.0166-1.0167)	1.0316	(1.0315-1.0317)	1.0368	(1.0367-1.0369)	1.0356	(1.0356-1.0357)	1.0325	(1.0325-1.0326)	1.0310	(1.0310-1.0311)
8-10	1.1253	(1.1252-1.1254)	1.0541	(1.0541-1.0542)	1.1126	(1.1125-1.1127)	1.1270	(1.1269-1.1270)	1.1200	(1.1199-1.1200)	1.1125	(1.1125-1.1126)	1.1134	(1.1133-1.1135)

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[*] Poisson regression with robust standard errors, and controlling for other listed demographic variables. All p-values were <0.001

[†] The values for “Capital Value” are all but identical to values for total match, as only 283 of the 3790836 individuals with a matched property record , or 0.007%, had “0” recorded as the property Capital Value.

Demographic variable	**Dwelling age**		**Dwelling Type**		**Floor area**		**Dwelling condition**		**Tenure index**		**Capital value**[*]		**Capital Value/m²**	
	IRR	**95% CI**	**IRR**	**95% CI**	**IRR**	**95% CI**	**IRR**	**95% CI**	**IRR**	**95% CI**	**IRR**	**95% CI**	**IRR**	**95% CI**
Rurality														
Main Urban	1.00	Baseline												
Secondary	1.2602	(1.2600-1.2603)	0.8059	(0.8059-0.8060)	1.2821	(1.2819-1.2822)	1.2490	(1.2489-1.2491)	1.2845	(1.2845-1.2848)	1.2855	(1.1458-1.1461)	1.2771	(1.2770-1.2773)
Minor	1.1779	(1.1778-1.1780)	0.8646	(0.8646-0.8647)	1.1869	(1.1868-1.1870)	1.1646	(1.1645-1.1647)	1.1957	(1.1955-1.1958)	1.1807	(1.2853-1.2856)	1.1898	(1.1897-1.1899)
Rural Centre	2.0088	(2.0085-2.0090)	1.2418	(1.2417-1.2419)	2.0331	(2.0329-2.0333)	1.9825	(1.9823-1.9827)	2.0255	(2.0253-2.0258)	2.0382	(1.1806-1.1809)	2.0305	(2.0303-2.0308)
Other rural	2.6194	(2.6192-2.6195)	1.5460	(1.5459-1.5460)	2.4655	(2.4654-2.4657)	2.5033	(2.5031-2.5034)	2.4686	(2.4684-2.4688)	2.4713	(2.0379-2.0384)	2.4650	(2.4649-2.4652)
Other	2.8561	(2.8520-2.8602)	1.8116	(1.8104-1.8129)	2.8697	(2.8653-2.8741)	2.8166	(2.8126-2.8206)	2.8611	(2.8568-2.8655)	2.9064	(2.9019-2.9108)	2.8780	(2.8737-2.8823)
Mean min. temperature (continuous)	1.0299	(1.0299-1.0299)	0.9876	(0.9876-0.9876)	1.0326	(1.0326-1.0326)	1.0339	(1.0339-1.0339)	1.0319	(1.0319-1.0319)	1.0337	(1.0337-1.0337)	1.0315	(1.0315-1.0315)

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[*] The values for “Capital Value” are all but identical to values for total match, as only 283 of the 3790836 individuals with a matched property record, or 0.007%, had “0” recorded as the property Capital Value.

7.3 RELATIONSHIPS BETWEEN DWELLING VARIABLES AND DWELLING AND DEMOGRAPHIC VARIABLES.

Relevant relationships between dwelling type and other variables have already been discussed in Chapter Six. Other relevant relationships are included here.

does vary by temperature. Although mean NZDep only increases marginally with decreasing temperature, distribution of dwelling types shows greater variation, with Quality Bungalows more common than Pre-war Bungalows in warmer areas, and vice versa in colder areas. If the "missing" dwelling types in the colder areas were all Quality Bungalows, the EWHI in Quality Bungalows would be non significantly higher than in Post-war Bungalows. Conversely, if the "missing" dwelling types in warmer areas were all Pre-war Bungalows, Pre-war Bungalows would still have a significantly higher EWHI than Post-war Bungalows, though the difference would be less.

7.4 RELATIONSHIPS BETWEEN DWELLING VARIABLES AND DWELLING AND DEMOGRAPHIC VARIABLES.

Relevant relationships between dwelling type and other variables have already been discussed in Chapter Six. Other relevant relationships are included here.

7.4.1 Dwelling condition

As there was little variation in dwelling condition within the dataset, even small differences in mean condition represent a large difference in proportion of standard error.

Dwelling condition was closely associated with meshblock NZDep decile (see Figure 6.15 on page 107), but condition was an individual-level variable, whereas NZDep was a Census meshblock-level variable.

There was also a clear pattern to the relationship between dwelling condition and occupant age (Figure 7.2), with the best condition housing enjoyed by those

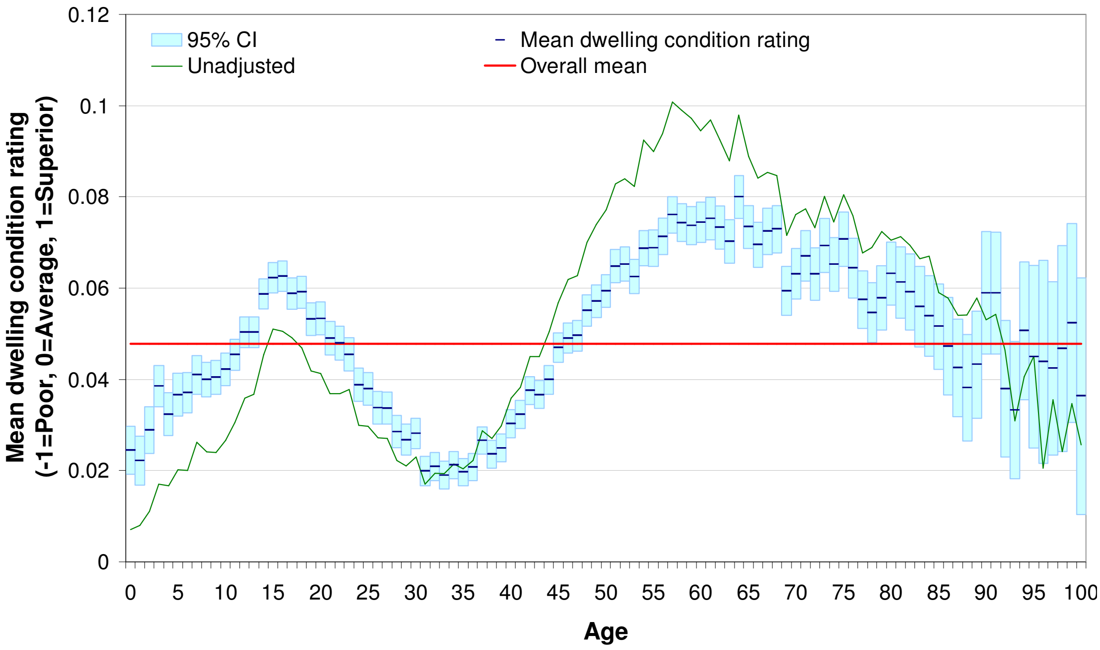

Figure 7.2 **Mean population-weighted dwelling condition by year of age, standardised by sex, ethnicity, meshblock NZDep, and rurality (Matched QV/NHI data).**

approaching the traditional retirement age (65), and a second peak for secondary-school-aged children, while the poorest condition housing was inhabited by infants and those (presumably including their parents) in their early 30s.

After the dwelling condition peak, among occupants aged in their mid-60s, condition declined with occupant age. It is not known whether this represents the elderly moving into poorer condition housing; whether this cohort has lived in poorer condition housing throughout their adult lives and still lives in it; or whether the elderly find it harder to maintain their dwellings, for physical or financial reasons, and the age-related decline in dwelling condition represents a deterioration in dwelling maintenance in old age. The distribution is not, however, simply a function of home ownership rates, as home ownership rates are highest in those aged over 65, while mean dwelling condition starts to decline after about this age.[91]

The implication of this distribution is that any adverse health effects from poor dwelling condition are not evenly spread across the population by age, and that, if not controlled for, age may confound the relationship between dwelling condition and EWH.

7.4.2 Tenure index

Public health research has repeatedly found both rental tenure[98] and housing condition to be separately associated with poorer health status. With such findings, it can be difficult to know whether to ascribe the poor health to the condition of the dwelling, or to tenants' lower socio-economic status.[99] At the same time, both health and housing research have worked on the supposition that rental dwellings are older, and of a standard lower than, or at least different to[68], that of owner-occupier dwellings.

However, little research, and none in New Zealand, has been done to ascertain whether there is any relationship between dwelling tenure and condition. While there is some overseas research on the overall condition of rental stock, it compares condition between different locations, or different time periods[100], rather than between rental and owner tenures.

Using the tenure index described in Chapter Three, I used Poisson regression to investigate relationships between QV dwelling fields, specifically dwelling age and condition; and assigned tenure index.

There was a statistically significant relationship between dwelling age, overall dwelling condition, and tenure index. The older a dwelling (until 1870), and the poorer its condition, the higher the proportion of rental properties in its surrounding meshblock.

7.4.2.1 Construction decade and tenure

Figure 7.3 shows the mean proportion of meshblock households in rental tenure by dwelling construction decade. A linear regression of tenure index over construction decade indicates that the proportion of renters in the surrounding meshblock increases 1.26% (RRR 1.0126, 95% CI 1.0125-1.0128, p=0.000) with each decade increase in dwelling age. I infer from these results that, on average, the older the dwelling, the higher the proportion of rental households in the surrounding meshblock.

The graph above shows that the regression does not well fit dwellings built before 1870. However, the sample included only 66 dwellings from this era, just over half of the 116 pre-1870 dwellings in QV records. This pattern for older houses is also consistent with BRANZ's finding for owner-occupied dwellings that average housing condition "deteriorates with age up to about 60 years old", then starts to improve as many houses are renovated. [68]

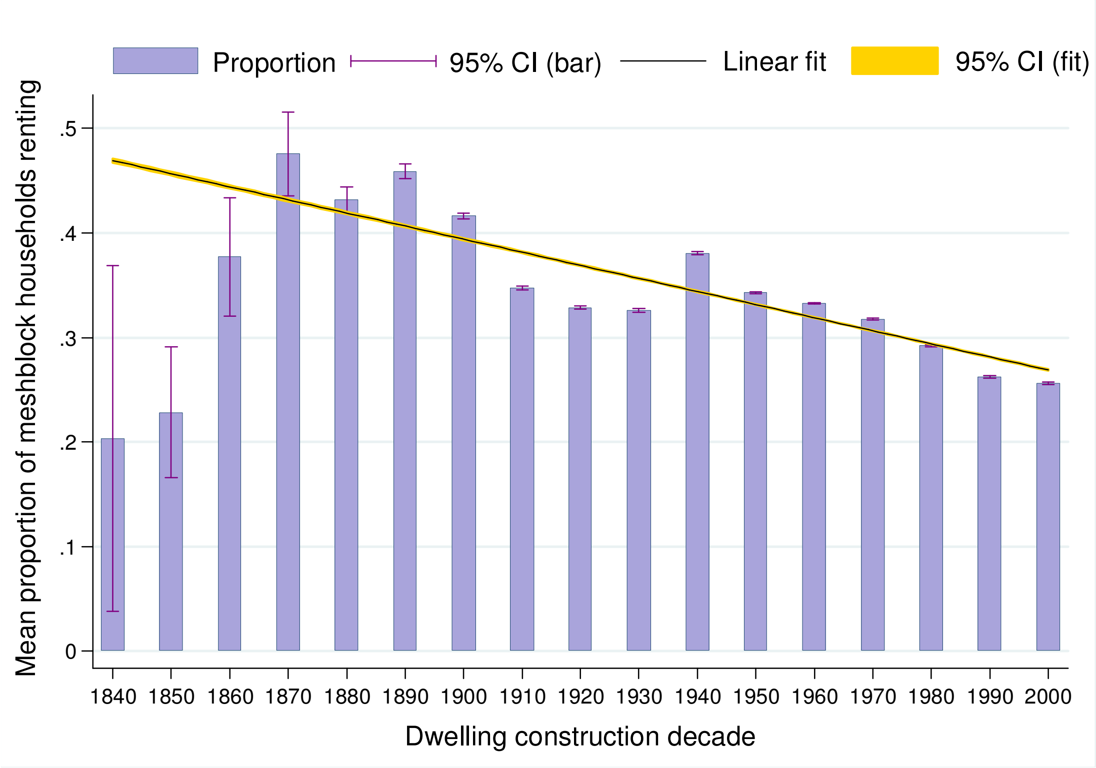

Figure 7.3 **Mean proportion of meshblock households renting by dwelling construction decade. (2006 Census/QV data)**

7.4.2.2 Dwelling condition, age and tenure

Before discussing the relationship between dwelling condition and tenure, it should be noted that there was a strong association between dwelling age and condition: the older the dwelling, the poorer its condition. Consequently, building age must be considered when investigating other associations with building condition.

Figure 7.4 shows the distribution of proportions of households in a dwelling's surrounding meshblock that are in rental tenure, by dwelling condition, after controlling for building age. It shows that rental proportions decrease with each category improvement in dwelling condition. As the distribution of rental

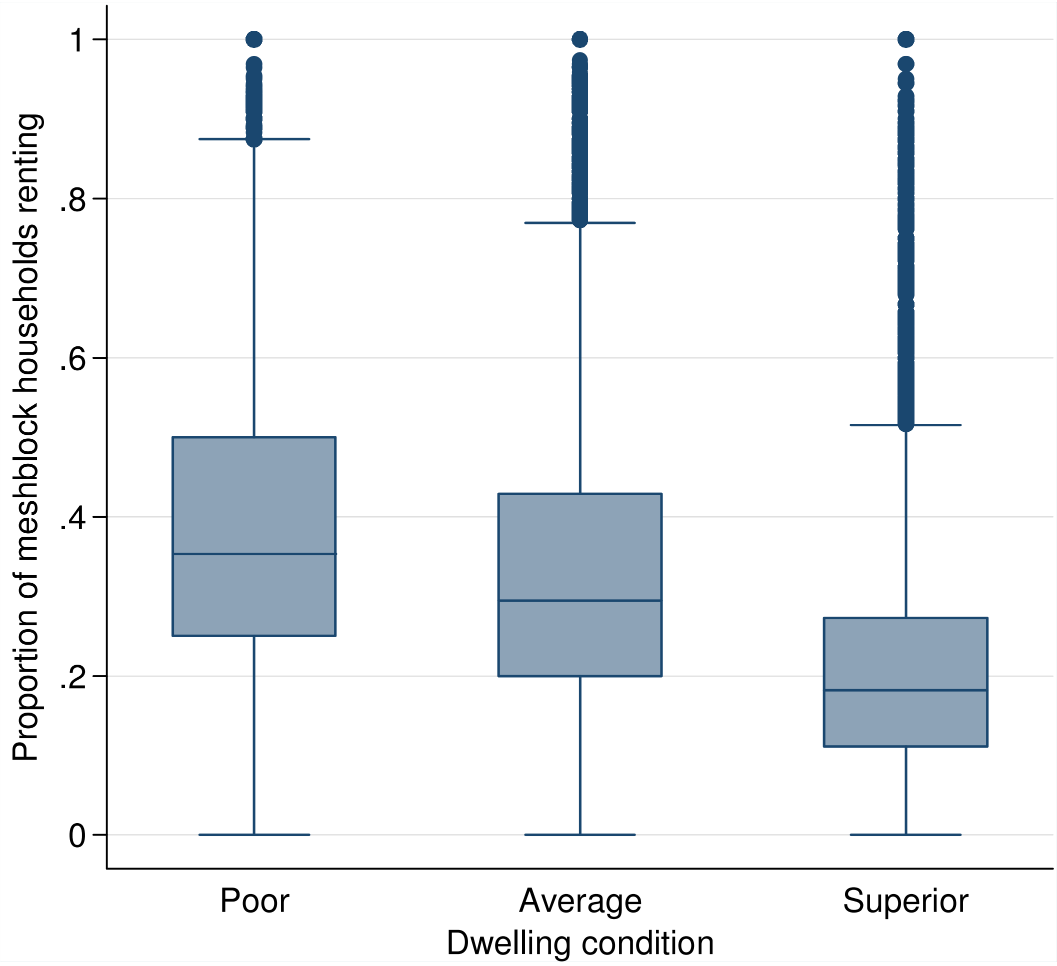

Figure 7.4 **Box and whisker chart showing distribution of proportions of meshblock households renting by dwelling condition. (2006 Census/QV data)**

proportions was closer to a Poisson distribution than a normal distribution, the mean rental proportions were compared using Poisson regression (Table 7.3).

I infer from these regressions that the better the overall condition of a dwelling, the lower the proportion of rental properties in its surrounding meshblock, even after controlling for dwelling age.

Table 7.3 **Dwelling condition and rental proportion, including results after controlling for building age.**

QV Condition	No. of dwellings	Mean rental proportion	Rental proportion relative to baseline	p-value	Relative rental proportion, controlling for dwelling construction decade	p-value
Superior	105788	21.0%	1.00 (Baseline)		1.00 (Baseline)	
Average	865646	32.6%	**1.5526 (1.5315-1.5741)**	**0.000**	**1.4674 (1.4471-1.4880)**	**0.000**
Poor	51976	38.0%	**1.8117 (1.7770-1.8471)**	**0.000**	**1.6524 (1.6201-1.6852)**	**0.000**
Continuous score (Superior – poor)			**1.3563 (1.3440-1.3686)**	**0.000**	**1.2930 (1.2894-1.2965)**	**0.000**

7.4.3 Capital Value and Capital Value/m^2 deciles

Individual Capital Value (CV) and CV/m^2 deciles were correlated with NZDep deciles, as shown in Figure 7.5 and Figure 7.6 below. In these figures the bubble size represents the number of dwellings of that NZDep decile and CV or CV/m^2 decile. The bubble sizes are larger towards the diagonal, particularly at the upper and lower ends of each decile range, showing that NZDep and CV or CV/m^2 are more likely to coincide in the upper and lower deciles, with less correlation in the middle deciles. Also, a comparison of the two associations shows that the correlation is more marked for CV than for CV/m^2; Spearman's rho is 0.7425 (p=0.000) for NZDep and CV, but 0.5701 (p=0.000) for NZDep and CV/m2.

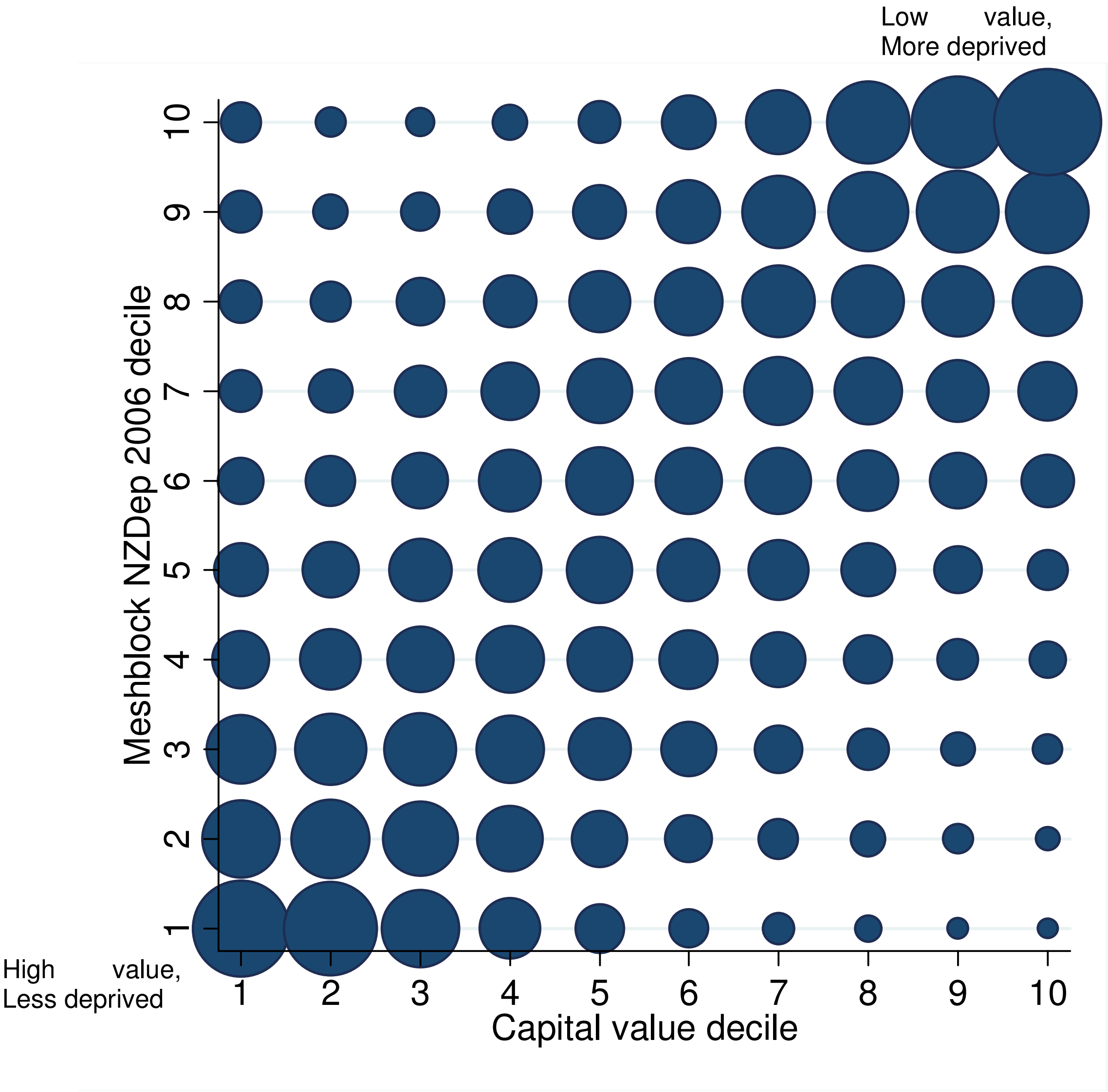

Figure 7.5 **Distribution of person-years by Capital value decile and NZDep decile (bubble size=number of person years). (2006 Census/QV data)**

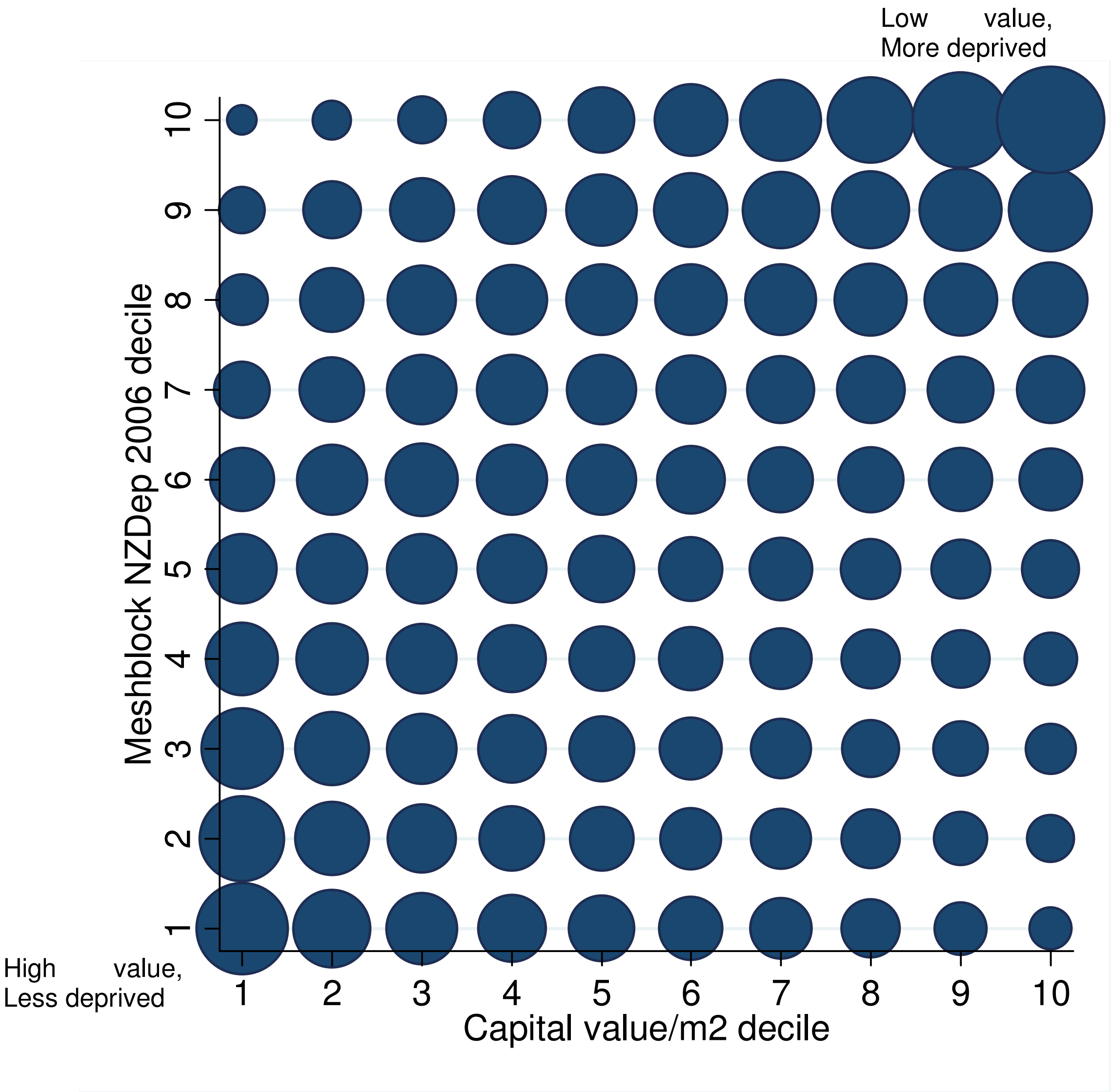

Figure 7.6 Distribution of person-years by Capital value/m^2 decile and NZDep decile (bubble size=number of person years). (2006 Census/QV data)

7.5 HOUSING AND HOSPITALISATION.

To my knowledge, this is the first time nationwide QV data have been used in health research, and there has been no previous description of the relationship between any of the listed housing attributes and health outcomes, such as hospitalisation rates. Therefore, a short description of these relationships follows.

There were strong, and sometimes unexpected, differences in overall hospitalisation rates by housing factors. These differences are discussed in the relevant sections below.

7.5.1 Construction decade

All-cause hospitalisation rates by decade of construction (Figure 7.7), show rates to be higher in more recently-built dwellings, even after adjustment for the demographic variables age, sex, ethnicity, rurality and NZDep decile. This difference would appear to indicate that more recent construction is either being built in locations, or of materials, or by a method, not conducive to good health, or that there is some other variable not adjusted for which is more common in those who live in newer houses.

7.5.2 Insulation Era

Figure 7.8 above shows all-cause hospitalisation rates by insulation era. Dwellings constructed before 1980 have lower hospitalisation rates than those built after 1980. On their own, these results might be interpreted as meaning that more insulation was bad for health, however the previous Figure 7.7 shows that the difference is related to the general pattern of increased hospitalisation rates with decreasing age of dwelling, rather than representing a sudden change for post-1980s houses.

7.5.3 Dwelling Type

As shown in Figure 7.9, hospitalisation rates varied by dwelling type, with rates lowest in Contemporary, Quality Old and Infill dwelling types, and highest in State Rentals, and in Post-war Bungalows built in the 1990s and 2000s. "No type" dwellings and people whose addresses could not be matched to a QV record also had high rates. These categories are discussed further in Chapter Six.

7.5.4 Dwelling floor area

All-cause hospitalisation rates are above average in the largest dwellings (decile 1, floor areas >250m^2), but then drop to their lowest rate in the second decile (floor areas 201-250m^2), and subsequently increase with decreasing floor area (Figure 7.10). It should be noted, however, that decile 1 includes many multi-unit properties where the floor area is recorded for the whole building rather than the individual dwelling units within it.

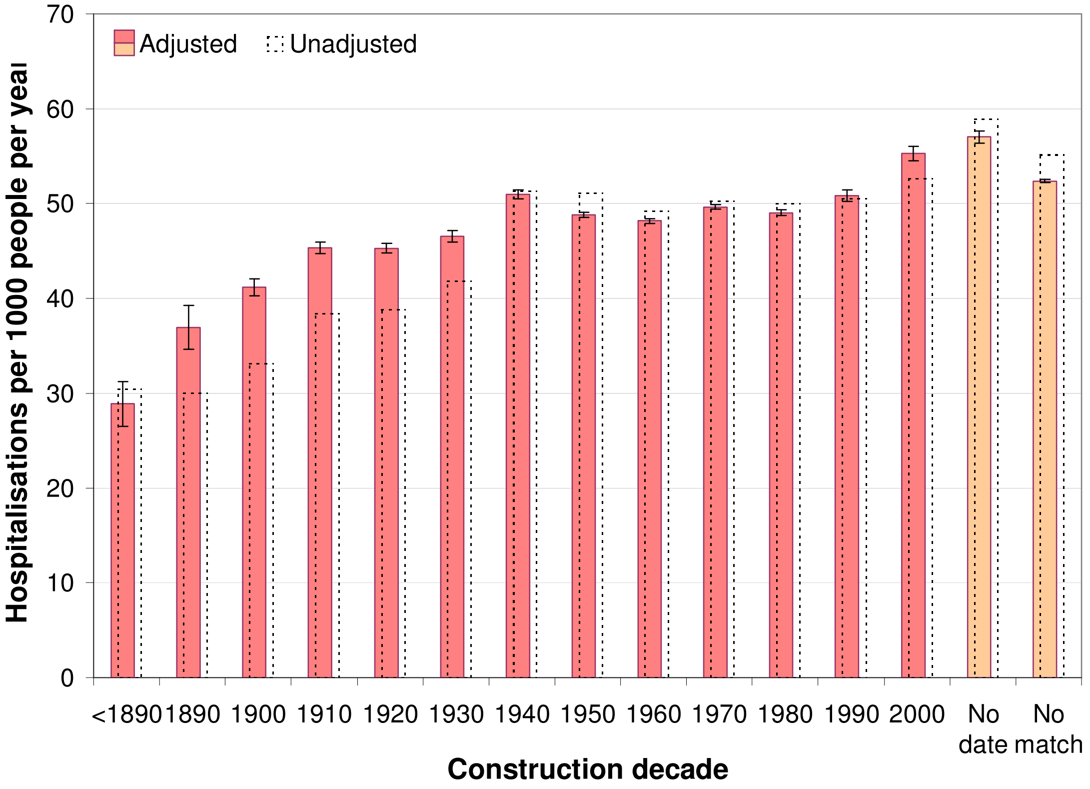

Figure 7.7 All-cause hospitalisation rates by decade of dwelling construction, adjusted for age, sex, ethnicity, rurality, and NZDep decile, 1 February 2000 – 31 January 2006 (Matched QV/NHI and NZHIS data).

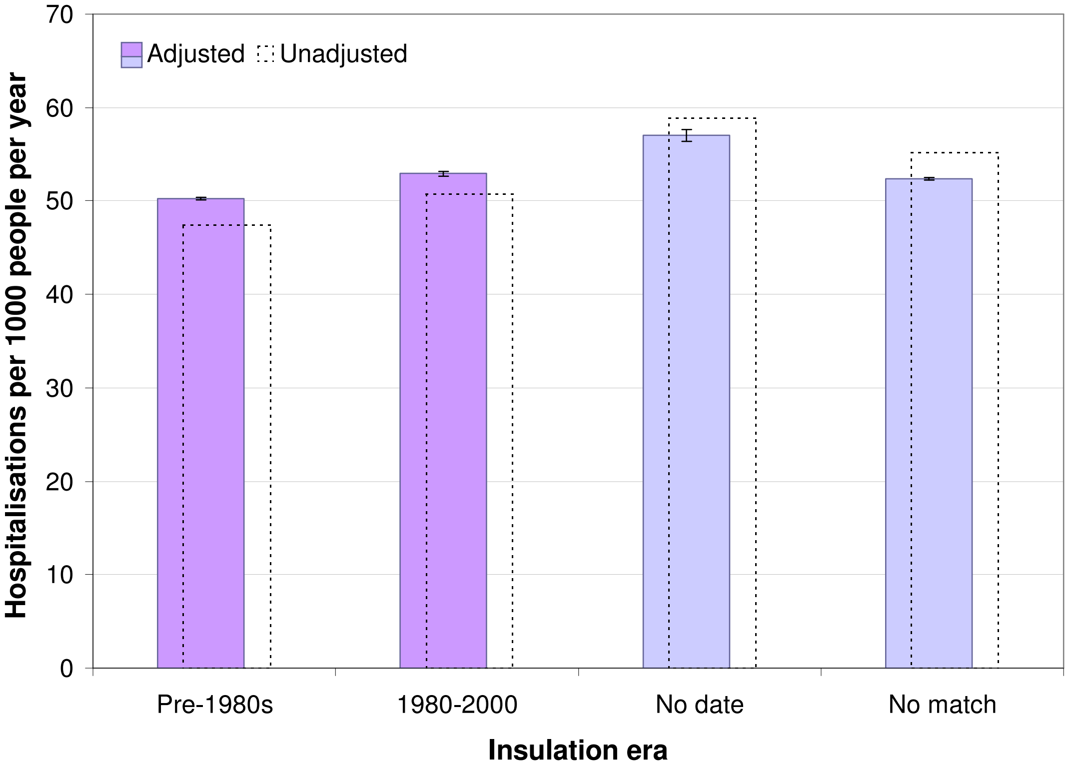

Figure 7.8 All-cause hospitalisation rates by insulation era, adjusted for age, sex, ethnicity, rurality, and NZDep decile, 1 February 2000 – 31 January 2006 (Matched QV/NHI and NZHIS data).

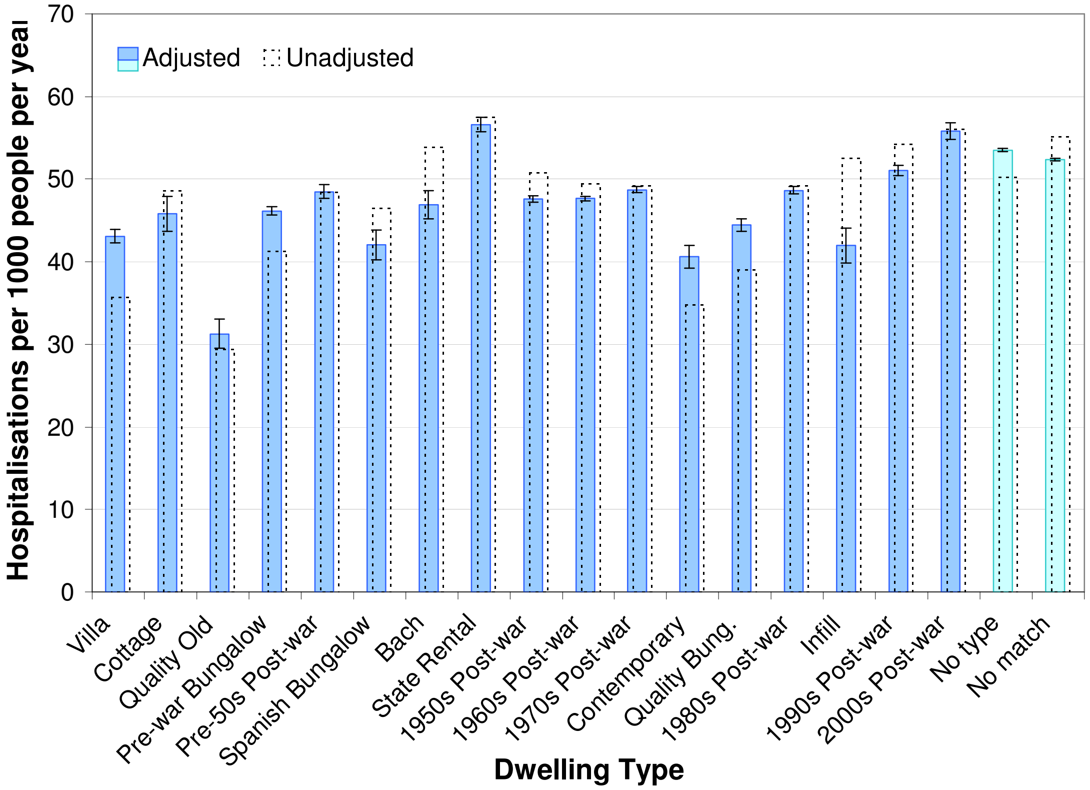

Figure 7.9 All-cause hospitalisation rates by dwelling type, adjusted for age, sex, ethnicity, rurality, and NZDep decile, 1 February 2000 – 31 January 2006. Dwelling types are shown in order of average age.[*] (Matched QV/NHI and NZHIS data).

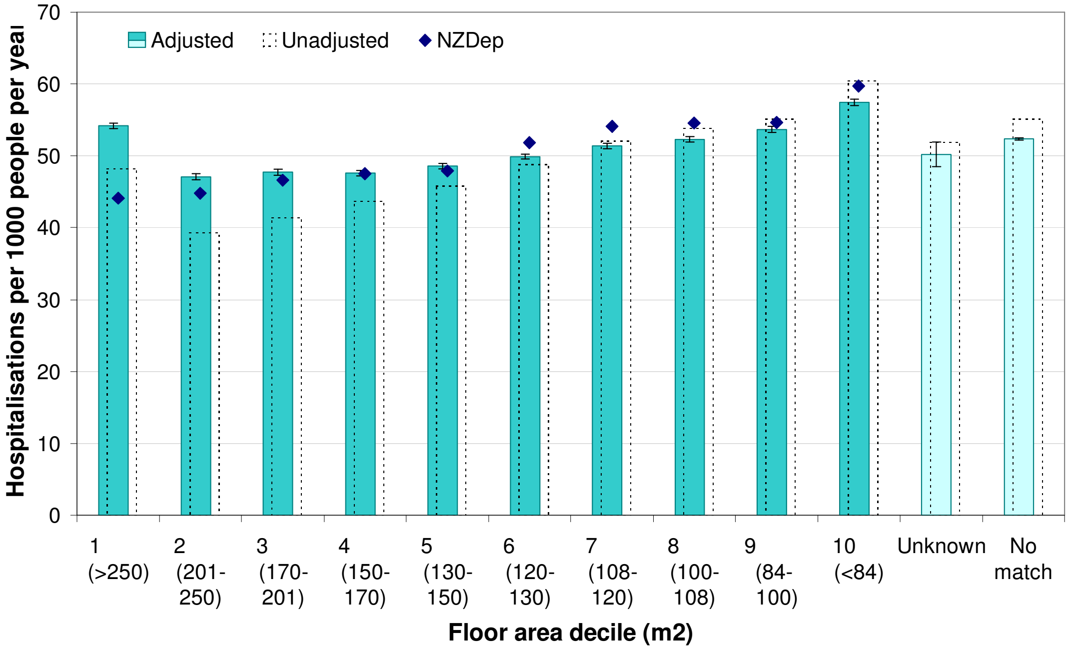

Figure 7.10 All-cause hospitalisation rates by floor area decile, adjusted for age, sex, ethnicity, rurality, and NZDep decile, 1 February 2000 – 31 January 2006 (Matched QV/NHI and NZHIS data).

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[*] Post-war Bungalows have been further stratified by construction decade.

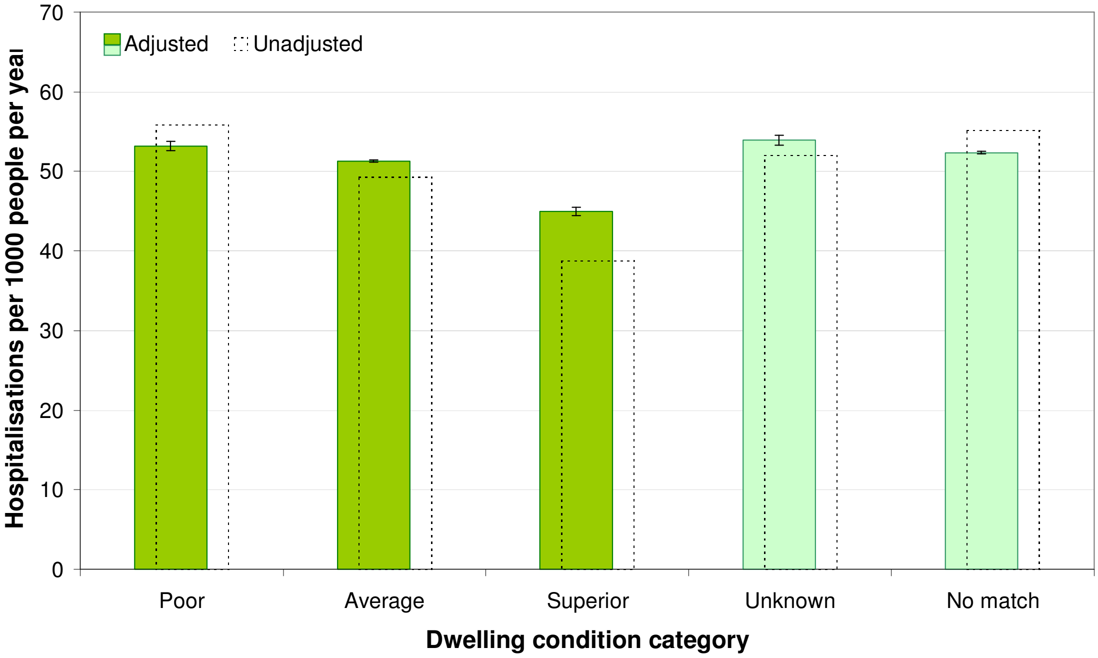

Figure 7.11 All-cause hospitalisation rates by dwelling condition category, adjusted for age, sex, ethnicity, rurality, and NZDep decile, 1 February 2000 – 31 January 2006 (Matched QV/NHI and NZHIS data).

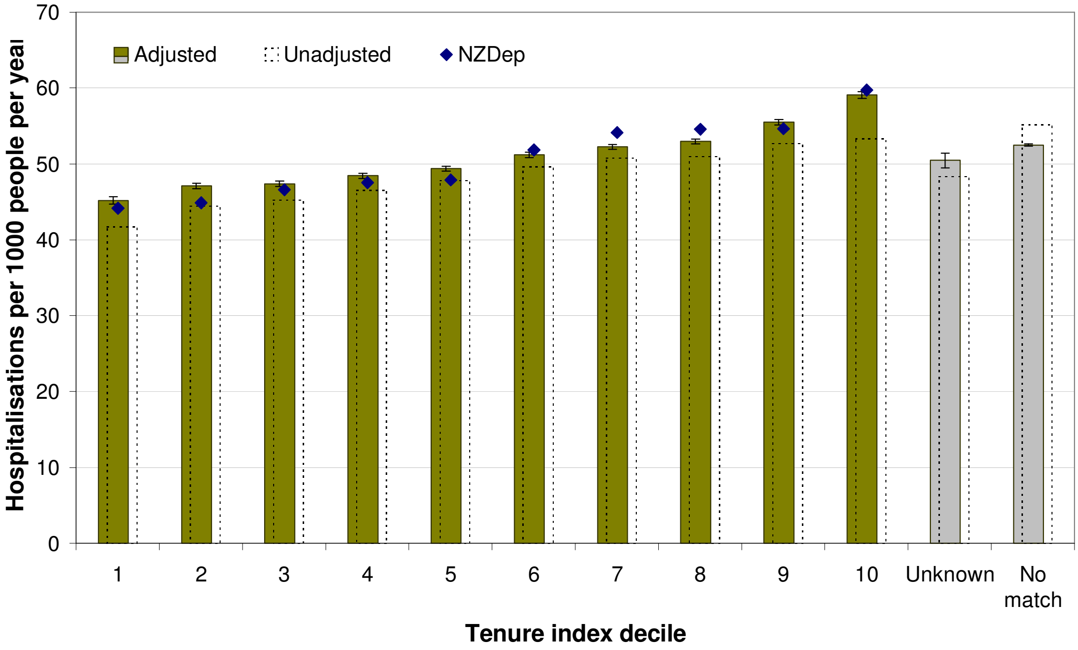

Figure 7.12 All-cause hospitalisation rates by tenure index decile and by NZDep, adjusted for age, sex, ethnicity, and rurality, 1 February 2000 – 31 January 2006.[*] (Matched QV/NHI and NZHIS data).

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[*] Rates for tenure index decile are not adjusted for NZDep, as tenure is one of the variables considered in NZDep.

7.5.5 Dwelling condition

Figure 7.11 shows hospitalisation rates by dwelling condition category, both before and after adjustment for demographic variables. Rates are higher in "Poor", and lower in "Superior", than in "Average" condition dwellings. The difference between "Superior" and "Average" condition dwellings is larger than the difference between "Average" and "Poor". Rates were highest, however, in dwellings where the condition was unknown.

7.5.6 Tenure index

All-cause hospitalisation rates increased with increasing tenure index (Figure 7.12). Hospitalisation rates were higher for people living in mesh-blocks containing more rental tenure households than for people living in areas with higher owner-occupier levels.

7.5.7 Capital Value

7.5.7.1 Capital Value decile

As with floor area decile, there is a trend of increasing hospitalisation rates with increasing decile from decile 2, but rates for decile 1 are close to average (Figure 7.13). Rates for people in unmatched dwellings are also average. No "unknown" category is included for CV decile because all dwellings had a recorded capital value (though 283 matched dwellings had the CV recorded as $0.)

7.5.7.2 Capital Value/m^2

Figure 7.14 shows hospitalisation rates by capital value/m^2 decile. There is a clear trend of increased hospitalisation rates with decreasing value/m^2 properties. Also, dividing capital value by m^2 appears to have cancelled out the higher hospitalisation rates which appear in decile 1 for Capital Value and Floor area deciles. This finding suggests that a large floor area may be contributing to the increased value of many of the highest value properties.

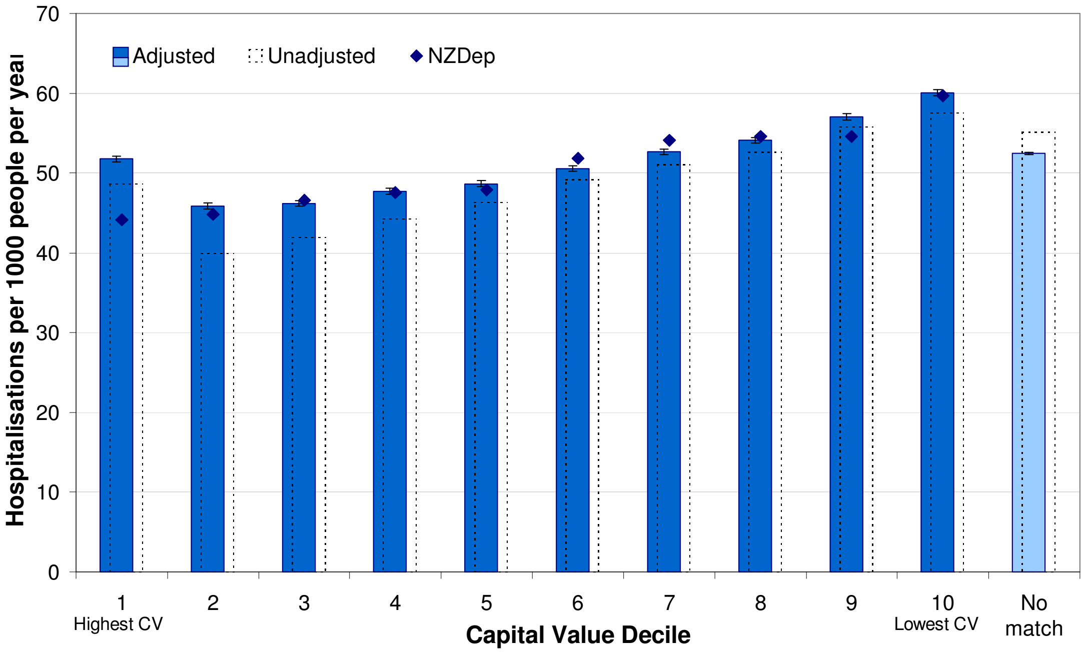

Figure 7.13 **All-cause hospitalisation rates by Capital Value decile and by NZDep, adjusted for age, sex, ethnicity, rurality, 1 February 2000 – 31 January 2006.[*] (Matched QV/NHI and NZHIS data)**

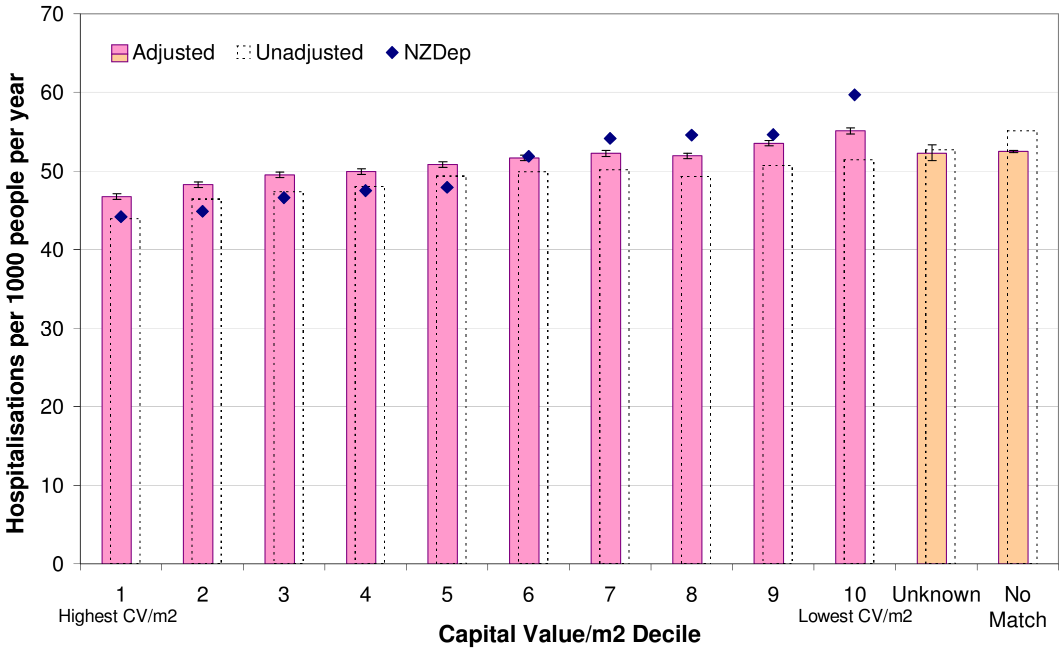

Figure 7.14 **All-cause hospitalisation rates by Capital Value/m^2 decile and by NZDep, adjusted for age, sex, ethnicity, rurality, 1 February 2000 – 31 January 2006.[*] (Matched QV/NHI and NZHIS data).**

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[*] Rates for Capital Value decile are not adjusted for NZDep because of the close correlation between NZDep and Capital Value.

7.6 HOUSING AND EWH

7.6.1 All-cause hospital admissions

7.6.1.1 Construction decade

Dwellings from the 1960s, the most common construction decade, were selected as the Baseline.

After controlling for other variables, there were no significant differences in EWHI by construction decade.

While the trend over construction decades was towards lower EWHIs with decreasing dwelling age (0.9999, 95% CI 0.9997–1.0001, p=0.162), the trend was small and was not significant. Nor were there significant results for any at-risk sub-group.

7.6.1.2 Insulation era

Pre-1980 housing had lower rates of hospitalisation, but higher unadjusted winter excess. Although there was a very small difference (RRR 1.0115, (95% CI 1.0024-1.0208, p=0.014)) between crude EWHIs for houses built before 1980 and houses built after, the RRR was only 1.0046 (95% CI 0.9949-1.0144, p=0.354) and no longer significantly different after controlling for other variables. Therefore, it would appear that whether houses were built before or after the 1978 changes to the Building Code had little or no impact on occupants' EWHIs. Nor were there any significant differences for analysis by at-risk sub-group.

7.6.1.3 Dwelling Type

Post-war Bungalows were selected as the Baseline group because they were the most common housing type.

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[*] Rates for Capital Value/m^2 decile are not adjusted for NZDep because of the close correlation between NZDep and Capital Value.

Table 7.4 EWHI by decade of dwelling construction – all cause hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Decade						
Pre-1890s	0.13	31.9 (429)	29.7 (796)	1.0751 (0.9560-1.2090)	0.9876 (0.8779-1.1111) 0.836	1.0154 (0.9017-1.1434) 0.801
1890s	0.31	29.8 (984)	28.6 (1882)	1.0429 (0.9656-1.1265)	0.9581 (0.8865-1.0365) 0.280	0.9775 (0.9036-1.0575) 0.571
1900s	1.46	35.3 (5407)	32.1 (9804)	1.1001 (1.0642-1.1373)	1.0106 (0.9763-1.0461) 0.549	1.0312 (0.9957-1.0680) 0.086
1910s	2.97	40.5 (12604)	37.4 (23231)	1.0823 (1.0591-1.1061)	0.9942 (0.9710-1.0181) 0.634	1.0104 (0.9864-1.0350) 0.399
1920s	3.83	41.0 (16456)	37.8 (30275)	1.0843 (1.0639-1.1050)	0.9960 (0.9751-1.0174) 0.714	1.0100 (0.9883-1.0321) 0.369
1930s	2.44	44.0 (11276)	40.7 (20816)	1.0805 (1.0561-1.1056)	0.9926 (0.9683-1.0176) 0.559	1.0058 (0.9807-1.0315) 0.654
1940s	3.75	54.1 (21278)	50.0 (39266)	1.0810 (1.0632-1.0992)	0.9931 (0.9742-1.0123) 0.478	0.9902 (0.9711-1.0097) 0.321
1950s	8.42	54.3 (48024)	49.5 (87338)	1.0968 (1.0847-1.1091)	1.0076 (0.9930-1.0224) 0.310	1.0053 (0.9904-1.0203) 0.490
1960s	12.11	52.1 (66141)	47.8 (121204)	1.0886 (1.0783-1.0989)	1 Baseline	Baseline
1970s	12.00	53.0 (66742)	49.0 (122992)	1.0825 (1.0723-1.0927)	0.9944 (0.9812-1.0078) 0.408	0.9997 (0.9861-1.0134) 0.961
1980s	7.53	52.4 (41417)	48.8 (76888)	1.0745 (1.0617-1.0874)	0.9871 (0.9721-1.0022) 0.094	0.9960 (0.9804-1.0119) 0.621
1990s	6.64	52.9 (36865)	49.4 (68712)	1.0702 (1.0568-1.0838)	**0.9831 (0.9677-0.9988) 0.035**	1.0006 (0.9839-1.0176) 0.943
2000s	3.79	55.4 (22021)	51.2 (40601)	1.0820 (1.0645-1.1000)	0.9940 (0.9754-1.0130) 0.535	1.0019 (0.9815-1.0228) 0.853
Continuous					0.9999 (0.9997-1.0000) 0.104	0.9999 (0.9997-1.0001) 0.162
Unknown	2.42	62.9 (15992)	57.0 (28884)	1.1043 (1.0831-1.1258)	1.0144 (0.9923-1.0365) 0.191	1.0190 (0.9962-1.0423) 0.103
No match	32.18	58.1 (196016)	53.7 (361785)	1.0807 (1.0748-1.0867)	0.9928 (0.9820-1.0027) 0.196	*0.9982*[*] *(0.9868-1.0097)* *0.761*

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.5 EWHI by dwelling insulation era – all cause hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Insulation Era						
Pre-1980	47.44	50.1 (249341)	46.1 (457604)	1.0869 (1.0816-1.0922)	**1.0115 (1.0024-1.0208) 0.014**	1.0046 (0.9949-1.0144) 0.354
1980-2000	17.96	53.2 (100303)	49.5 (186201)	1.0746 (1.0663-1.0828)	1 Baseline	1 Baseline
Unknown	2.42	62.9 (15992)	57.0 (28884))	1.1043 (1.0832-1.1258)	**1.0277 (1.0065-1.0493) 0.010**	1.0183 (0.9966-1.0406) 0.099
No match	32.18	58.1 (196016)	53.7 (361785)	1.0830 (1.0807-1.0867)	1.0057 (1.0000-1.0153) 0.234	*1.0006*[*] *(0.9905-1.0108) 0.908*

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[*]. As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.6 EWHI by dwelling type – all cause hospitalisations 2000-2006.

	% of pers on years	Rate per 1000 person years (No of hospitalisations)				Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)		Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted			Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.		
		Winter		Non-winter									
Dwelling Type													
Bach	0.46	55.5	(2665)	53.1	(5080)	1.0466	(0.9987-1.0969)	0.9665	(0.9219-1.0133)	0.158	0.9779	(0.9310-1.027)	0.373
Post-war Bung.	28.67	53.1	(159802)	49.1	(294371)	1.0828	(1.0763-1.0895)	1	Baseline			Baseline	
Contemporary	0.76	35.6	(2847)	34.4	(5487)	1.0351	(0.9892-1.0830)	0.9558	(0.9131-1.0005)	0.053	0.9831	(0.9377-1.0307)	0.481
Cottage	0.36	49.8	(1876)	48.2	(3617)	1.0346	(0.9785-1.0939)	0.9554	(0.9033-1.0105)	0.111	0.9670	(0.9134-1.0237)	0.248
Infill	0.22	55.1	(1250)	51.3	(2321)	1.0741	(1.0027-1.1505)	0.9919	(0.9257-1.0627)	0.816	0.9909	(0.9206-1.0665)	0.807
Pre-War Bung.	3.61	44.1	(16680)	39.9	(30102)	1.1053	(1.0846-1.1264)	**1.0207**	**(1.0007-1.0412)**	**0.043**	**1.0296**	**(1.0089-1.0506)**	**0.005**
Quality Bung.	4.23	40.0	(17774)	38.5	(34122)	1.0390	(1.0203-1.0580)	**0.9595**	**(0.9413-0.9780)**	**0.000**	**0.9781**	**(0.9580-0.9985)**	**0.036**
Quality Old	0.32	30.6	(1041)	28.7	(1951)	1.0643	(0.9872-1.1474)	0.9828	(0.9114-1.0599)	0.653	1.0108	(0.9362-1.0914)	0.784
Spanish Mission	0.24	49.4	(1267)	45.1	(2308)	1.0953	(1.0228-1.1730)	1.0115	(0.9443-1.0835)	0.745	1.0207	(0.9523-1.0941)	0.562
State House	2.75	61.9	(17891)	55.3	(31865)	1.1200	(1.0997-1.1407)	**1.0343**	**(1.0145-1.0544)**	**0.001**	1.0007	(0.9799-1.0220)	0.946
Villa	2.06	38.1	(8222)	34.5	(14878)	1.1024	(1.0731-1.1325)	1.0180	(0.9903-1.0465)	0.206	**1.0297**	**(1.0012-1.0591)**	**0.041**
Unknown	24.14	53.0	(134321)	48.8	(246587)	1.0866	(1.0794-1.0938)	1.0034	(0.9944-1.0125)	0.457	1.0088	(0.9992-1.0184)	0.072
No match	32.18	58.1	(196016)	53.7	(361785)	1.0807	(1.0748-1.0867)	0.9980	(0.9988-1.0062)	0.633	*1.0001*[*]	*(0.9914-1.0089)*	*0.980*

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.7 EWHI by floor area decile – all cause hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Floor area decile						
1 – Large	7.43	50.5 (39,377)	47.1 (73,269)	1.0720 (1.0589-1.0852)	1 Baseline	1 Baseline
2	6.76	40.7 (28,895)	38.5 (54,463)	1.0583 (1.0433-1.0735)	0.9872 (0.9689-1.0060) 0.180	0.9924 (0.9732-1.0119) 0.440
3	6.75	43.1 (30,587)	40.5 (57,354)	1.0638 (1.0491-1.0786)	0.9923 (0.9741-1.0109) 0.416	0.9885 (0.9697-1.0077) 0.238
4	6.75	45.7 (32,384)	42.6 (60,181)	1.0734 (1.0590-1.0880)	1.0013 (0.9832-1.0197) 0.888	0.9943 (0.9757-1.0133) 0.557
5.	6.68	48.5 (34,024)	44.4 (62,218)	1.0909 (1.0766-1.1054)	1.0176 (0.9995-1.0361) 0.057	1.0062 (0.9875-1.0252) 0.520
6	6.72	51.1 (36,037)	47.7 (67,058)	1.0720 (1.0584-1.0858)	1.0000 (0.9824-1.0179) 1.000	0.9851 (0.9670-1.0035) 0.112
7	6.80	55.2 (39,377)	50.5 (71,907)	1.0924 (1.0791-1.1059)	**1.0190 (1.0015-1.0369) 0.033**	0.9960 (0.9780-1.0144) 0.669
8	7.04	57.5 (42,436)	52.0 (76,666)	1.1042 (1.0912-1.1174)	**1.0300 (1.0126-1.0477) 0.001**	1.0044 (0.9865-1.0228) 0.630
9	7.00	59.1 (43,458)	53.1 (77,838)	1.1137 (1.1007-1.1269)	**1.0389 (1.0215-1.0567) 0.000**	1.0083 (0.9903-1.0268) 0.368
10 - Small	5.39	63.7 (36,045)	58.8 (66,422)	1.0825 (1.0687-1.0965)	1.0098 (0.9920-1.0279) 0.281	0.9831 (0.9648-1.0017) 0.074
1-10 (Continuous)					**1.0042 (1.0028-1.0057) 0.000**	1.0002 (0.9985-1.0018) 0.837
Unknown	0.51	56.3 (3016)	49.7 (5313)	1.1325 (1.0830-1.1842)	1.0564 (1.0086-1.1065) 0.020	1.0386 (0.9893-1.0903) 0.127
No match	32.18	58.0 (196,016)	53.7 (361,785)	1.0807 (1.0748-1.0867)	1.0082 (0.9947-1.0218) 0.236	0.9987 (0.9849-1.0128) 0.858

People living in Pre-war Bungalows had a higher EWHI than people living in Post-war Bungalows, while people living in Quality Bungalows had a lower EWHI.

While State Rentals also had a higher EWHI than Post-war Bungalows, the difference disappeared after controlling for other variables, indicating that the difference is likely due to the higher proportions of more deprived, Māori, and Pacific Peoples living in State Rentals.*

While the results below are for all age categories, sub-groups with higher overall EWHIs experienced housing differences in different ways. For those in the two 60+ age groups, living in a pre-war bungalow had a greater effect on the EWHI than for all age groups (RRR 1.0517, 95% CI 1.0161-1.0886, p=0.004), while living in a cottage substantially reduced the EWHI (RRR 0.8652, 95% CI 0.7854-0.9531, p=0.003). Children under 5 years and Pacific Peoples, however, showed no significant differences for any housing type, and trends were not all consistent with results for all age or ethnic groups.

7.6.1.4 *Floor area decile*

Although the unadjusted EWHI was higher in some of the higher floor area deciles (smaller dwellings), and showed a trend of increasing EWHI with smaller floor sizes (1.0042, 95% CI 1.0028-1.0057, p=0.000), the differences and trend became very small, and statistically non significant, after adjusting for demographic factors.

7.6.1.5 *Dwelling condition*

People living in dwellings rated as "Poor" condition had a higher unadjusted EWHI than in those living in "Superior" condition dwellings. While the overall direction of results remained the same after controlling for demographic variables, differences were no longer significant. Within sub-groups, NZ Europeans had a significantly higher adjusted EWHI in "Poor" condition dwellings (RRR 1.0344, 95% CI 1.0031-1.0666, p=0.031) than in "Superior" dwellings, while Pacific Peoples had a

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* Differences in age and sex distribution between State Rentals and other dwelling types would have reduced the difference in unadjusted EWH rather than increased it.

significantly lower adjusted EWHI in "Average" condition dwellings (RRR 0.8914, 95% CI 0.8006-0.9925, p=0.036); in "Poor" condition dwellings the direction of the result was the same (RRR 0.9100, 95% CI 0.8094-1.023, p=0.115), but was not significant.

7.6.1.6 Tenure index

With NZDep excluded from the model, tenure index was implicated in EWH, both before and after adjustment for other demographic factors. The EWHI (Table 7.9) in decile 10, with highest meshblock rental tenure levels, was 2.20% higher than in decile 1 (RRR 1.0220, 95% CI 1.0020-1.0423, p=0.031), and there was a significant trend across deciles, with the EWHI increasing with increasing rental tenure (RRR 1.0027, 95% CI 1.0011-1.0042, p=0.001).

7.6.1.7 Capital Value and Capital Value/m^2 deciles.

There was no significant increase in EWHI with increasing CV decile (Table 7.10). However, it is the higher EWHI in CV decile 1 that prevents a significant trend across deciles. Across the nine deciles 2-10, the trend is 1.0020 (95% CI 1.0002-1.0038, p=0.033). As there is also a significant difference between deciles 1 and 2 (RRR 0.9741, 95% CI 0.9552-0.9933, p=0.008), it would appear that there is some other factor that distinguishes occupants of decile 1 properties from other high decile occupants.

For CV/m^2, people living in lowest value properties had a 2.55% higher all-cause EWHI than people living in the highest value properties (RRR 1.0255, 95% CI 1.0061-1.0454, p=0.010). However, there was no significant trend across CV/m^2 after controlling for other variables (Table 7.11).

Surprisingly, although there was a closer association between NZDep and CV than between NZDep and CV/m^2, there was a larger difference in EWHI between CV/m^2 deciles than between CV deciles. However, there were larger differences in EWHI by NZDep than by either of the two CV deciles.

Table 7.8 EWHI by dwelling condition – all cause hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Condition						
Superior	6.57	40.0 (27414)	37.9 (51842)	1.0547 (1.0394-1.0701)	1 Baseline	1 Baseline
Average	54.96	52.0 (298783)	47.9 (549364)	1.0846 (1.0798-1.0894)	**1.0284 (1.0129–1.0441) 0.000**	1.0030 (0.9868–1.0194) 0.720
Poor	3.37	60.0 (20115)	53.9 (37828)	1.1119 (1.0936-1.1305)	**1.0543 (1.0312–1.0778) 0.000**	1.0147 (0.9909–1.0391) 0.229
Poor-Superior (continuous)					**0.9750 (0.9649-0.9852) 0.000**	0.9941 (0.9828-1.0056) 0.314
Unknown	3.22	54.4 (18326)	50.1 (33655)	1.0944 (1.0732-1.1161)	**1.0377 (1.0127-1.0633) 0.003**	1.0159 (0.9901-1.0424) 0.229
No match	31.88	58.0 (196016)	53.7 (361785)	1.0807 (1.0748-1.0867)	**1.0247 (1.0089-1.0408) 0.002**	*1.0048*[*] *(0.9885-1.0213) 0.566*

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.9 EWHI by tenure index decile – all cause hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, rurality, annual average minimum temperature, and winter interaction terms.[*]**
		Winter	**Non-winter**			
Tenure index decile						
1	5.82	43.3 (26,441)	40.9 (49,815)	1.0588 (1.0431-1.0747)	1 Baseline	1 Baseline
2	6.01	46.1 (29,138)	43.6 (54,920)	1.0583 (1.0434-1.0734)	0.9996 (0.9792-1.0203) 0.966	0.9962 (0.9752-1.0177) 0.729
3	6.09	46.9 (30,002)	44.4 (56,678)	1.0559 (1.0412-1.0708)	0.9973 (0.9771-1.0179) 0.794	0.9929 (0.9721-1.0141) 0.509
4	6.28	48.6 (32,027)	45.5 (59,803)	1.0683 (1.0539-1.0829)	1.0090 (0.9889-1.0296) 0.383	1.0003 (0.9796-1.0214) 0.978
5.	6.32	50.2 (33,306)	46.6 (61,746)	1.0761 (1.0618-1.0905)	1.0163 (0.9962-1.0368) 0.113	1.0051 (0.9845-1.0261) 0.629
6	6.50	52.5 (35,844)	48.2 (65,570)	1.0904 (1.0765-1.1046)	**1.0299 (1.0098-1.0504) 0.003**	1.0116 (0.9911-1.0324) 0.270
7	6.68	53.7 (37,640)	49.3 (68,916)	1.0894 (1.0758-1.1032)	**1.0289 (1.0091-1.0492) 0.004**	1.0109 (0.9906-1.0316) 0.295
8	7.03	54.0 (39,868)	49.5 (72,901)	1.0909 (1.0777-1.1043)	**1.0304 (1.0107-1.0504) 0.002**	1.0115 (0.9913-1.0321) 0.268
9	7.42	56.0 (43,630)	51.1 (79,393)	1.0962 (1.0835-1.1091)	**1.0353 (1.0159-1.0551) 0.000**	1.0095 (0.9895-1.0298) 0.355
10	8.85	57.5 (53,419)	51.2 (94,965)	1.1221 (1.1103-1.1341)	**1.0598 (1.0406-1.0794) 0.000**	**1.0220 (1.0020-1.0423) 0.031**
1-10 (Continuous)					**1.0063 (1.0049-1.0077) 0.000**	**1.0027 (1.0011-1.0042) 0.001**
Unknown	0.81	50.8 (53,419)	47.1 (94,965)	1.0797 (1.0405-1.1205)	1.0198 (0.9799-1.0613) 0.336	1.0188 (0.9779-1.0613) 0.373
No match	32.18	58.0 (196,016)	53.7 (361,785)	1.0807 (1.0748-1.0867)	**1.0207 (1.0046-1.0371) 0.011**	1.0051 (0.9885-1.0220) 0.550

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[*] The results in this table do not control for NZDep decile, as tenure status is one of the components of NZDep.

Table 7.10 EWHI by Capital Value decile – all cause hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, rurality, annual average minimum temperature, and winter interaction terms.[*]**
		Winter	**Non-winter**			
CV decile						
1	6.85	51.0 (36662)	47.5 (68078)	1.0742 (1.0606-1.0879)	1 Baseline	1 Baseline
2	6.84	41.1 (29509)	39.3 (56358)	1.0445 (1.0298-1.0593)	**0.9723 (0.951-0.9909) 0.004**	**0.9741 (0.9552-0.9933) 0.008**
3	6.91	43.8 (31745)	41.1 (59439)	1.0653 (1.0509-1.0800)	0.9918 (0.9734-1.0104) 0.385	0.9886 (0.9698-1.0078) 0.243
4	6.67	46.3 (32407)	43.3 (60451)	1.0694 (1.0551-1.0839)	0.9955 (0.9773-1.0142) 0.637	0.9835 (0.9649-1.0025) 0.089
5.	6.83	49.0 (35118)	45.0 (64318)	1.0892 (1.0752-1.1035)	1.0140 (0.9957-1.0326) 0.134	1.0015 (0.9828-1.0206) 0.874
6	6.69	52.2 (36695)	47.7 (66877)	1.0945 (1.0807-1.1085)	**1.0189 (1.0008-1.0374) 0.041**	1.0026 (0.9840-1.0215) 0.785
7	6.83	54.0 (38722)	49.6 (71009)	1.0878 (1.0744-1.1014)	1.0127 (0.9949-1.0308) 0.163	0.9947 (0.9765-1.0132) 0.573
8	6.93	56.2 (40884)	50.8 (73815)	1.1049 (1.0916-1.1183)	**1.0286 (1.0107-1.0468) 0.002**	1.0040 (0.9857-1.0226) 0.669
9	6.58	59.3 (40933)	54.0 (74455)	1.0966 (1.0835-1.1100)	**1.0209 (1.0032-1.0390) 0.020**	0.9916 (0.9735-1.0101) 0.371
10	6.68	61.2 (42961)	55.6 (77889)	1.1003 (1.0874-1.1133)	**1.0243 (1.0067-1.0422) 0.007**	0.9945 (0.9763-1.0130) 0.559
1-10 (Continuous)					**1.0047 (1.0033-1.0062) 0.000**	1.0010 (0.9995-1.0026) 0.192
No match	32.18	58.0 (196016)	53.7 (361785)	1.0807 (1.0748-1.0867)	1.0061 (0.9922-1.0201) 0.389	0.9920 (0.9779-1.0063) 0.269

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[*] The results in this table do not control for NZDep decile, as CV decile was an alternative measure of SES.

Table 7.11 EWHI by CV/m^2 decile – all cause hospitalisations 2000-2006.

	% of person years	Rate per 1000 person years (No of hospitalisations)		Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)	Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted	Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, rurality, annual average minimum temperature, and winter interaction terms.[*]
		Winter	Non-winter			
CV/m^2 decile						
1	6.73	45.6 (32185)	43.0 (60660)	1.0584 (1.0442-1.0728)	1 Baseline	1 Baseline
2	6.69	48.6 (34181)	45.3 (63456)	1.0745 (1.0605-1.0887)	1.0152 (0.9963-1.0345) 0.116	1.0094 (0.9901-1.0291) 0.342
3	6.73	49.9 (35291)	46.0 (64939)	1.0841 (1.0701-1.0982)	**1.0243 (1.0053-1.0436) 0.012**	1.0153 (0.9960-1.0351) 0.121
4	6.69	50.1 (35644)	46.6 (65325)	1.0884 (1.0745-1.1026)	**1.0284 (1.0093-1.0478) 0.003**	1.0193 (0.9999-1.0391) 0.051
5.	6.71	52.0 (36671)	48.1 (67592)	1.0822 (1.0686-1.0961)	**1.0225 (1.0037-1.0417) 0.019**	1.0106 (0.9914-1.0302) 0.280
6	6.68	52.9 (37095)	48.4 (67716)	1.0927 (1.0790-1.1067)	**1.0324 (1.0135-1.0517) 0.001**	1.0170 (0.9977-1.0367) 0.084
7	6.69	52.7 (36973)	48.9 (68481)	1.0769 (1.0634-1.0906)	**1.0175 (0.9988-1.0365) 0.067**	1.0013 (0.9823-1.0207) 0.896
8	6.70	51.2 (36551)	47.9 (67254)	1.0841 (1.0704-1.0980)	**1.0243 (1.0055-1.0435) 0.011**	1.0078 (0.9886-1.0274) 0.430
9	6.71	53.7 (37841)	49.2 (69120)	1.0921 (1.0785-1.1058)	**1.0318 (1.0130-1.0510) 0.001**	1.0140 (0.9948-1.0336) 0.154
10	6.71	54.8 (38595)	49.7 (69836)	1.1024 (1.0888-1.1162)	**1.0416 (1.0226-1.0609) 0.000**	**1.0255 (1.0061-1.0454) 0.010**
1-10 (Continuous)					**1.0027 (1.0013-1.0041) 0.000**	1.0010 (0.9995-1.0025) 0.179
Unknown	0.78	56.3 (4609)	50.1 (8310)	1.1064 (1.0673-1.1469)	**1.0453 (1.0059-1.0863) 0.024**	1.0346 (0.9941-1.0767) 0.095
No match	32.18	58.0 (196016)	53.7 (361785)	1.0807 (1.0748-1.0867)	**1.0211 (1.0063-1.0361) 0.005**	1.0089 (0.9938-1.0241) 0.248

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[*] The results in this table do not control for NZDep decile, as CV/m^2 decile was an alternative measure of SES.

7.6.1.8 Housing in the 65+ age group.

Although some of the results closely match those already described, results for the 65+ age group are summarised in this section because other winter excess studies are often limited to that age group.

For those aged 65+, house type was more important than for younger ages; the elderly were clearly better off living in smaller dwelling types such as Cottages (RRR 0.8541, 95% CI 0.7674-0.9506 p=0.004) and Baches (RRR 0.8950, 95% CI 0.8194-0.9775 p=0.014), or in Quality Bungalows (RRR 0.9642, 95% CI 0.9312-0.9984 p=0.041), than in the baseline Post-war Bungalow, and worse off in Villas (RRR 1.0560, 95% CI 1.0006-1.1208, p=0.048) and Pre-war Bungalows (RRR 1.0607, 95% CI 1.0219-1.1011 p=0.002), which are generally larger, older, and harder to heat.

However, although total hospitalisation rates by floor area decile followed the same pattern as for all age groups, regressions for EWHI by floor area decile in those aged 65+ returned unusual results, with significantly lower EWHIs in deciles 2, 3, and 6, than in other deciles.

In the 65+ ages, the lower EWHI in Cottages and Baches was most strongly influenced by results in ICD-10 Chapter IX (Circulatory) (see below); while the higher EWHI in pre-war bungalows was most influenced by ICD-10 Chapters XIX (Injury) and II (Neoplasms).

7.6.2 Respiratory admissions

7.6.2.1 Construction Decade

Eighteen-nineties dwellings had a significantly lower $EWHI_{10}$ than 1960s dwellings (RRR 0.7889, 95% CI 0.6357-0.9791, p=0.031), and 1990s dwellings significantly more (RRR 1.1010, 95% CI 1.0054-1.2055, p=0.038) (Table 7.12). Otherwise, there was no significant difference (and very little insignificant difference either) in $EWHI_{10}$ between dwellings built in the 1960s, and dwellings built in any other decade. Unmatched dwellings, however, had significantly lower EWH_{10} than 1960s dwellings

(RRR 0.9524, 95% CI 0.9259-0.9797, p=0.001). There was no trend in EWH_{10} across construction decades.

7.6.2.2 *Insulation Era*

Insulation era made no significant difference to EWH_{10} (Table 7.13).

7.6.2.3 *Dwelling Type*

The unadjusted $EWHI_{10}$ was significantly lower in Baches, and higher in Spanish Bungalows and State Rentals, than in Post-war Bungalows (Table 7.14).

After controlling for demographic variables, the direction of results remained the same for most house types, but was no longer significant for Baches. State Rentals were no longer different from the baseline. EWH_{10} in Spanish Bungalows, however, remained significantly higher (RRR 1.2227, 95% CI 1.0170-1.4701, p=0.32) than in Post-war Bungalows.

7.6.2.4 *Floor area decile*

The unadjusted $EWHI_{10}$ increased with decreasing dwelling size, but there was no significant difference in $EWHI_{10}$ by floor area after controlling for demographic factors (Table 7.15).

7.6.2.5 *Dwelling condition*

There were large differences in unadjusted $EWHI_{10}$ by dwelling condition (Table 7.16), with the EWHI 5.93%% (RRR 1.0593, 95% CI 1.0144-1.1061, p=0.009) higher in

"Average" dwellings, and 11.43% (RRR 1.1143, 95% CI 1.0527-1.1795, p=0.000) higher in "Poor" dwellings, than in "Superior" dwellings. There was a significant trend of decreasing $EWHI_{10}$ with increasing dwelling condition rating. As with the all-cause EWHI, however, after controlling for demographic variables, the association was weaker and no longer significant.

Table 7.12 EWHI by decade of dwelling construction – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	Rate per 1000 person years (No of hospitalisations)				Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)		Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted			Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.		
		Winter		Non-winter									
Decade													
Pre-1890s	0.13	3.9	(53)	2.7	(73)	1.4483	(1.0168-2.0629)	0.8058	(0.5654-1.1486)	0.233	0.8089	(0.5652-1.1578)	0.246
1890s	0.31	4.3	(144)	3.2	(210)	1.3678	(1.1065-1.6909)	**0.7611**	**(0.6149-0.9420)**	**0.012**	**0.7889**	**(0.6357-0.9791)**	**0.031**
1900s	1.46	6.6	(1011)	3.4	(1044)	1.9317	(1.7717-2.1062)	1.0748	(0.9828-1.1754)	0.114	**1.1010**	**(1.0054-1.2055)**	**0.038**
1910s	2.97	7.6	(2369)	4.3	(2660)	1.7789	(1.6831-1.8801)	0.9898	(0.9322-1.0509)	0.737	1.0091	(0.9494-1.0726)	0.771
1920s	3.83	7.5	(3030)	4.3	(3442)	1.7560	(1.6723-1.8439)	0.9770	(0.9258-1.0312)	0.399	0.9916	(0.9384-1.0478)	0.764
1930s	2.44	8.2	(2112)	4.6	(2347)	1.7950	(1.6925-1.9037)	0.9988	(0.9377-1.0638)	0.969	1.0101	(0.9472-1.0771)	0.760
1940s	3.75	11.2	(4423)	6.3	(4954)	1.7815	(1.7107-1.8552)	0.9912	(0.9461-1.0385)	0.711	0.9877	(0.9422-1.0355)	0.608
1950s	8.42	11.1	(9821)	6.3	(11043)	1.7740	(1.7265-1.8229)	0.9871	(0.9526-1.0228)	0.473	0.9897	(0.9545-1.0262)	0.574
1960s	12.11	11.0	(13944)	6.1	(15479)	1.7973	(1.7566-1.8389)	1	Baseline		1	Baseline	
1970s	12.00	10.7	(13414)	6.0	(14980)	1.7863	(1.7452-1.8285)	0.9939	(0.9620-1.0269)	0.715	1.0024	(0.9695-1.0364)	0.888
1980s	7.53	10.1	(7979)	5.7	(8989)	1.7706	(1.7180-1.8248)	0.9852	(0.9486-1.0232)	0.439	0.9998	(0.9611-1.0400)	0.991
1990s	6.64	9.0	(6314)	5.3	(7338)	1.7164	(1.6596-1.7751)	**0.9550**	**(0.9169-0.9947)**	**0.027**	0.9823	(0.9403-1.0262)	0.424
2000s	3.79	10.6	(4220)	5.8	(4627)	1.8196	(1.7452-1.8971)	1.0124	(0.9654-1.0618)	0.611	1.0368	(0.9839-1.0926)	0.176
Continuous									Regression did not resolve		1.0000	(0.9996-1.0005)	0.836
Unknown	2.42	11.5	(2928)	6.3	(3180)	1.8365	(1.7465-1.9310)	1.0218	(0.9670-1.0798)	0.443	1.0315	(0.9733-1.0932)	0.295
No match	32.18	10.2	(34398)	6.2	(41472)	1.6545	(1.6310-1.6783)	**0.9205**	**(0.8960-0.9457)**	**0.000**	***0.9524***[*]	***(0.9259-0.9797***	***0.001***

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.13 EWHI by dwelling insulation era – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Insulation Era						
Pre-1980	47.44	10.1 (50321)	5.7 (56232)	1.7853 (1.7640-1.8070)	1.0130 (0.9898-1.0367) 0.273	0.9974 (0.9728-1.0226) 0.838
1980-2000	17.96	10.1 (55839)	6.0 (65606)	1.7624 (1.7279-1.7976)	1 Baseline	1 Baseline
Unknown	2.42	11.5 (2928)	6.3 (3180)	1.8365 (1.7466-1.9310)	1.0420 (0.9873-1.0998) 0.135	1.0304 (0.9734-1.0908) 0.303
No match	32.18	10.2 (34398)	6.2 (41472)	1.6545 (1.6310-1.6783)	**0.9387 (0.9161-0.9619) 0.000**	***0.9530*[*] *(0.9283-0.9783) 0.000***

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.14 EWHI by dwelling type – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Dwelling Type						
Bach	0.46	9.6 (460)	6.3 (605)	1.5169 (1.3437-1.7124)	**0.8583 (0.7596-0.9699) 0.014**	0.8975 (0.7890-1.0209) 0.100
Post-war Bung.	28.67	10.8 (32394)	6.1 (36567)	1.7673 (1.7410-1.7939)	1 Baseline	1 Baseline
Contemporary	0.76	5.7 (453)	3.4 (541)	1.6704 (1.4744-1.8924)	0.9452 (0.8335-1.0718) 0.379	0.9810 (0.8614-1.1172) 0.772
Cottage	0.36	9.2 (348)	5.4 (407)	1.7056 (1.4782-1.9680)	0.9651 (0.8358-1.1145) 0.629	0.9725 (0.8398-1.1262) 0.709
Infill	0.22	8.9 (202)	4.8 (217)	1.8565 (1.5327-2.2486)	1.0505 (0.8668-1.2731) 0.615	1.0646 (0.8670-1.3073) 0.550
Pre-War Bung.	3.61	8.4 (3161)	4.7 (3535)	1.7837 (1.7002-1.8714)	1.0093 (0.9599-1.0614) 0.717	1.0186 (0.9677-1.0722) 0.480
Quality Bung.	4.23	5.9 (2614)	3.5 (3081)	1.6923 (1.6064-1.7829)	0.9576 (0.9071-1.0110) 0.117	1.0182 (0.9605-1.0794) 0.544
Quality Old	0.32	4.3 (147)	2.8 (192)	1.5272 (1.2320-1.8931)	0.8642 (0.6968-1.0718) 0.184	0.9158 (0.7372-1.1375) 0.427
Spanish Mission	0.24	9.4 (240)	4.4 (223)	2.1474 (1.7895-2.5768)	**1.2151 (1.0120-1.4590) 0.037**	**1.2227 (1.0170-1.4701) 0.032**
State House	2.75	16.3 (4721)	8.8 (5095)	1.8488 (1.7770-1.9234)	**1.0461 (1.0028-1.0914) 0.037**	0.9860 (0.9412-1.0330) 0.554
Villa	2.06	7.0 (1505)	4.0 (1719)	1.7464 (1.6297-1.8716)	0.9882 (0.9207-1.0607) 0.743	0.9987 (0.9293-1.0732) 0.971
No type	24.14	10.1 (28184)	5.6 (25521)	1.8063 (1.7760-1.8372)	1.0221 (0.9993-1.0455) 0.058	**1.0296 (1.0053-1.0545) 0.017**
No match	32.18	10.2 (34398)	6.2 (41472)	1.6545 (1.6310-1.6783)	**0.9361 (0.9170-0.9557) 0.000**	***0.9641***[*] ***(0.9431-0.9856) 0.001***

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.15 EWHI by floor area decile – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Floor area decile						
1	7.43	8.3 (6,441)	4.8 (7,518)	1.7089 (1.6530-1.7667)	1 Baseline	1 Baseline
2	6.76	6.7 (4,728)	3.7 (5,292)	1.7822 (1.7136-1.8535)	1.0429 (0.9906-1.0979) 0.110	1.0473 (0.9930-1.1046) 0.089
3	6.75	7.5 (5,352)	4.3 (6,045)	1.7660 (1.7022-1.8322)	1.0334 (0.9834-1.0860) 0.194	1.0191 (0.9679-1.0731) 0.471
4	6.75	8.2 (5,780)	4.6 (6,565)	1.7562 (1.6952-1.8194)	1.0277 (0.9790-1.0788) 0.270	1.0162 (0.9662-1.0688) 0.532
5.	6.68	9.3 (6,524)	5.2 (7,218)	1.8031 (1.7437-1.8644)	**1.0551 (1.0064-1.1061) 0.026**	1.0439 (0.9937-1.0966) 0.087
6	6.72	9.8 (6,946)	5.6 (7,857)	1.7635 (1.7075-1.8213)	1.0319 (0.9852-1.0809) 0.184	1.0047 (0.9572-1.0546) 0.849
7	6.80	11.7 (8,340)	6.5 (9,269)	1.7949 (1.7426-1.8488)	**1.0503 (1.0046-1.0981) 0.031**	1.0095 (0.9631-1.0581) 0.693
8	7.04	13.1 (9,645)	7.2 (10,666)	1.8039 (1.7549-1.8543)	**1.0556 (1.0110-1.1022) 0.014**	0.9996 (0.9546-1.0468) 0.987
9	7.00	13.6 (10,020)	7.5 (11,001)	1.8169 (1.7684-1.8668)	**1.0632 (1.0186-1.1098) 0.005**	0.9960 (0.9511-1.0429) 0.864
10	5.39	13.1 (7,442)	7.4 (8,343)	1.7793 (1.7246-1.8358)	1.0412 (0.9947-1.0898) 0.083	1.0028 (0.9553-1.0526) 0.910
1-10 (Continuous)					**1.0043 1.0007-1.0080 0.019**	0.9974 (0.9933-1.0016) 0.229
Unknown	0.51	10.3 (551)	5.5 (592)	1.8568 (1.6534-2.0853)	1.0866 (0.9630-1.2259) 0.178	1.0536 (0.9282-1.1958) 0.419
No match	32.18	10.2 (34398)	6.2 (41472)	1.6545 (1.6310-1.6783)	0.9681 (0.9337-1.0038) 0.080	*0.9651*[*] *(0.9293-1.0022) 0.065*

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.16 EWHI by dwelling condition – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
Condition						
Superior	6.50	5.9 (4049)	3.5 (4808)	1.6799 (1.6111-1.7516)	1 Baseline	1 Baseline
Average	55.13	10.3 (59698)	5.8 (66923)	1.7794 (1.7599-1.7991)	**1.0593 (1.0144-1.1061) 0.009**	1.0085 (0.9632-1.0560) 0.718
Poor	3.47	13.9 (5023)	7.4 (5353)	1.8719 (1.8012-1.9453)	**1.1143 (1.0527-1.1795) 0.000**	1.0304 (0.9692-1.0954) 0.337
Poor – Superior (Continuous)					**0.9531 (0.9293-0.9774) 0.000**	0.9887 (0.9609-1.0173) 0.436
Unknown	2.68	10.7 (5023)	5.9 (3282)	1.8227 (1.7346-1.9152)	**1.0850 (1.0169-1.1577) 0.014**	1.0377 (0.9691-1.1112) 0.289
No match	32.22	10.2 (34398)	6.2 (41472)	1.6545 (1.6310-1.6783)	0.9849 (0.9423-1.0294) 0.499	*0.9640*[*] *(0.9205-1.0096) 0.120*

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

Table 7.17 EWHI by tenure index decile – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, rurality, annual average minimum temperature, and winter interaction terms.***
		Winter	**Non-winter**			
Tenure index decile						
1	5.82	6.7 (4,094)	4.0 (4,878)	1.6742 (1.6060-1.7452)	1 Baseline	
2	6.01	7.6 (4,831)	4.4 (5,584)	1.7257 (1.6605-1.7935)	1.0308 (0.9740-1.0909) 0.294	1.0320 (0.9732-1.0944) 0.293
3	6.09	7.9 (5,083)	4.6 (5,871)	1.7270 (1.6634-1.7931)	1.0316 (0.9754-1.0910) 0.277	1.0274 (0.9695-1.0888) 0.361
4	6.28	8.6 (5,658)	5.0 (6,558)	1.7211 (1.6610-1.7834)	1.0280 (0.9733-1.0858) 0.322	1.0239 (0.9674-1.0836) 0.415
5.	6.32	9.2 (6,082)	5.3 (6,964)	1.7422 (1.6833-1.8032)	1.0407 (0.9860-1.0983) 0.147	1.0312 (0.9751-1.0904) 0.282
6	6.50	9.9 (6,737)	5.6 (7,604)	1.7673 (1.7103-1.8262)	**1.0557 (1.0012-1.1130) 0.045**	1.0316 (0.9765-1.0899) 0.267
7	6.68	10.6 (7,455)	5.8 (8,097)	1.8365 (1.7796-1.8952)	**1.0970 (1.0413-1.1557) 0.000**	**1.0677 (1.0113-1.1273) 0.018**
8	7.03	11.2 (8,266)	6.4 (9,439)	1.7469 (1.6961-1.7993)	1.0435 (0.9916-1.0980) 0.102	1.0191 (0.9660-1.0752) 0.488
9	7.42	12.3 (9,605)	6.9 (10,699)	1.7908 (1.7421-1.8408)	**1.0697 (1.0177-1.1243) 0.008**	1.0315 (0.9786-1.0874) 0.248
10	8.85	14.2 (13,207)	7.5 (13,841)	1.9034 (1.8586-1.9494)	**1.1370 (1.0838-1.1927) 0.000**	**1.0810 (1.0263-1.1386) 0.003**
1-10 (Continuous)					**1.0112 (1.0076-1.0149) 0.000**	**1.0051 (1.0011-1.0092) 0.012**
Unknown	0.81	8.8 (751)	4.9 (831)	1.8025 (1.6332-1.9895)	1.0767 (0.9674-1.1984) 0.176	1.0720 (0.9603-1.1968) 0.215
No match	32.18	10.2 (34,398)	6.2 (41,472)	1.6545 (1.6310-1.6783)	0.9882 (0.9458-1.0326) 0.597	0.9890 (0.9444-1.0358) 0.640

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* The results in this table do not control for NZDep decile, as tenure status is one of the components of NZDep.

7.6.2.6 Tenure index

As with the all-cause EWHI, the EWHI_{10} increased with increasing mesh-block rental tenure levels both before and after adjustment for demographic variables (Table 7.17). After adjustment, the EWHI_{10} was significantly higher than decile 1 in deciles 7 (RRR 1.0677, 95% CI 1.0113-1.1273, p=0.018) and 10 (RRR 1.0810, 95% CI 1.0263-1.1386, p=0.003), and there was a significant trend of increasing EWHI with increasing proportion of households renting (1.0051, 95% CI 1.0011-1.0092, p=0.012).

7.6.2.7 CV and CV/m^2

The unadjusted EWHI_{10} increased with decreasing relative capital value, with a significant trend of 1.0079 (95% CI 1.0042-1.0116, p=0.000), but after adjusting for demographic factors, differences were no longer significant (Table 7.18).

The unadjusted EWHI_{10} was higher in the lower value deciles, with a trend of 1.0061 (95% CI 1.0026-1.0096, p=0.001) across deciles 1-10. After controlling for demographic variables, the trend was no longer significant, but the EWHI_{10} in CV/m^2 decile 10 remained significantly higher than in decile 1, with an RRR of 1.0526 (95% CI 1.017-1.1061, p=0.043) (Table 7.19).

As with all-cause hospitalisations, the difference in EWHI between highest and lowest deciles was significant for CV/m^2 decile, but not significant for CV decile. The difference was also more than twice as big for EWHI_{10} (5.26% compared with the 2.55% for all-cause EWHI), but, as with all-cause, was less than the difference for NZDep decile 10, which was 7.90% (RRR 1.0790, 95% CI 1.0310-1.1293, p=0.001) higher than the EWHI_{10} in NZDep decile 1.

7.6.2.8 Sub-groups

There were no significant differences in EWHI_{10} by housing type, construction era, condition, nor insulation era in the 0 to 4 years age group, nor in those aged 65+.

Table 7.18 EWHI by CV decile – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	Rate per 1000 person years (No of hospitalisations) Winter	Non-winter	Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)	Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted	Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, rurality, annual average minimum temperature, and winter interaction terms.[*]
CV decile						
1	6.85	8.1 (5844)	4.8 (6827)	1.7074 (1.6488-1.7681)	1 Baseline	1 Baseline
2	6.84	6.4 (4622)	3.8 (5501)	1.6760 (1.6117-1.7429)	0.9816 (0.9314-1.0344) 0.487	0.9801 (0.9285-1.0346) 0.467
3	6.91	7.3 (5277)	4.0 (5859)	1.7966 (1.7310-1.8647)	1.0522 (0.9999-1.1073) 0.051	1.0469 (0.9931-1.1036) 0.089
4	6.67	8.1 (5694)	4.6 (6438)	1.7643 (1.7025-1.8283)	1.0333 (0.9830-1.0862) 0.199	1.0126 (0.9616-1.0664) 0.635
5.	6.83	9.1 (6497)	5.2 (7445)	1.7409 (1.6839-1.7998)	1.0196 (0.9716-1.0700) 0.431	0.9961 (0.9474-1.0473) 0.878
6	6.69	10.4 (7277)	5.8 (8136)	1.7841 (1.7286-1.8415)	1.0449 (0.9968-1.0953) 0.068	1.0207 (0.9717-1.0722) 0.415
7	6.83	11.3 (8103)	6.3 (8989)	1.7982 (1.7450-1.8530)	**1.0532 (1.0058-1.1028) 0.028**	1.0215 (0.9734-1.0719) 0.387
8	6.93	12.3 (8925)	6.7 (9662)	1.8427 (1.7904-1.8964)	**1.0792 (1.0315-1.1292) 0.001**	1.0345 (0.9863-1.0850) 0.164
9	6.58	13.6 (9383)	7.6 (10497)	1.7831 (1.7341-1.8334)	1.0443 (0.9987-1.0920) 0.057	0.9980 (0.9518-1.0465) 0.934
10	6.68	14.5 (10147)	7.9 (11012)	1.8381 (1.7892-1.8884)	**1.0765 (1.0300-1.1251) 0.001**	1.0225 (0.9752-1.0721) 0.357
1-10 (Continuous)					**1.0079 (1.0042-1.0116) 0.000**	1.0019 (0.9979-1.0059) 0.362
No match	32.18	10.2 (34398)	6.2 (41472)	1.6545 (1.6310-1.6783)	0.9690 (0.9331-1.0062) 0.102	0.9666 (0.9296-1.0052) 0.089

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[*] The results in this table do not control for NZDep decile, as CV decile was an alternative measure of SES.

Table 7.19 EWHI by CV/m^2 decile – respiratory (ICD-10 Chapter X) hospitalisations 2000-2006.

	% of person years	Rate per 1000 person years (No of hospitalisations)		Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)	Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted	Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, rurality, annual average minimum temperature, and winter interaction terms.*
		Winter	Non-winter			
CV/m^2 decile						
1	6.73	7.4 (5259)	4.3 (6123)	1.7133 (1.6513-1.7776)	1 Baseline	1 Baseline
2	6.69	8.5 (5975)	4.8 (6738)	1.7689 (1.7084-1.8316)	1.0324 (0.9814-1.0861) 0.217	1.0238 (0.9720-1.0784) 0.374
3	6.73	9.3 (6544)	5.3 (7475)	1.7464 (1.6894-1.8053)	1.0193 (0.9700-1.0711) 0.450	1.0106 (0.9604-1.0633) 0.685
4	6.69	9.8 (6890)	5.5 (7645)	1.7978 (1.7402-1.8573)	1.0493 (0.9989-1.1022) 0.055	1.0481 (0.9964-1.1026) 0.069
5.	6.71	10.4 (7302)	5.9 (8248)	1.7660 (1.7113-1.8225)	1.0307 (0.9820-1.0819) 0.221	1.0185 (0.9687-1.0708) 0.474
6	6.68	10.4 (7287)	5.9 (8320)	1.7471 (1.6930-1.8029)	1.0197 (0.9715-1.0703) 0.430	0.9995 (0.9507-1.0508) 0.986
7	6.69	11.0 (7702)	6.1 (8589)	1.7886 (1.7345-1.8445)	1.0440 (0.9950-1.0953) 0.079	1.0253 (0.9754-1.0777) 0.326
8	6.70	10.7 (7495)	6.1 (8601)	1.7383 (1.6853-1.7930)	1.0146 (0.9669-1.0646) 0.556	0.9894 (0.9411-1.0402) 0.677
9	6.71	11.7 (8222)	6.3 (8849)	1.8534 (1.7986-1.9099)	**1.0818 (1.0316-1.1344) 0.001**	1.0451 (0.9947-1.0981) 0.080
10	6.71	11.7 (8237)	6.3 (8839)	1.8589 (1.8040-1.9156)	**1.0850 (1.0346-1.1378) 0.001**	**1.0526 (1.0017-1.1061) 0.043**
1-10 (Continuous)					**1.0061 (1.0026-1.0096) 0.001**	1.0025 (0.9987-1.0063) 0.193
Unknown	0.78	10.5 (856)	5.8 (939)	1.8185 (1.6576-1.9950)	1.0614 (0.9607-1.1726) 0.241	1.0418 (0.9393-1.1555) 0.438
No match	32.18	10.2 (34398)	6.2 (41472)	1.6545 (1.6310-1.6783)	0.9656 (0.9282-1.0046) 0.083	0.9724 (0.9337-1.0127) 0.176

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[*] The results in this table do not control for NZDep decile, as CV/m^2 decile was an alternative measure of SES.

Table 7.20 EWHI by dwelling type – circulatory (ICD-10 Chapter IX) hospitalisations for ages 65+, 2000-2006.

	% of person years	**Rate per 1000 person years (No of hospitalisations)**		**Winter:non winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Unadjusted**	**Winter:non-winter ratio relative to reference category (95% CI), p-value. Controlled for age, gender, ethnicity, NZDep decile, rurality, annual average minimum temperature, and winter interaction terms.**
		Winter	**Non-winter**			
House Type						
Bach	0.43	39.9 (206)	45.8 (472)	0.8638 (0.7358-1.0141)	**0.7820 (0.6653-0.9191) 0.003**	**0.7712 (0.6532-0.9106) 0.002**
Post-war Bung.	26.06	47.1 (14585)	42.5 (26256)	1.1047 (1.0830-1.1267)	1 Baseline	1 Baseline
Contemporary	0.59	35.2 (247)	29.9 (419)	1.1431 (0.9809-1.3322)	1.0348 (0.8869-1.2075) 0.664	1.0600 (0.9037-1.2433) 0.474
Cottage	0.35	37.0 (152)	40.2 (329)	0.9279 (0.7669-1.1227)	0.8400 (0.6936-1.0174) 0.075	**0.8179 (0.6739-0.9927) 0.042**
Infill	0.23	45.5 (122)	42.8 (229)	1.0751 (0.8741-1.3224)	0.9733 (0.7906-1.1982) 0.798	0.9549 (0.7658-1.1908) 0.682
Pre-War Bung.	2.71	45.1 (1450)	38.4 (2465)	1.1785 (1.1051-1.2568)	1.0668 (0.9974-1.1411) 0.060	1.0463 (0.9772-1.1203) 0.194
Quality Bung.	4.15	35.6 (1759)	33.4 (3287)	1.0816 (1.0226-1.1440)	0.9792 (0.9226-1.0391) 0.487	0.9661 (0.9067-1.0295) 0.288
Quality Old	0.23	31.9 (89)	26.2 (146)	1.1758 (0.9049-1.5278)	1.0643 (0.8185-1.3840) 0.642	1.0900 (0.8363-1.4207) 0.524
Spanish Mission	0.23	51.1 (142)	51.1 (283)	1.0080 (0.8250-1.2317)	0.9125 (0.7461-1.1161) 0.373	0.8968 (0.7319-1.0987) 0.293
State House	1.71	50.6 (1030)	42.4 (1723)	1.1948 (1.1064-1.2903)	1.0816 (0.9991-1.1710) 0.053	1.0706 (0.9837-1.1652) 0.114
Villa	1.33	37.2 (587)	33.6 (1055)	1.1122 (1.0062-1.2295)	1.0068 (0.9091-1.1151) 0.896	0.9909 (0.8934-1.0991) 0.863
Unknown	22.46	48.1 (12828)	42.6 (22700)	1.1271 (1.1034-1.1513)	1.0203 (0.9911-1.0504) 0.175	1.0142 (0.9838-1.0457) 0.364
No match	39.52	56.3 (26456)	49.6 (46459)	1.1367 (1.1200-1.1535)	**1.0290 (1.0039-1.0547) 0.023**	*1.0083*[*] *(0.9783-1.0392) 0.591*

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[*] As QV data includes the meshblock for each dwelling, the regressions for this column use meshblock rather than Census Area Unit-level NZDep. Meshblock-level NZDep is preferable where available because it is based on smaller area units. However, meshblocks are unknown for people living in "No match" dwellings, so no meshblock-based RRR is available for that group. The figure included for "No match" dwellings in this column comes from the same regression run using Census Area Unit-level NZDep.

7.6.3 Circulatory admissions.

There were no significant differences in circulatory EWHI by any housing variable when all age groups were considered together. However, when ages 65+ were considered separately, people living in Baches (RRR 0.7712, 95% CI 0.6532-0.9106, p=0.002) and Cottages (RRR 0.8179, 95% CI 0.6739-0.9927, p=0.042) had a significantly lower $EWHI_9$ than people living in post-war bungalows (Table 7.20). The result for Baches should be treated with caution, given that Baches are the one housing type where occupancy is likely to vary by season, with higher occupancy in summer than in winter.

When the model also controlled for Dwelling Condition, the RRRs for Baches (RRR 0.7447, 95% CI 0.6253-0.8871, p=0.001) and Cottages (RRR 0.8033, 95% CI 0.6605-0.9771, p=0.028) were accentuated.

7.7 CONCLUSION

The only consistent relationship between the static dwelling attributes and EWH was for dwelling type, with significant results for all-cause and respiratory EWH, and in circulatory EWH in those aged 65+. The greatest differences from the all-cause Post-war Bungalow baseline were for the high EWHI Pre-war Bungalows and Villas, and the low EWHI Quality Bungalows.

However, these differences may well be overestimated, since the only control for socio-economic status available was NZDep, which is an ecological measure, and living in a Quality Bungalow may be an additional marker of socio-economic status not accounted for in the NZDep measure. Equally, they could be underestimated, since this analysis includes a number of biases towards the null. However, a regression comparing EWHIs between the three "healthiest" dwelling types(Contemporary, Cottage and Quality Bungalow) and the three "least healthy" dwelling types (Pre-war Bungalow, Spanish Mission and Villa), controlling for the usual demographic variables, found EWH to be 5.25% worse in the "least healthy" types, than in the "healthiest" types (RRR 1.05247, 95% CI 1.0269- 1.0786, p=0.000).

Differences in EWHI by dwelling type were not consistent across disease categories, which may imply that different housing factors are important for different aspects of health: it is possible, for example, that mould and damp might be more prevalent in Pre-war Bungalows, Spanish Mission dwellings and Villas, and have a greater effect on respiratory illness, while exposure to sunlight and ease of heating in Baches and Cottages respectively, might have a greater effect on circulatory illness.

The other significant finding for dwelling trait was the association between poor dwelling condition and an increased EWHI among NZ Europeans. This result is important both because NZ Europeans are the largest ethnic group in New Zealand, and because it raises the question of why poor dwelling condition increases the EWHI in one ethnic group, but decreases it, or has no effect, in other ethnic groups.

Significant results for respiratory EWHI by construction decade were somewhat perverse, with the lowest and highest EWHIs not only in consecutive construction decades, but in consecutive construction decades with little differences in predominant housing styles or construction methods. It is therefore difficult to read any meaning into them.

In dynamic dwelling attributes, there were significant associations between EWHIs, both respiratory and all-cause; tenure index; and CV/m^2 decile.

Another important finding in this chapter was the large and highly significant differences in average annual hospitalisation rate within each of the dwelling attributes examined. The method selected for this study was designed to examine differences between rate ratios rather than rates alone, and the rates reported here may be confounded by variables which do not confound winter: non-winter ratios (because the winter: non-winter comparison controls for them). However, although not the focus of this thesis, these results deserve further investigation and raise interesting questions about the health outcomes that may be most relevant for assessing the heatlh effects of housing conditions.

CHAPTER 8 DISCUSSION

In carrying out this research I had two main aims. The first was to describe excess winter hospitalisation, and the second was to see whether that excess was associated with housing attributes.

I have achieved both of these aims, though perhaps the second less fully than the first. In this chapter, I discuss the results for each research aim, and the implications of those results for New Zealand public health, including public health research.

I begin the chapter with a discussion of the data sources used in this study. The data sources, and their integrity, lie at the core of the results for the primary aims, and should be addressed first.

After discussing the data sources, I provide a summary of the study's main findings on EWH for all-cause, respiratory and circulatory hospitalisations. I assess associations for chance, bias and confounding, and then compare them with previous findings.

Next, I examine the association between EWH and housing, assess the likelihood of causality in that relationship using Bradford-Hill criteria, and then, as before, compare the results with previous research.

Last, I discuss the overall implications of the research findings for health policy and public health research.

8.1 DATA SOURCES

Health research data sources are not a central theme in this thesis, but they underpin it. This is the first time, to my knowledge, that the NHI has been used as the basis for a cohort study. I would recommend it to other researchers as a possible population for cohort study purposes. However, before doing so, researchers may need to consider how best to deal with the possible presence of double-counted individuals, and with the likelihood that some people listed in the NHI may not have been present in New Zealand for all, or even any, of the study period. This study did not need to adjust for over-count because the winter:non-winter comparison effectively controlled for it already, but other study types may not have this advantage.

This is also the first time individual-level QV data have been used in health research. Overall, the data were a rich and valuable tool, which I would again recommend for other studies investigating the relationship between housing conditions and health outcomes. However, there were some limitations to the data. In particular, it would be useful to see an independent validation of the data quality. In addition, smaller-scale studies may need to consider the effect of missing data on their statistical power, particularly for dwelling type, which was less populated than other variables.

Also, the lessons I have learnt from using NMDS discharge data, which resulted in the different exclusion categories described in Chapter Three, have wider implications for future use of that data. In particular, it would be helpful to see researchers develop a protocol for the use of that data. The protocol would identify appropriate, standard, exclusions for studies of routine hospitalisations, to compensate for differences in admissions policies between regions and eras.

8.2 EXCESS WINTER HOSPITALISATION

8.2.1 Main findings

8.2.1.1 All cause EWH

From 1 February 2000 to 31 January 2006 there were 1,596,126 acute overnight hospitalisations in New Zealand. Of these hospitalisations, 561,652 fell in winter, 1,034,474 in non-winter, meaning winter hospitalisation rates were 1.08 times higher than expected from non-winter rates. This equates to an average of 59 more hospitalisations per day in winter than in non-winter, adding up to an annual winter excess hospitalisation burden of 7,166 across the country (compared to, for example, a mean 6,592 traffic accident hospitalisations per year over the same period[101] or 1600 excess winter deaths per year[11]). The winter excess was 2% (1% unadjusted) greater for women than for men; and 4% (5% unadjusted) and 8% (10% unadjusted) higher for Māori and Pacific Peoples respectively than for NZ Europeans. The EWHI was 2% lower (3% unadjusted) in Rural Centres than in Main Urban centres. The EWHI was highest in the first year of life at 1.74 (1.78 unadjusted), decreased with each year of age to 0.93 (0.91 unadjusted) at age eight, then increased with increasing age to 2.09 (1.43 unadjusted) in 98 year olds (100 years unadjusted). EWHIs also increased with increasing census-area deprivation, and decreased with increasing census-area annual average minimum temperature.

- Sub-groups

In most cases, where a group had a significant relative risk ratio (RRR) at general descriptive level, other general results were also exaggerated for that group. There were, however, some exceptions. While the RRR was higher overall for NZDep 8-10, the RRR for Pacific peoples was higher in NZDep 4-7 than NZDeps 8-10.

- Comparison with overall all-cause hospitalisation rates

A cursory inspection of EWHIs might suggest that winter merely exacerbates existing disease patterns, given the effect for socio-economic deprivation and ethnicity. However, there are some important differences which show this not to be the case; overall hospitalisation rates are higher for men than for women, and higher for Māori than for Pacific Peoples; yet women and Pacific Peoples have a higher EWHI. Further, while overall hospitalisation has a U-shaped relationship with age, unlike EWH it peaks in the elderly rather than in the under-5 age group.

8.2.1.2 Respiratory EWH (EWH$_{10}$)

Respiratory EWH (EWH$_{10}$) had an overall winter excess index of 1.74 (95% CI 1.72-1.75) and accounted for 76.01% of total EWH. The burden of winter respiratory illness equated to 7,514 excess hospitalisations per year. The EWHI$_{10}$ varied by age group, gender, ethnicity, rurality and NZDep tertile. Results lay in the same direction as all-cause EWHIs for all factors except ethnicity and rurality; while Pacific Peoples' EWHI$_{10}$ was higher than NZ European (RRR 1.10, 95% CI 1.06-1.13, p=0.000), the Māori EWHI$_{10}$ was not (RRR 0.99, 95% CI 0.96-1.01, p=0.298); and the

EWHI$_{10}$ was higher in Minor Urban areas (RRR 1.05, 95% CI 1.02-1.08, p=0.002) than in Main Urban areas, rather than lower in Rural Centres.

8.2.1.3 Circulatory EWH (EWH$_{9}$)

Circulatory EWH (EWH$_{9}$) had an overall winter excess index of 1.10 (95% CI 1.09-1.11, p=0.000) and accounted for 13.72% of total EWH. The burden of winter circulatory illness was 1,360 excess hospitalisations per year. The only demographic factor to modify the EWHI$_{9}$ was age group; while case numbers were low in pre-30 year age groups, the EWHI$_{9}$ was lower in the 30-59 year age group (RRR 0.96, 95% CI 0.94-0.98, p=0.000), and higher in the 80+ age group (RRR 1.08, 95% CI 1.06-1.10, p=0.000), than in the 60-79 year age group.

8.2.1.4 Other ICD-10 Chapters

The most consistent result across other disease chapters showing a winter excess was that EWHIs were higher in those at either end of the age range. The exception was EWH in ICD-10 Chapter XIX (Injury, poisoning and other external causes), for which hospitalisations showed a summer excess until about 78 years, then an increasing EWHI with increasing age.

8.2.2 Relationship to previous findings

8.2.2.1 All cause

As the literature review noted, few other all-cause hospitalisation studies have been done. Crighton et al.'s Ontario study[13] is the most similar in scope to this study, but uses a different method for calculating seasonality, preventing an EWHI comparison. Peak and trough hospitalisation seasons were different between the two studies, with Ontario showing a spring peak and autumn trough, as opposed to New Zealand's winter peak and summer trough. Patterns by age and gender, however, were similar, with highest seasonal difference in the youngest age-groups, negligible variation in young adults, and difference increasing again with increasing age in adults.

It was not possible to compare the EWHI in New Zealand with Moran et al.'s for Ireland,[10] as they do not provide one.

Comparison between New Zealand EWH and EWM [11] shows a significant difference in winter excess patterns between hospitalisations and death. However, the overall direction of results is consistent:

- differences in excess lie in the same direction for EWH and EWM between New Zealand men and women; and
- differences in excess lie in the same direction for EWH and EWM with increasing age in New Zealand adults.

As New Zealand EWM patterns are consistent with those found in overseas studies, it seems reasonable to postulate that the differences between EWM and EWH may also be found in other countries. From Moran et al.'s graphs of Irish EWH and EWM[10], I infer that Ireland also has higher EWM than EWH. However, since EWHIs differ from EWMIs in both New Zealand and Ireland (the only studies available which include both indices), it would not be appropriate to compare New Zealand EWH directly with other countries' EWM. Unfortunately, this conclusion severely limits the number of studies available for comparison with these results.

- Deprivation

It was unexpected to find that the EWHI was higher in the highest deprivation tertile, since it has been rare internationally for studies to show any difference in seasonal mortality by deprivation; but unsurprising, as the null findings for deprivation have generally been contrary to expectations.

- Ethnicity

The result showing EWHIs to vary by ethnicity was also unexpected; ethnicity has not previously been shown to be a risk factor for seasonal mortality either here or overseas, and has not been included in studies of all-cause seasonal morbidity. Although Māori and Pacific Peoples' generally experience poorer health than NZ

Europeans[102, 103], it is not clear why the difference in poor health should be greater in winter than in summer. Possible reasons are discussed later in the chapter.

- Rurality

Rural areas had lower EWHIs than urban areas. The best explanation for this difference is that rurality may protect against influenza[104] and other infectious diseases. Other possible explanations are that people in rural areas have less exposure to air pollution than people in cities, or that the wider availability of cheaper or free firewood means home heating is more affordable; however, testing either of these explanations lies outside the scope of this study.

Lesser access to health services could not explain the urban-rural difference in EWHI. If rural health followed patterns for other low health service access groups, such as high socio-economic deprivation, or Māori/Pacific ethnicity, then EWHIs would be expected to be higher in rural areas. Further, if access to health services in rural areas were poor due to geographical isolation, one would expect bad winter weather to exacerbate, rather than reduce, such isolation.

8.2.2.2 Respiratory EWH

Other studies' findings on gender and EWH_{10} vary widely; some studies find EWH_{10} to be higher among men [48, 105], while others find it higher among women[14]. Given the lack of congruence, it would be premature to make any categorical statements about whether EWH_{10} is likely to be higher among men or women generally.

Findings on age were more homogenous. All studies where such ages were included found EWH_{10} to be highest for ages under-5, lowest for the school-aged group [14, 105], and to increase with increasing age beyond that.[48] The results for New Zealand continue this pattern.

Of the three studies of EWH_{10}, only Rudge and Gilchrist's included ethnicity.[48] They found that enumeration districts with higher percentages of white pensioners had higher winter episode counts. While their result was not what might be expected from the New Zealand results, UK ethnic groups are not easily comparable with NZ ethnic groups. Probably more important was the fact that there was a difference by ethnicity at all, though Rudge and Gilchrist do not appear to have separated the effect of ethnicity from the effect of dwelling age or household size, which may have confounded their result.

Neither Maheswaran et al. nor Rudge and Gilchrist found any association between EWH_{10} and socio-economic deprivation (as measured by Townsend score), unlike the New Zealand results using NZDep. Rudge and Gilchrist did find that fuel poverty, as measured by their Fuel Poverty Risk Index (FPRI), was associated with EWH_{10}, but the FPRI is less clearly comparable with NZDep index than is the Townsend score. The FPRI finding is discussed further in relation to the EWH/housing results below.

8.2.2.3 Circulatory EWH

Maheswaran et al. suggested that a lack of cardiovascular admission winter excess might be due to health service differences over the year-end holiday period. Visual inspection of the distribution of New Zealand circulatory admissions shows that while there is a pronounced dip in the Christmas/New Year period, the admission rate remains below average through January and February, meaning that this dip is not the sole cause of New Zealand's EWHI. It would therefore be surprising if a similar dip in Yorkshire could on its own counter higher admissions during the rest of winter. However, Maheswaran et al.'s results highlight one of the difficulties in using Curwen's index: that it works best for mortality data, which are less subject to administrative variation; and for data with a smooth annual morbidity pattern, as it does not well account for discontinuities such as holiday period admission dips, or second summer peaks.

Watkins et al.'s findings that winter excess was greater in more affluent areas[21] was not reflected in the findings of this study.

A study of New Zealand EWM from cardiovascular disease found differences by deprivation among NZ Europeans.[22] However, a sub-analysis of the EWH_9 data used in this study, controlling only for sex, age and annual average minimum temperature [results not shown], found no difference, significant or otherwise, in EWHI$_9$ for NZ Europeans by NZDep quintile, demonstrating once again that patterns found in EWM are not necessarily repeated in EWH.

8.2.2.4 Other ICD-10 Chapters

Unlike Maheswaran et al.'s study, there was a remaining excess in non-respiratory, non-circulatory admissions. Other studies did not generally include other chapters. Though there has been a small amount of research into seasonality of injury, it is not easily comparable with the methods used in this study.

8.2.3 Implications for Public Health

8.2.3.1 All-cause EWHI only useful for case management

I have come to the conclusion that it is not generally useful to talk about winter excess in all-cause hospitalizations, except possibly for hospital caseload management. In relation to deaths it does make sense, since, in New Zealand at least (2000-2004), all but four ICD-10 chapters had a winter excess, and those four accounted for only 6% of deaths. For hospitalization, however, only seven chapters had a significant winter excess, and those seven accounted for only 40% of hospitalizations. It makes more sense, for hospitalizations, to consider winter excess either by individual ICD-10 chapter, or for excess chapters only.

Otherwise, lumping hospitalizations together without considering cause can be misleading. The higher all-cause winter excess for Māori, for instance, is a stroke of the broad all-cause brush; respiratory illness makes up a greater proportion of Māori hospitalizations than NZ European, so although Māori winter respiratory excess is no worse, the higher overall excess for respiratory illness makes Māori all-cause excess appear higher than NZ European.

8.2.3.2 Tenure

The significant association between increased EWHI and increased likelihood of living in an area with higher rental tenure, as measured by meshblock tenure index is important for wider housing and health research, not because of its size, which was small, but because there are few measures of tenure-health relationships; and because of the absence of literature on considering both tenure and dwelling condition in relation to health outcomes.

Several causal pathways are possible for this association. Socio-economic status is the most likely pathway, and a strong possible confounder. Unfortunately it was not possible with the data available to test the role of SES in the tenure-EWHI relationship, because tenure is a component of the main SES measure available.

The relationship between tenure index and EWHI could also be related to dwelling condition, given that tenure index was also a marker of dwelling condition, and that condition was significantly associated with EWHI in NZ Europeans.

8.3 STRENGTHS AND WEAKNESSES OF EWH DESCRIPTIVE STUDY

8.3.1 Study design

I did not initially intend to conduct a cohort study: I set out expecting to do a case-control study, with winter hospitalisations as the cases, and non-winter hospitalisations as the controls. However, this design presented problems: since both cases and controls were hospitalised groups, a denominator would still be necessary to define rates. If rates had not been included in the analysis, it would have been much more difficult, for example, to attribute the greater all-cause EWHI among Māori to their higher rates of respiratory illness.

I was also concerned, perhaps more than strictly necessary, about the numerator-denominator bias that would have arisen from using New Zealand census data as the denominator[106]. This bias arises in part from differences in how people report their ethnicity for health purposes, and how we report ethnicity on the census. Using the entire NHI database as the denominator population removed this bias, as the ethnicity data were collected in the same way for the numerator as for the denominator. As discussed below, an alternative bias is introduced, in the form of double-counting, but the twin advantages of cohort over case control, and no numerator-denominator bias, supported the choice of a cohort study.

Cohort studies usually come with a general warning that associations between exposure and disease are not necessarily causal[107], due to the usual absence of randomisation in the study (as with all observational studies). A further limitation was that some population sub-groups and variables had large amounts of missing data, making it risky to ascribe causality to results for housing variables.

8.3.2 Strengths and weaknesses of winter exposure measure.

Had I opted to use a winter/summer comparison, or a three-month winter, as a smaller number of overseas studies have done, it would have entailed difficult decisions, as peak and trough morbidity do not align neatly with seasons. The three peak months are July – September, rather than the true winter months of June – August. A three-month winter would have given an overall EWHI of 1.080 rather than 1.083. A three month winter/summer comparison would have used the three trough months of January – March as "summer", rather than the actual summer of December – February, and gave a higher ratio (1.130), though it would be inapt to describe it as an index, since its method is different. The three month comparison would, however, be tidier than a four month comparison, as the two three month seasons do at least sit six months apart: a four month winter/summer comparison would have required the four trough months of January – April to be "summer", rather than the expected December – March, creating a lopsided arrangement of a one month "autumn", and a three month "spring". The four month comparison results in a ratio of 1.118, higher than the winter: non-winter index, but slightly lower than the three month winter/summer ratio.

Although the winter:summer ratio might have offered some advantages over the winter:non-winter index used, in that a higher ratio could have increased my ability to show differences between different exposures, it would also have raised some problems. Using three summer months would have over-emphasised the Christmas/New Year holiday effect, and while the Christmas/New Year period may represent optimum health, it is a variable in addition to "summer". Comparing winter with all of non-winter dilutes the holiday effect.

Using the four month winter/summer split would also have been questionable: as the peak and trough periods were not equidistant, there was clearly a difference in effect between autumn and spring, which highlights the preferability of the winter: non-winter option selected.

8.3.3 Non-causal explanations for associations between EWHI and demographic factors

8.3.3.1 Chance

Given the size of the study, and the low p-values for the associations found, it is unlikely that the results are due to chance. However, it should be noted that there are 27 categories included in the model. Using a 95% confidence interval, on average one in twenty results will show significance where none is present. It is therefore certainly possible that at least one of the associations found to be significant is really a chance finding.

However, most of the significant results are supported by the trends within the regressions: for each variable, stepwise regression showed that the addition of extra variables to the model had expected effects on results. The lack of surprises in the progression from a single-variate to a multi-variate model supports the likelihood that the results found are not the result of statistical error.

8.3.3.2 Bias

The most significant of the potential challenges that come with cohort studies, canvassed in the Methods chapter, is that some people included in the study through their registration on the NHI may not have been in the country for all or part of the study period, and therefore neither their exposure, nor any outcome, could be measured. This bias is more likely to have impacted on rates, which may be an under-measure, than on ratios, which would be unaffected because the error in the denominator would be equal across both exposed and unexposed populations.

8.3.3.3 Differential misclassification bias

The likelihood of exposure being misclassified is all but nil: for those hospitalised, NZHIS admission dates are considered highly reliable; and once the winter (exposed) and non-winter (unexposed) periods were allocated there could be no question of which group any person day fell under.

The potential for misclassification as a "case" is small – NZHIS methods would appear robust enough to make it unlikely that someone hospitalised would be recorded under an incorrect NHI number.

Any misclassification is more likely to be for demographic information than "case"/"non-case" or winter exposure allocation, and would apply to the whole cohort group, though demographic misclassification may be more likely for the non-hospitalised, since they may have had less contact with the health system and therefore less opportunities to correct errors:

- Age

There are some clear cases, as mentioned earlier, where the date of birth has been incorrectly recorded, introducing errors to age data. The more extreme and obvious of these errors appear to be restricted to the "non-case" group, as there were no unlikely ages among those with a hospital admission.

- Gender

Gender has been dichotomised for analysis, but in fact there were a relatively small number of people of gender "unknown", who were classified as "Male" for analytical purposes. Some of these will be transgender or intersex people who have elected not to nominate themselves as "male" or "female", whereas others will be simply "unknown". However, their numbers are sufficiently small as to be unlikely to have a biasing effect, and misclassification would not appear to be any more likely in winter than non-winter.

- Ethnicity

Where someone other than the individual estimates an ethnicity, it may not reflect the individual's current ethnic identification. Misclassification for this reason may vary slightly by ethnicity and season, due to higher and lower melanin levels, but the effect is unlikely to be large.

- Address

Address on its own is not a variable in the model, but the individual's address is used as the basis for a number of other variables, namely NZDep group, territorial authority, rurality, and all housing data. Address is also the data field with the greatest potential for error. New Zealanders are a mobile nation – according to Statistics New Zealand, 25.8% of the population had moved at least once in the two years to March 2007[*]. Hospitalisation data record the Census Area Unit of the patient on the date of admission, which could provide an area-level check of whether the patient's current NHI address is likely to be the same as their address at date of admission. However, as there was no way of establishing whether a current listed address was also the address on any particular non-hospitalisation day, non-CAU matching hospitalisations were included rather than excluded, to keep data comparable between case and non-case groups.

Most importantly, however, people who have been hospitalised are more likely to have a correct address entered on the NHI – and the more recent the hospitalisation, the more correct it is likely to be.

It is therefore address which introduces greatest possibility of differential misclassification bias, which occurs when "the ascertainment of exposure has been influenced by the presence or absence of disease."[107]

While this misclassification will be non-differential for the main exposure of interest,

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[*] http://www.stats.govt.nz/~/media/Statistics/Browse-for-stats/SurveyDynamicsMotivationsMigrationNZ/HOTPMar2007qtr/surveyofdynamicsandmotivationformigrationinnzmar07qtrhotp.ashx downloaded 24 August 2009.

winter, it may vary by demographic factors: higher deprivation groups, for example, are more likely to rent, and have less security of tenure, contributing to greater mobility. Movers are more likely to be:

- younger;
- of "Māori" or "Other" ethnicity;
- never married or single; and/or
- employed;

Likelihood of moving also varied by region, and people who had moved at all were more likely to have moved more than once.

8.3.3.4 Other biases

Other potential issues of bias arising from using a cohort study method do not apply to this research. No group was, or could be, more likely to be exposed than another; and apart from travel, the exposure status of cohort members could not change.

8.3.3.5 Confounding

An important point in considering these results is that winter is more than a system of particular weather patterns colder than the rest of the year: people's behaviour and diet also change in response to winter. Therefore, when I assess the effect of winter on hospitalisation rates, "winter" is being used as shorthand for a collection of climatic and behavioural patterns: when I write of an association between winter and higher hospitalisation rates, I mean winter in its broader sense, not just its climatic patterns.

One implication of this conglomeration is that `Winter' as a cause of higher hospitalisation rates is both specific, in that there are no other causes, and non-specific, in that winter is a composite variable. At the same time, this meaning for winter makes it difficult to identify confounders for the pathway from winter to high hospitalisation rates, since any possible confounders must be associated with winter, and therefore may be considered part of the overall winter effect.

However, assessing the association between a demographic variable and EWHI introduces the demographic variable as a second exposure. Figure 2.2 in Chapter Two identifies the host vulnerability factors "pre-existing illness" and "smoking" as possible confounders for demographic variables age (pre-existing illness), ethnicity (smoking) and NZDep (both).

Smoking may be a confounder in the association between ethnicity and EWH: as discussed earlier under possible explanations for the higher EWHI in Pacific Peoples, it is unlikely to explain all the difference in EWHI between ethnic groups, but it may explain some of it, in combination with other factors.

Otherwise, it is not possible to gauge the extent to which smoking may confound results for NZDep, nor pre-existing illness for NZDep and age.

8.3.3.6 Effects of missing data

Demographic data were complete for 94% of the population. The "sex" and "ethnicity" fields were both 100% complete, and the four other fields varied from 1% missing ("Age", and "annual average minimum temperature") to 5% ("Rurality").

I tried imputing missing demographic data from means and modes within Census Area Units, to see the direction of effect on all-cause EWH results. All changes to results were minimal except that Pacific Peoples had a 0.027 higher EWHI using imputed data.

8.4 EWH AND HOUSING

8.4.1 Main findings

There was an association between housing type and EWHI: pre-war bungalow and villa dwellers had higher all-cause EWHIs than post-war bungalow dwellers, and quality bungalow dwellers a lower all-cause EWHI. If the relationship between dwelling type and hospitalisation rate is causal, then over half the winter excess in hospitalisations may be attributed to living in non-Quality Bungalow dwellings.

These associations were stronger for those aged 65+, whose EWHI was also lower if they lived in the two smallest dwelling types: Baches and Cottages.

There were also significant differences in winter excess by dwelling type in the respiratory and circulatory ICD-10 chapters. The EWHI$_{10}$ was higher in the Spanish Mission dwelling type, while EWH$_{9}$s were lower in Baches and Cottages in those aged 65+.

EWHIs and EWHI$_{10}$s also increased significantly with increasing tenure index.

There was no association between dwelling age, including insulation era, and EWH, nor between all EWH and dwelling condition, though there was an association between EWH and dwelling condition in NZ Europeans, which likely contributed to the overall non-significant trend, with EWH decreasing across the three condition categories from "poor" to "superior".

8.4.1.1 Tenure and dwelling condition

This study used only ecological data on tenure status. It is possible that in any given meshblock, the rentals were the newer and better quality dwellings. However, while I cannot say definitively that rental dwellings are older and in poorer condition than owner-occupier dwellings, it is a reasonable working assumption.

Given that there was a relationship between EWHI and tenure index, and a relationship between tenure index and dwelling condition, but no overall relationship between dwelling condition and EWHI, it is possible (though speculative) that home ownership may somehow be protective against EWH from poor dwelling condition.

About a third of the NZ population lives in rental accommodation. The New Zealand Government confirmed in May 2009 that it would commit NZ$323.3 million to fitting 180,000 dwellings with insulation and/or clean heating devices. However, previous retrofitting schemes have had limited uptake in the private rental sector. A recent phone survey of landlords concluded that the availability of subsidies alone was unlikely to be sufficient to promote widespread uptake.[108] Given that rental tenure is associated with poorer health status, including for illnesses shown to be responsive to improvement in insulation levels, maximum benefit from nationwide insulation investment may well require careful targeting to ensure landlord uptake.

8.4.2 Relationship to previous findings

The finding of an association between housing factors and EWH is in keeping with those of Wilkinson et al.[47], but only to an extent: one of the strong findings in that study was an association between housing age and EWH, which was not found in this study. However, British housing is of quite different construction to New Zealand housing. The most widespread New Zealand housing types, pre- and post-war bungalows, do not appear in Britain, while differences between British houses arising from their construction eras may be echoed in different ages of New Zealand housing.

8.4.3 Non-causal explanations for EWH and housing results

8.4.3.1 Bias

Overall, biases in these results are towards the null. The accuracy of neither QV fields nor tenure index has been tested, so the potential for misclassification bias cannot be assessed. If there is non-differential misclassification, it is likely to mean either that the degree of association between housing variables and EWHI has been underestimated. There may also be some differential misclassification of dwelling variables, in that dwelling types are probably more likely to be misclassified as a type similar to the "true" type (e.g. Villas as Cottages, and vice versa) than as some dissimilar type. Again, the extent of any such misclassification cannot be assessed.

Selection bias occurs when "… there is a systematic difference between the characteristics of the people selected for a study and the characteristics of those who are not."[109] If people in a particular dwelling type (exposure) were less likely to have their address matched, it would lead to selection bias. Unfortunately, I couldn't tell whether selection bias affected this study or not, since there was no way of telling the effect of any dwelling-type distribution between the “match” and “no match” groups.

It was quite clear that there was likely to be a difference in dwelling-type distribution between matched and unmatched groups, since one of the main challenges for matching was where an address featured two numbers, (e.g. 1/2 High St) since it was not possible to be sure which dwelling the address referred to (Flat 2 at 1 High St, or Flat 1 at 2 High St). The important point is that addresses unmatched for this reason are primarily multi-unit properties.

I tested a sub-sample of these types of addresses; there was no difference, significant or otherwise, between the EWHI in “Flat” type unmatched addresses, and in other unmatched addresses, so the higher proportion of flats in the unmatched group cannot explain the difference in EWHI between matched and unmatched dwellings.

Imputing housing data from modes and mean building age increased and made significant the results for Cottages (lower EWHI) and villas (higher EWHI).

The important conclusion of this testing is that it supports the assumption that, in general, while they may exist for a variety of reasons, biases in these results are likely to be towards the null. The obvious difficulty with findings baised towards the null is that relationships that do exist may be hidden.

There is also the possibility that New Zealand housing stock is almost universally poor in construction, heating and/or insulation, in which case a general link between EWH and housing attributes would have been missed.

8.4.3.2 Chance

Again, across the eight housing and housing-related variables, there are 82 output categories (“no match” being a single category across all variables) for each set of hospitalisations. On average, with a 95% confidence interval, we would expect to find about four significant results by chance; with three of them marginally significant ($p<0.05$), and perhaps one highly significant ($p<0.01$). The seven significant results found were more than might be expected, but, as in the description of all-cause hospitalisation, may include some results significant by chance.

Again, it is the consistency of the results across different sub-groups which supports the results being real rather than accidental.

8.4.3.3 Confounding

There are potential confounders that have not been included in the model. The most obvious of these is poor air quality, which is associated both with location and cold weather, and could conceivably be associated with dwelling type – older dwellings, for example, are more likely to have open fires, which contribute to poor outdoor and indoor air quality. While small area data are available on air quality, these are not available by season. It would be worth including the effect of air quality in a subsequent study, if the required data are available.

Another possible confounder may be described as "culture". For those who have choice, what dwelling type they live in is a matter of "taste", which may reflect their social status or class as well as education, and which in turn may change the likelihood of other behaviours, such as dress and diet. This may be related to possible residual confounding by socio-economic status: NZDep is an ecological-level variable, while dwelling variables are individual level. Someone living in a Quality Bungalow in an area where other types of Bungalow predominate, is presumably likely to be of higher socio-economic status than his or her mesh-block neighbours. Therefore, their NZDep score is more likely to be an underestimate of their individual socio-economic status. On the other hand, it is less clear that living in a State Rental is an additional marker of low socio-economic status, since State tenants pay income-related rents, while their neighbours must pay market rents or meet mortgage payments.

There is also the possibility that dwelling size, and the often associated household size, may confound results for dwelling type. For example, the finding that the $EWHI_9$ in over-65-year olds was lower for those that live in Cottages may have been confounded by living circumstances. Cottages are small, so inhabitants may be more likely to live alone, or with spouse only. Recent research suggests that women living alone have lower CHD rates than women living with a spouse, who in turn have lower CHD than women in multi-generational households.[110] While living arrangements do not generally change between winter and the rest of the year, if one is to have a CHD hospitalisation, it is more likely to happen in the winter. For people with a lower overall yearly likelihood of a CHD hospitalisation, winter and non-winter rates will be closer, making the EWHI lower. Still, results of alternative models (not shown) do not support dwelling size or number of occupants as confounders.

There is the additional issue that each model included only one dwelling variable. There may be residual confounding between dwelling variables.

8.4.4 Positive features of causation

Having established an association between dwelling type and EWHI, I now consider whether the relationship is likely to be causal, using Bradford-Hill considerations.[111] Experiment and analogy have been excluded, as this study did not involve experiment, and there is no suitable analogy for the relationship.

8.4.4.1 Strength of Association.

As the percentage differences in EWHI between dwelling types are small, the association is weak, and could be due to confounding. It could be residual confounding by deprivation, for example, since housing is an individual level variable and NZDep is an ecological measure. On the other hand, using the more detailed mesh-block level NZDep rather than census area NZDep estimates made negligible difference to RRRs for housing attributes.

8.4.4.2 Consistency.

No other study has looked at the association between all-cause EWH and housing factors, so no direct consistency can be established. It is not possible to say whether the finding that Fuel Poverty Risk increases risk of respiratory EWH[48 49] is consistent with the results of this study, because it is not yet clear whether any of the dwelling types in this study are more likely to contribute to fuel poverty than others. However, other studies have shown improvements to housing to reduce overall morbidity, which is consistent with these results.[3 30]

8.4.4.3 Specificity.

The association between dwelling type and EWHI is not limited to any particular demographic sub-group. Nor does there appear to be any one disease category responsible for the association. Therefore, the association does not have specificity. However, both EWHI and "dwelling type" are very broad measures, making specificity less relevant to causation in this relationship.

8.4.4.4 Temporality.

Most people admitted to hospital do so from home, so exposure to this environment preceeds the acute health event of interest. However, there are a few instances where this time sequence may not be the case. As I have only the most recent address for people, it is possible that they have moved since the recorded hospitalisation, in which case their recorded address, the 'cause', is measured after the health effect. On the other hand, address records are usually only changed in association with a health episode, so the more recent the hospitalisation, the more likely it is that the recorded address accurately reflects their actual address and their address at the time of hospitalisation. However, there is no evidence that people are more likely to move if they are (or are not) hospitalised, and associations between housing and EWHI did not reduce as the number of years since hospitalisation increased, so any lack of temporality should only bias results towards the null.

8.4.4.5 Dose Response Relationship

There was a dose response relationship between dwelling type and EWHI, since the EWHI was most elevated in dwelling types expected to be poorest quality, and lowest in Quality Bungalows, which would be expected to be of higher average quality.

8.4.4.6 Theoretical Plausibility.

The theoretical basis for an association between EWHI and housing has been laid out in the literature review. The theory, in relation to dwelling type, is that poor housing leads to EWH by causing cold, damp conditions, which in turn bring about physical responses which increase circulatory and respiratory illness.

8.4.4.7 Coherence

The association between dwelling type and EWHI does not conflict with established understandings of the association between housing conditions and health in general.

8.4.4.8 Conclusion

It is possible, perhaps even likely, that living in a particular dwelling type has a causal relationship with EWHI, but the small size of the relationship and the broad nature of both EWHI and "dwelling type" mean that the implications of that relationship are more suggestive than directive. It is also possible that the results were due to confounding.

8.4.5 Effect of missing data

Where data were missing, the only group to have an EWHI significantly, or even non-significantly, different from those with all cells filled, were those with only one dataset filled (primarily age), who had an EWHI lower than those with all variables filled (RRR 0.87, 95% CI 0.79-0.96, p=0.004).

Running models excluding the missing variable found no significant difference in results for housing variables between those with missing data and those without, except for Quality Bungalows, where exclusion of missing data reduced the winter effect: people with missing data in Quality Bungalows had an EWHI 12% higher than those without, though by numbers they only contributed an extra 1% to total EWH for Quality Bungalows.

However, there is also the question of data reliability. While wall insulation was mandatory from 1978 on, the new Building Code regulations mandating it were not generally enforced until after 1980. However, the 2005 BRANZ House Condition

Survey found that a large number of post-1980 houses do not have adequate ceiling insulation despite the 1978 change, so the likelihood of them having adequate wall insulation is even less. Only 29% of NZ houses have wall insulation, and of these, many are foil only. In other words, it would be risky to assume that any New Zealand dwelling is properly insulated on the basis of its age.

8.5 DISCUSSION

As the literature review has noted, studies of winter excess repeatedly expect housing to explain a large part of that excess. The reader can sense, and share, the slight frown when the results, or the literature, do not resoundingly endorse this hypothesis. The inclination is to assume that a null finding here must be due to lack of the right kind of data, or the right kind of method. However, it is more likely that the problem is not with the data or method, but with a fundamental misinterpretation of the nature of winter excess. Winter excess is not winter illness: it is the difference between winter and summer illness. If your summer health is as bad as your winter health, your winter excess will be low. People in poor housing may have poor health in the summer as well as in the winter. As noted earlier, winter is not just a difference in temperature, but temperature is certainly part of it. Poor housing and/or fuel poverty may expose the occupant to a greater annual temperature range, but if the maximum in that range is still below recommended indoor temperatures, the occupant is still at greater risk of illness in summer than their well-housed neighbour.

This point is important because the New Zealand climate is predominantly maritime temperate. New Zealand daily maximum outdoor temperatures only lie within the WHO recommended indoor range (18 to 24) for at most four months of the year. However, daily minimum outdoor temperatures only reach that recommended range in the far north of the country. A study of 1991 – 1994 Christchurch data found very little difference, other than a time lag, between indoor and outdoor temperatures.[112] Since BRANZ data show Christchurch housing conditions to be only slightly worse than Auckland and Wellington for pre-1970s dwellings[68], it would be fair to generalize from the Christchurch data and hypothesis that, on average, New Zealand indoor temperatures only fall within the WHO recommended range for (the warmest) part of the day, over at most four months of the year. For some cities in the South Island, maximum outdoor temperatures rarely reach the WHO recommended level, and it is therefore doubtful whether indoor temperatures do either.

The importance of this point is in relation to housing: if we are comparing winter with non-winter, we are assuming that in non-winter our poor housing quality is less important because there is less adverse climate to be protected from. This is a reasonable starting point. However, if the climate is always adverse, and our housing does not make it better, I would expect higher rates of low temperature-related conditions in non-winter as well as winter, which would reduce the overall EWHI.

Still, UK (with high EWM) and Nordic (with lower EWM) average temperatures are even less climatically favourable. UK and Nordic mean daily maximum temperatures fall within the WHO recommended range[*] for at most 3 months of the year, and average daily minimums never reach the ideal range. It would be interesting to compare national EWM or EWH with annual average temperature range. Hypothetically there might be a relationship between EWH/EWM and some function of annual average minimums (which may dictate to what extent people feel it necessary to insulate their houses) and total temperature variation (which influences physiological responses to climate).

The original point, that the EWHI measures the difference between winter and non-winter illness, not the severity of winter illness alone, is also important in relation to differences between groups. Female excess, for example, is higher than male excess, even though the female winter hospitalization rate is lower than the male: the female summer hospitalization rate is lower again, making the difference greater. If would

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[*] http://www.metoffice.gov.uk/climate/uk/averages/19712000/areal/uk.html, downloaded 25 September 2009; climate pages for Bergen, Oslo, Stockholm, and Helsinki from www.weatheronline.co.uk, downloaded 25 September 2009.

be easy to assume from EWHIs that female health is worse than males; or at least that it is worse in winter – in fact, it is neither. The difference between male and female EWHI could be reduced by measures that made female non-winter hospitalisation rates closer to those of males, but that would hardly be desirable.

Therefore, identifying a significant difference in EWHI between one dwelling type and another does not automatically mean that all dwellings should emulate the type with the lower EWHI. However, it does mean that research should seek to identify what it is about the different dwelling types that makes their EWHI different.

8.5.1 Results in relation to hypothesised pathways

The literature review included an hypothesis of pathways mediating the effects of winter climatic conditions on EWH (see Figure 2.2). This study looked at only some of the environmental exposures (poorly insulated housing; rurality; location; winter) and host factors (low SES; extremes of age; ethnicity; sex) included in that hypothesis. The results suggest the following comments on the associated pathways:

- the "physical effects of the outdoor winter environment" were measured as "winter", and were implicated for some demographic groups but not others;
- the "physical effects of the indoor winter environment" were measured using housing variables, and were weakly implicated; and
- it is not possible to comment on the effects of winter activities and behavioural adaptations: while low SES and age were measured, and were implicated, both factors influenced other pathways, so it is not possible to tell which pathway they are modifying.
- However, as ethnicity had a strong effect on results, even after controlling for NZDep, both winter physiology and the effects of winter activities and behavioural adaptations are implicated.

In addition, the study provided evidence on some of the other hypothesised pathways:

- although the level of winter epidemic infections was not measured, the results for both respiratory and infectious causes, support this hypothesised pathway.
- Although injury hazards were not measured, results for the injury chapter support winter injury hazards as a pathway for some age groups.

Overall, the findings from this study would be consistent with winter epidemic infections making a relatively large contribution to EWH.

8.5.2 Interventions

Intervention options vary depending on the desired outcome: if it is to reduce the winter hospitalisation excess in those who experience it most strongly, interventions should be aimed at young children in low socio-economic groups; if it is to reduce absolute EWH, and/or EWM, interventions should be aimed at those over 60; if it is to reduce disparities in EWHIs, interventions should be aimed at Pacific Peoples. In each case, respiratory illness is the prime disease candidate for intervention, with circulatory illness also worthy of attention due to its high numbers.

It would also be useful to see further research aimed at identifying why EWH varies by ethnicity.

There is also the issue of overall health. The EWHI could, for example, be very effectively reduced by increasing the "non-winter" hospitalisation rate. It could be argued, for example, that the reason for the high EWHI among 0-4 year olds is in part because their non-winter hospitalisation rate is so low, while their share in the winter respiratory disease burden is equal to the rest of the population.

Although it would be tempting to offer a winter public holiday as an intervention[*], another public holiday would be unlikely to have either a lasting, or a significant, impact on EWH, as hospitalisations return to their previous level immediately following the public holiday.

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[*] I ought to suggest August, but I'd prefer something closer to my birthday in June…

Ultimately, a descriptive study such as this one may suggest who to target for intervention, but not what that intervention ought to be.

8.5.3 Why is the $EWHI_{10}$ higher among Pacific Peoples?

In contrast to the findings for Māori, the greater all-cause excess for Pacific Peoples is a `real' difference: although, as for Māori, the greater Pacific all-cause excess is attributable to respiratory disease, for Pacific Peoples, it reflects a greater winter respiratory excess rather than a higher respiratory incidence.

There are a number of potential explanations for the higher winter excess among Pacific Peoples, which are discussed below.

8.5.3.1 Housing

In 1991, Kearns et al. wrote that Pacific Island households reported "living in worse housing, and [being] less satisfied than either the Māori or the Pakeha households in the sample."[113] However, if housing were the driver, I would expect to have found meaningful differences in EWHI by housing attributes, between Pacific Peoples and NZ Europeans.

8.5.3.2 Crowding.

Statistics New Zealand data show crowding to be consistently more common among Pacific Peoples than other ethnic groups.[114] [115] Given the association between crowding and infectious disease,[116] [117] and the other evidence in this study supporting a possible role for infectious disease in EWH, greater levels of crowding among Pacific People may contribute to their increased EWHI. Access to good data on crowding (not available at time of writing) would allow this possibility to be investigated further.

8.5.3.3 Diet

Though it is widely mentioned as a possible contributing factor, diet has received no research attention whatsoever as a cause of EWH or EWM[*], so it is difficult to comment on whether or not it is a contributing factor.

8.5.3.4 Vitamin D

Vitamin D, however, is a more likely contributor: Vitamin D levels are certainly seasonal, and have been found to be lower in Pacific Peoples than in Māori or NZ European and Others.[119] [120] However, the nadir of Vitamin D levels is in October to November, when the respiratory hospitalisation peak is already well past. It is therefore less plausible that vitamin D deficiency, through reduced resistance to infection, is responsible for increased respiratory risk on its own.

8.5.3.5 Clothing

Clothing has been shown to have a relationship with EWM at an ecological level.[121] However, while dress certainly changes with season, there is no information available on differences in dress by ethnicity in general, let alone by season.

8.5.3.6 Smoking

Smoking has been widely and heavily implicated in respiratory illness, and Pacific Peoples' smoking rates are higher than NZ European rates.[115] However, smoking rates are higher in Māori than among Pacific Peoples, and are therefore unlikely to be behind differences in EWHI by ethnicity.

8.5.3.7 Deprivation

Results for Māori and Pacific Peoples may include residual confounding by deprivation that is not accounted for by the ecological-level NZDep measure.

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[*] Cox et al's study, for example, examined seasonality of fruit and vegetable consumption and CVD, but not the seasonality of the CVD. [118]

8.5.3.8 Delayed presentation

Hospitalisation requires a certain level of morbidity. A health condition may deteriorate to a level requiring hospitalisation because the patient has not received treatment earlier in the disease course. While income is not the only barrier to primary care,[122] it is possible that delayed presentation could be more likely in winter if part of the reason for the delay was concern about costs of doctors' visits. Primary care costs could be less affordable in winter, when heating costs place greater strain on household budgets.

However, a qualitative study of Samoan families with a child hospitalised for pneumonia did not support the theory of delayed presentation[123];[*] nor did a quantitative study of appendicitis hospitalisations in adults.[125] Delayed presentation appears to be reported more often in illnesses with a longer latent period, particularly cancer. However, finer strata analysis [results not shown] indicates that differences between NZ European and Pacific EWHI_{10}s only appear in older ages, who have not been found to delay presentation.

8.5.4 Results for housing variables

The main significant findings for housing variables were for dwelling type, with a secondary finding for dwelling quality among NZ Europeans. In the case of Quality Bungalows, and dwelling quality, I consider it highly likely that the significantly lower EWHI is at least partly due to residual confounding by socio-economic status[†]. However, the same cannot be said for the difference in result between Pre- and Post-war Bungalows, where, if residual deprivation were having an effect, the results would be expected to be inverted, since, if anything, NZDep by dwelling type would suggest that Pre-war Bungalow dwellers are of slightly higher socio-economic status

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[*] Scott et al found Māori faced barriers in addition to income, to accessing primary care.[122] Other researchers have found that Pacific and Mäori children hospitalized with pneumonia had more severe pneumonia than NZ European children[124], which would be consistent with delayed presentation.

[†] Much of the difference may be due to lower overall (both winter and summer) rates of respiratory and circulatory illness among Quality Bungalow dwellers. However, as the methods used in this study were not designed to measure rates alone, it is not possible to test this accurately.

than those dwelling in Post-war Bungalows. Similarly, residual confounding by SES is unlikely to be the driver for differences between Post-war Bungalows and Villas (all-cause EWHI), Spanish Bungalows ($EWHI_{10}$); or Baches or Cottages ($EWHI_{9}$), since the differences in mean mesh-block NZDep between these dwelling types is very small.

Therefore, we must look to other explanations for these differences in EWHI. While pre-war and post-war dwellings are substantially different overall, the difficulty lies in identifying pertinent differences between Post-war Bungalows, and Pre-war Bungalows and Villas, that do not also apply to other predominantly pre-war dwellings that do not have elevated EWHIs. Numbers for Spanish Bungalows and Quality Old dwellings were small, so lack of a significant result has less bearing on possible explanations, though the trend in both was also towards higher EWHIs. Therefore, the main counterfactual for Pre-war Bungalows and Villas is the Cottage which, although its excess for all-cause EWHI is non-significant, trends towards lower EWHI than Post-war Bungalows despite most examples being built before 1950.

Poor dwelling condition cannot be responsible, since mean dwelling condition is poorer in Cottages than in Villas or Pre-war Bungalows. Therefore, the most obvious difference between Pre-war Bungalows and Villas, with higher EWHIs, and Cottages with a lower EWHI, is their size. The average floor area for Pre-war Bungalows and Villas are $134m^2$ and $140m^2$ respectively, while the average floor area for Cottages is only $95m^2$. Higher EWHIs in the larger dwellings could be due to their being more difficult to heat, or, alternatively, to higher transmission of infectious winter illnesses through having more occupants. However, adjusted year-round hospitalisation rates were similar between the three house types. If higher infection rates were responsible for the difference, we would expect year-round rates to be higher as well.

Still, it is not dwelling size alone that makes the difference, since results for floor area decile showed little in the way of trend, and were non significant. Instead, it is more likely to be related to earlier dwellings, which are more prone to draughts, being harder to heat. Cottages, although as draughty, could be easier to heat than their construction contemporaries because of their small size.

8.5.5 Housing Interventions

If thermal efficiency describes the factor involved in the association between certain dwelling types and EWHI, then an associated problem is fuel poverty. In 1988, Brenda Boardman defined fuel poverty as occurring when a household needs to spend more than 10% of its income in order to heat its home to an adequate level.[126] Even a draughty house may be able to be heated to an adequate level if enough energy is put into it, however inefficient that may be. Fuel poverty is also likely to be part of the association between higher socio-economic deprivation and higher EWHI.

Fuel poverty can be relieved in one of three ways: the household income can be increased, so that the same energy spend becomes a smaller percentage of that income; household energy costs per unit can be reduced, so that the same quantity of energy costs less; or the dwelling can be altered, so that less energy is required to reach the same indoor temperature. The most sustainable of these options is the last. Government programmes to improve insulation levels are a step in the right direction, but, given that landlords are less likely to take up the subsidies offered, the programmes are less likely to reach people in rental accommodation. We may infer from the significant association between rental tenure and EWHI that it is those in rental accommodation who are most likely to benefit from fuel poverty relief.

As there are improvement plans in place for both State- and local authority-owned rental housing stock, it is the private rental market which requires more attention from policy-makers. As mentioned above, private landlords are generally reluctant to spend money on improving the thermal efficiency of their rented properties. Relying on "the market" to rectify this reluctance presupposes that tenants at the lower end of the rental market have economic power, or a "choice" of tenancies. An Australian study in 1977 found that "tenants in Australia are, both individually and as a group, economically powerless. They are at the mercy of wider economic forces which effectively determine, as a residual, the amount and quality of housing available to them."[127] In the absence of market imperative, legislative imperative may be the only tool available to improve the thermal efficiency of private rental housing stock.

8.5.6 Avenues for further research

A number of questions have arisen from the results of this research which cannot be answered within the research itself, and greater understanding of EWH would arise from their exploration.

The first of these is the higher level of EWHI in Pacific Peoples. A clearer understanding of the causes of EWH in Pacific Peoples could provide valuable clues to the aetiology of EWH, and also suggest possible interventions to improve the health of Pacific Peoples.

The second is a further examination of the differences between dwelling types, and how those differences contribute to differences in EWHI, in order to target interventions more efficiently at factors adverse to health.

The third is the relationship between tenure and dwelling quality, and tenure and EWHI. Detailed individual-level information on tenure remains a missing link in New Zealand housing and health research, and would provide better quality results not only for the relationship between EWHI and tenure, but also, if linked to individual dwelling quality data, for the relationship between tenure and dwelling quality (a vital piece of research in its own right) and the interaction between both variables in EWH.

CHAPTER 9 CONCLUSION AND IMPLICATIONS

This thesis has brought together two themes: excess winter hospitalisation (EWH), and dwelling attributes. There were findings for each individual theme, and for their conjunction.

9.1 EXCESS WINTER HOSPITALISATION

As with most other studies of winter excess, age showed the largest influence on EWH indices (EWHIs), and gender also made a difference. Other findings were new: in New Zealand at least, low socio-economic status does contribute to both excess winter mortality and excess winter hospitalisation. It is equally clear that ethnicity is a contributing factor, though the precise aetiological relationship between ethnicity and EWH is undetermined. Household crowding (through infectious disease risk) could be a contributing factor. Vitamin D deficiency is alluring as a biological explanation, but does not well fit month-by-month hospitalisation distribution. Culturaly determined behaviours may also contribute, but this study was not designed to investigate these.

9.2 DWELLING FACTORS, AND THEIR RELATIONSHIP TO HEALTH.

This thesis provides a summary of New Zealand's main recognisable dwelling types, their age and exterior materials, and the distribution of the population within them.

An incidental finding was that there was a strong relationship between the dwelling attributes tenure index and dwelling condition. Although ecological rather than individual level, this finding has implications for New Zealand's housing stock in relation to changing rates of home ownership.

Investigating the relationship between dwelling factors and year round health was not a primary goal of this thesis, and the statistical method was not designed to measure rates alone. Nevertheless, basic analysis of hospitalisation rates by dwelling factors showed marked differences. Notably, rates appeared to increase with decreasing dwelling age, and across the five most common dwelling types, were highest in Post-war Bungalows and State Rentals, and lowest in Villas. Further research in this area could provide valuable additional evidence about the relationships between New Zealand housing and health.

9.3 DWELLING FACTORS AND EXCESS WINTER HOSPITALISATION.

The main finding of this thesis was that some dwelling types had higher EWHIs than others: which dwelling types were higher or lower varied somewhat by diagnosis. None of the other static dwelling attributes (construction decade, insulation era, floor area) showed an association with EWHI.

Of the dynamic dwelling attributes considered, high levels of renting, and low Capital Value per square metre (CV/m^2), were each associated with higher EWHI, while dwelling condition showed no association. However, tenure and CV/m^2 were also closely related to household socio-economic status. Since socio-economic deprivation was also associated with higher EWHI, the contribution of each variable to EWH cannot be determined. EWHIs did not vary significantly by dwelling condition.

9.4 IMPLICATIONS

9.4.1 Housing interventions

The main public health implication of this research is that it does not necessarily support investment in housing improvement as a strategy solely to reduce EWH. Instead, it appears that any effect of housing improvements would more likely be on total year-round hospitalisation rates.

If the aims of national housing thermal efficiency interventions, such as insulation or heating retrofit programmes, include a short-term reduction in the winter: non-winter morbidity ratio, they could be better targeted, at those at either end of their life-span, and in particular at Pacific Peoples. However, housing interventions will last beyond the lifespan of current occupants, and may, with future occupants, benefit groups more at risk of excess winter morbidity.

9.4.2 Recommendations for further research

9.4.2.1 Data-related recommendations:

In relation to the future use of the main datasets drawn on for this study, I recommend the following:

- NMDS Data
    - That a protocol be established for the use of NMDS discharge data, identifying appropriate, standard, exclusions for studies of routine hospitalisations.
- NHI Index
    - That the NHI be considered by other researchers as a possible population for cohort study purposes.
- QV data
    - That the QV dataset be considered for other studies investigating the relationship between housing conditions and health outcomes.
    - That researchers also further investigate the potential use of CV (or CV/m^2) as an alternative measure of wealth and socio-economic position.

9.4.2.2 Areas for further research:

This thesis has highlighted a number of areas deserving further research:

- The interaction between housing tenure, dwelling condition, and health (including winter excess) would benefit from individual-level measures of housing tenure, and a finer measure of dwelling condition.
- Results could be enhanced by a time-series study of how the relationship (if any) between daily outdoor temperature and hospital admissions is modified by housing factors.
- This thesis found large differences in hospitalisation rates by dwellings factors. More sophisticated analysis of these differences, including rates by

disease category, could enhance understanding of the effects of housing on health.

- The condition, design and construction of New Zealand's national housing stock are still not well understood. A full stocktake of our housing, including an assessment of the common strengths and flaws of common dwelling designs, would be advantageous not only to health research, but to other areas relying on an understanding of the housing stock, notably economics and energy efficiency.

REFERENCES

1. Housing New Zealand: provision and policy at the crossroads: five-yearly report. Wellington: National Housing Commission, 1988.
2. Hippocrates. On Airs, Waters, and Places, 400 B.C.E.
3. Howden-Chapman P, Matheson A, Crane J, Viggers H, Cunningham M, Blakely T, et al. Effect of insulating existing houses on health inequality: cluster randomised study in the community. *British Medical Journal* 2007(334):460.
4. Howden-Chapman P, Pierse N, Nicholls S, Gillespie-Bennett J, Viggers H, Cunningham M, et al. Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. *BMJ* 2008;337:a1411.
5. Schipper L, Unander F, Marie-Lilliu C, Walker I, Murtishaw S. Indicators of Energy Ues and Efficiency in New Zealand: An International Perspective: Comparison of Trends Through 1995. Paris: International Energy Agency, 2000.
6. Healy JD. Excess Winter Mortality in the EU: Identifying Key Risk Factors. *Housing, Fuel Poverty and Health: A Pan-European Analysis*. Aldershot: Ashgate Publishing Limited, 2004:140-160.
7. Curwen M. Excess winter mortality: a British phenomenon? *Health Trends* 1991;4:169-175.
8. Gemmell I, McLoone P, Boddy FA, Dickinson GJ, Watt GCM. Seasonal variation in mortality in Scotland. *International Journal of Epidemiology* 2000;29:279-279.
9. Isaacs N, Donn M. Health and housing - seasonality in New Zealand mortality. *Australian Journal of Public Health* 1993;17(1):68-70.
10. Moran C, Johnson H, Johnson Z. Seasonal patterns of morbidity and mortality in the elderly in Ireland. *International Journal of Circumpolar Health* 2000;59(3-4):170-5.
11. Davie G. The seasons of "Six Feet Under": Trends and Determinants of Excess Winter Mortality in New Zealand from 1980 to 2000 [Masters Project]. University of Melbourne, 2004.
12. Rau R. Seasonality in Human Mortality. A Demographic Approach. Universität Rostock, 2004.
13. Crighton EJ, Moineddin R, Upshur REG, Mamdani M. The Seasonality of Total Hospitalizations in Ontario by Age and Gender. *Canadian Journal of Public Health. Revue Canadienne de Sante Publique* 2003;94(6):453-457.
14. Maheswaran R, Chan D, Fryers PT, McManus C, McCabe H. Socio-economic deprivation and excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone, UK. *Public Health* 2004;118:167-176.
15. Garfield M, Ridley S, Kong A, Burns A, Blunt M, Gunning K. Seasonal variation in admission rates to intensive care units. *Anaesthesia* 2001;56:1136-40.

16. Segal AO, Crighton EJ, Moineddin R, Mamdani M, Upshur REG. Croup Hospitalizations in Ontario: A 14-Year Time-Series Analysis. *Pediatrics* 2005;116(1):51-55.
17. Blaisdell CJ, Weiss SR, Kimes DS, Levine ER, Myers M, Timmins S, et al. Using Seasonal Variations in Asthma Hospitalizations in Children to Predict Hospitalization Frequency. *Journal of Asthma* 2002;39(7):567-575.
18. Dushoff J, Plotkin JB, Levin SA, Earn DJ. Dynamical resonance can account for seasonality of influenza epidemics. *Proceedings of the National Academy of Sciences of the United States of America* 2004;101(48):16915-6.
19. Hajat S, Haines A. Associations of cold temperatures with GP consultations for respiratory and cardiovascular disease amongst the elderly in London. *International Journal of Epidemiology* 2002;31(4):825-830.
20. Hajat S, Bird W, Haines A. Cold Weather and GP consultations for respiratory conditions by elderly people in 16 locations in the UK. *European Journal of Epidemiology* 2004;19(10):959-968.
21. Watkins SJ, Byrne D, McDevitt M. Winter excess morbidity: is it a summer phenomenon? *Journal of Public Health Medicine* 2001;23(3):237-241.
22. Hales S, Telfar Barnard L, Baker M, Venugopal K, Mann S, Howden-Chapman P. Seasonal patterns of cardiovascular disease in New Zealand: a small area analysis of physical environmental factors: Personal communication, 2009.
23. Douglas AS. Seasonality of hip fracture and haemorrhagic disease of the newborn. *Scottish Medical Journal* 1993;38(2):37-40.
24. Healy JD. *Housing, Fuel Poverty and Health: A Pan-European Analysis*. Aldershot: Ashgate Publishing Ltd, 2004.
25. Howden-Chapman P, Carroll P, editors. *Housing and Health: Research, Policy and Innovation*. Wellington: Steele Roberts Ltd, 2004.
26. Marsh A, Gordon D, Pantazis C, Heslop P. Home Sweet Home? The impact of poor housing on health. Bristol: University of Bristol, 1999:90.
27. World Health Organization. Health Impact of Low Indoor Temperatures. Copenhagen: World Health Organization; Regional Office for Europe, 1987.
28. Emenius G, Korsgaard J, Wickman M. Window pane condensation and high indoor vapour contribution - markers of an unhealthy indoor climate? *Clinical and experimental allergy* 2000;30:418-425.
29. Thomson H, Petticrew M, Morrison D. Health effects of housing improvement: systematic review of intervention studies. *British Medical Journal* 2001;323:187-190.
30. Lloyd EL, McCormack C, McKeever M, Syme M. The effect of improving the thermal quality of cold housing on blood pressure and general health: a research note. *Journal of Epimediol Community Health* 2008;62:793-797.
31. Donaldson GC, Ermakov SP, Komarov YM, McDonald CP, Keatinge WR. Cold related mortalities and protection against cold in Yakutsk, eastern Siberia: observation and interview study. *British Medical Journal* 1998;317:978-982.

32. Donaldson GC, Tchernjavskii VE, Ermakov SP, Bucher K, Keatinge WR. Winter mortality and cold stress in Yekaterinburg, Russia: interview survey. *British Medical Journal* 1998;316(7130):514-518.
33. Keatinge WR, Coleshaw SRK, Holmes J. Changes in seasonal mortalities with improvement in home heating in England and Wales from 1964-1984. *International Journal of Biometeorology* 1989;33:71-76.
34. Kunst AE, Looman CWN, Mackenbach JP. The decline in winter excess mortality in The Netherlands. *International Journal of Epidemiology* 1991;20(4):971-7.
35. McDowall M. Long term trends in seasonal mortality. *Population Trends* 1981;26:16-19.
36. Elton P, Vickers J. Excess winter deaths [comment]. *Journal of Public Health Medicine* 2001;23(1):84.
37. Keatinge WR. Seasonal mortality among elderly people with unrestricted home heating. *British Medical Journal* 1986;293:732-733.
38. Clinch JP, Healy JD. Housing standards and excess winter mortality. *Journal of Epidemiology and Community Health* 2000;54:719-720.
39. Curriero FC, Heiner KS, Samet JM, Zeger SL, Strug L, Patz JA. Temperature and Mortality in 11 Cities of the Eastern United States. *American Journal of Epidemiology* 2002;155(1):80-87.
40. Healy JD. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. *Journal of Epidemiology and Community Health* 2003(57):784-789.
41. Howieson SG, Hogan M. Multiple Deprivation and Excess Winter Deaths in Scotland. *Journal of the Royal Society of Health* 2005;125(1):18-22.
42. McKee CM. Deaths in Winter: Can Britain learn from Europe? *European Journal of Epidemiology* 1989;5(2):178-182.
43. Sakamoto-Momiyama M. Changes in the seasonality of human mortality: a medico-geographical study. *Social Sciences and Medicine* 1978;12d:29-42.
44. Lerchl A. Changes in the seasonality of mortality in Germany from 1946 to 1995: the role of temperature. *International Journal of Biometeorology* 1998;42:84-88.
45. Wilkinson P, Pattenden S, Armstrong B, Fletcher A, Kovats RS, Mangtani P, et al. Vulnerability to winter mortality in elderly people in Britain: population based study. *British Medical Journal* 2004;329(7467):647-651.
46. Shah S, Peacock J. Deprivation and excess winter mortality. *Journal of Epidemiology and Community Health* 1999;53:499-502.
47. Wilkinson P, Landon M, Armstrong B, al e. *Cold comfort: the social and environmental determinants of excess winter deaths in England, 1986-96* London: The Policy Press, 2001.
48. Rudge J, Gilchrist R. Measuring the health impact of temperatures in dwellings: investigating excess winter morbidity and cold homes in the London Borough of Newham. *Energy and Buildings*, 2007:847-858.
49. Rudge J, Gilchrist R. Excess winter morbidity among older people at risk of cold homes: a population-based study in a London borough. *Journal of Public Health* 2005;27(4):353-358.

50. Aylin P, Morris S, Wakefield J, Grossinho A, Jarup L, Elliot P. Temperature, housing, deprivation and their relationship to excess winter mortality in Great Britain, 1986-1996. *International Journal of Epidemiology* 2001;30:1100-1108.
51. Gouveia N, Hajat S, Armstrong B. Socioeconomic differentials in the temperature-mortality relationship in Sao Paulo, Brazil. *International Journal of Epidemiology* 2003;32:390-397.
52. Donaldson GC, Keatinge WR. Cold related mortality in England and Wales; influence of social class in working and retired age groups. *Journal of Epidemiology and Community Health* 2003;57:790-791.
53. Schwartz J, Spix C, Touloumi G, Bacharova L, Barumamdzadeh T, le Tetre A, et al. Methodological issues in studies of air pollution and daily counts of deaths or hospital admissions. *Journal of Epimediology and Community Health* 1996;50(supplement 1):S3-11.
54. van Rossum CTM, Shipley MJ, Hemingway H, Grobbee DE, Mackenbach JP, Marmot MG. Seasonal variation in cause-specific mortality: Are there high-risk groups? 25-year follow-up of civil servants from the first Whitehall study. *International Journal of Epidemiology* 2001;30:1109-1116.
55. Woodall AA. Winter mortality in elderly people in Britain: Outdoor exposure and effect of windchill should be taken into consideration [letter]. *British Medical Journal* 2004;329(7472):976-a.
56. Lawlor DA, Harvey D, Dews HG. Investigation of the association between excess winter mortality and socio-economic deprivation. *Journal of Public Health Medicine* 2000;22(2):176-181.
57. Wilson JS, Smith AF, Goodwin J, Hawker J, Taylor R. A Systematic Review of the Biological and Health Effects of Exposure to Cold Temperature in Healthy and Diseased Adults Including the Elderly. In: Health Do, editor: Birmingham Health Technology Assessment Group, University of Birmingham, 2001:140.
58. Mackenbach JP, Looman CW, Kunst AE. Air pollution, lagged effects of temperature, and mortality: The Netherlands 1979-87. *Journal of Epimediol Community Health* 1993;47(2):121-6.
59. The Eurowinter Group. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. *The Lancet* 1997;349:1341-1346.
60. Lawlor DA, Maxwell R, Wheeler BW. Rurality, deprivation, and excess winter mortality: an ecological study. *Journal of Epidemiology and Community Health* 2002;56:373-374.
61. Rau R. Winter mortality in elderly people in Britain: Lack of social gradient in winter excess mortality is obvious in Denmark [comment]. *British Medical Journal* 2004;329:976-977.
62. Smeeth L, Thomas SL, Hall AJ, Hubbard R, Farrington P, Vallance P. Risk of myocardial infarction and stroke after acute infection or vaccination. *New England Journal of Medicine* 2004;351(25):2611-8.
63. Malcolm L. Trends in hospital bed utilisation in New Zealand 1989 to 2006: more or less beds in the future? *New Zealand Medical Journal* 2007;120(1264).

64. Linnekin J, Poyer L. *Cultural Identity and Ethnicity in the Pacific*. Honolulu: University of Hawaii Press, 1990.
65. Barnard LF. To make a house of a tree: Community and Identity among New Zealand Chilenas/Hacer una casa de un arbol: comunidad e identidad entre chilenas neocelandesas. University of Auckland, 1996.
66. Salmond C, Crampton P. NZDep2001 Index of Deprivation User's Manual: Department of Public Health, Wellington School of Medicine and Health Sciences, 2002.
67. Definitions and Questionnaires: Statistics New Zealand, 2001.
68. BRANZ. New Zealand 2005 House Condition Survey. Wellington: BRANZ, 2005:146.
69. Langley J, Stephenson S, Thorpe C, Davie G. Accuracy of injury coding under ICD-9 for New Zealand public hospital discharges *Injury Prevention* 2006;12:58-61.
70. StataMP Statistical Programme: Release 10.1 [program]. College Station, TX: Stata Software, 2007.
71. McNutt L-A, Wu C, Xue X, Hafner JP. Estimating the relative risk in cohort studies and clinical trials of common outcomes. *American Journal of Epidemiology* 2003;157(10):940-943.
72. Zou G. A modified Poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology* 2004;159(7):702-706.
73. Poisson regression: Wikipedia.
74. Hall JN, Moore S, Harper SB, Lynch JW. Global Variability in Fruit and Vegetable Consumption. *American Journal of Preventive Medicine* 2009;36(5):402-409.
75. Scharoun-Lee M, Adair LS, Kaufman JS, Gordon-Larsen P. Obesity, race/ethnicity and the multiple dimensions of socioeconomic status during the transition to adulthood: A factor analysis approach. *Social Science & Medicine* 2009;68:708-716.
76. Nahya S. Seasonal variation of deaths in Finland - is it still diminishing? *International Journal of Circumpolar Health* 2000;59(3-4):182-187.
77. Baker MG, Wilson N, Huang QS, Paine S, Lopez L, Bandaranayake D, et al. Pandemic influenza A(H1N1)V in New Zealand: the experience from April to August 2009. *Eurosurveillance* 2009;14(34):pii=19319.
78. Davie GS, Baker MG, Hales S, Carlin JB. Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. *BMC Public Health* 2007;7(263).
79. Meier CR, Jick SS, Derby LE, Vasilakis C, Jick H. Acute respiratory-tract infections and risk of first-time acute myocardial infarction. *The Lancet* 1998;351:1467-71.
80. Cleveland WS. Robust Locally Weighted Regression and Smoothing Scatterplots. *Journal of the American Statistical Association* 1979;74(368):829-836.
81. Mills CF, Tobias M, Baker M. A re-appraisal of the burden of infectious disease in New Zealand: aggregate estimates of morbidity and mortality. *New Zealand medical journal* 2002;115:254-257.

82. Clark J. Ephemera: The Elusive Canon of New Zealand Architecture. *Fabrications : The Journal of the Society of Architectural Historians, Australia and New Zealand* 2004;14(1&2):47-58.
83. Salmond J. *Old New Zealand Houses 1800-1940*. Auckland: Reed Publishing (NZ) Ltd, 1986.
84. Hodgson T. *Proud Possessions: Architectural style and the old New Zealand house*. Wellington: Bookcase, 2003.
85. Toomath W. *Built in New Zealand: The Houses We Live In*. Auckland: HarperCollins, 1996.
86. Lloyd Jenkins D. Shape of the new. *Listener* 2005;197(3375):15-21.
87. Shaw P. *A History of New Zealand architecture*. 3rd Edition ed. Auckland: Hodder Moa Beckett Publishers Limited, 2003.
88. Kutty NK. Determinants of Structural Adequacy of Dwellings. *Journal of Housing Research* 1999;10(1):27-43.
89. Blane D, Mitchell R, Bartley M. The "inverse housing law" and respiratory health. *Journal of Epimediol Community Health* 2000;54:745-749.
90. Ryan V, Burgess G, Easton L. New Zealand House Typologies to Inform Energy Retrofits.: Beacon Pathway Limited, 2008.
91. Amitrano LJ, Kirk NR, Page IC. Market Segmentation of New Zealand's Housing Stock: Beacon Pathway Limited, 2006.
92. Mitchell D, Chaplin G. *The Elegant Shed: New Zealand Architecture since 1945.* Auckland: Oxford University Press, 1984.
93. Schrader B. *We call it home: a history of state housing in New Zealand*. Auckland: Reed Publishing Ltd, 2005.
94. Wells J. The History of State Housing Construction in New Zealand. University of New Zealand, 1944.
95. Wilson N, Howden-Chapman P, Crane J, Wickens K, Chapman R. Potential Health Impacts Associated with Mould in "Leaky Buildings": A review commissioned by the Auckland City Council. Wellington: Housing and Health Research Programme, Department of Public Health, University of Otago, 2007.
96. Zureik M, Neukirch C, Liard R, Bousquet J, Neukirch F. Sensitisation to airborne moulds and severity of asthma: cross sectional study from European Community respiratory health survey *British Medical Journal* 2002;325(7361):411.
97. (U.S.) IoM, Health CoDISa, Prevention BoHPaD. *Damp Indoor Spaces and Health*. Washington, D.C.: The National Academies Press, 2004.
98. Macintyre S, Ellaway A, Hiscock R, Kearns A, Der G, McKay L. What features of the home and the area might help to explain observed relationships between housing tenure and health? Evidence from the west of Scotland. *Health and Place* 2003;9(3):207-218.
99. Davis P, Jenkin G, Coope P. New Zealand Socio-economic Index 1996: An update and revision of the New Zealand Socio-economic Index of Occupational Status. Wellington: Statistics New Zealand, 1996.

100. Moon C-G, Stotsky JG. The Effect of Rent Control on Housing Quality Change: A Longitudinal Analysis. *The Journal of Political Economy* 1993;101(6):1114-1148.
101. Monthly Road Crash Statistics Update: July 2009: Ministry of Transport, 2009.
102. Blakely T, Tobias M, Atkinson J, Yeh L-C, Huang K. Tracking Disparity: Trends in ethnic and socioeconomic inequalities in mortality, 1981–2004. Wellington: Ministry of Health, 2007.
103. Our Health, Our Future/Hauora Pakari, Koiora Roa: The Health of New Zealanders 1999. Wellington: Ministry of Health, 1999.
104. McSweeny K, Colman A, Fancourt N, Parnell M, Stantiall S, Rice G, et al. Was rurality protective in the 1918 influenza pandemic in New Zealand. *New Zealand Medical Journal* 2007;120(1256):http://www.nzma.org.nz/journal/120-1256/2579/.
105. Crighton EJ, Moineddin R, Mamdani M, Upshur REG. Influenza and pneumonia hospitalizations in Ontario: a time-series analysis. *Epidemiology and Infection* 2004;132:1167-1174.
106. Ajwani S, Blakely T, Robson B, Atkinson J, Fawcett J, Kiro C. Unlocking the numerator-denominator bias for the 1980s and 1990s. *NZCMS Technical Report No.4*. Wellington: Department of Public Health, Wellington School of Medicine and Health Sciences, University of Otago, 2003.
107. Koepsell TD, Weiss NS. *Epidemiologic Methods: Studying the Occurrence of Illness*. New York: Oxford University Press, 2003.
108. Saville-Smith K. Appendix C: Landlords Energy Working Paper - Preliminary Analysis of the Telephone Survey Data: Beacon Pathway Ltd, 2008.
109. Beaglehole R, Bonita R, Kjellstrom T. *Basic epidemiology*. Geneva: World Health Organisation, 1993.
110. Ikeda A, Iso H, Kawachi I, Yamagishi K, Inoue M, Tsugane S. Living arrangement and coronary heart disease: the JPHC study. *Heart* 2009;95:577-583.
111. Hill AB. The environment and disease: association or causation? *Proceedings of the Royal Society of Medicine* 1965;58:295-300.
112. Schluter PJ, Macey PM, Ford RPK. The relationship between inside and outside ambient temperatures in Christchurch, New Zealand. *Paediatric and Perinatal Epidemiology* 2000;14:275-282.
113. Kearns RA, Smith CJ, Abbott MW. Another day in paradise? Life on the margins of urban New Zealand. *Social Science & Medicine* 1991;33(4):369-379.
114. What is the extent of crowding in New Zealand? An analysis of crowding in New Zealand households 1986-2001. Wellington: Statistics New Zealand, 2003.
115. The Social Report 2008. Wellington, NZ.: Ministry of Social Development, 2008.
116. McNicholas A, Lennon D, Crampton P, Howden-Chapman P. Overcrowding and infectious diseases - when will we learn the lessons of our past? *New Zealand Medical Journal* 2000;113(1121):453-454.
117. Baker M, Das D, Venugopal K, Howden-Chapman P. Tuberculosis associated with household crowding in a developed country. *Journal of Epidemiology and Community Health* 2008;62:715-721.

118. Cox BD, Whichelow MJ, Prevost AT. Seasonal consumption of salad vegetables and fresh fruit in relation to the development of cardiovascular disease and cancer. *Public Health Nutrition* 2000;3(1):19-29.

119. Rockell JEP, Skeaff CM, Williams SM, Green TJ. Serum 25-hydroxyvitamin D concentrations of New Zealanders aged 15 years and older. *Osteoporosis International* 2006;17(9):1382-1389.

120. Rockell J, E., Green TJ, Skeaff CM, Whiting SJ, Waylor RW, Williams SM, et al. Season and Ethnicity Are Determinants of Serum 25-Hydroxyvitamin D Concentrations in New Zealand Children Aged 5–14 y. *Journal of Nutrition* 2005;135:2602-2608.

121. Donaldson GC, Rintamaki H, Nayha S. Outdoor clothing: Its relationship to geography, climate, behaviour and cold-related mortality in Europe. *International Journal of Biometeorology* 2001;45(1):45-51.

122. Scott KM, Marwick JC, Crampton PR. Utilization of general practitioner services in New Zealand and its relationship with income, ethnicity and government subsidy. *Health Services Management Research* 2003;16(1):45-55.

123. Young N. The pre-hospital experiences of Samoan families who have had a child admitted to hospital with pneumonia: a qualitative investigation. *Pacific Health Dialog* 2001;8(1):20-28.

124. Grant CC, Pati A, Tan D, Vogel S, Aickin R, Scragg R. Ethnic comparisons of disease severity in children hospitalised with pneumonia in New Zealand. *Journal of Paediatric and Child Health* 2001;37(1):32-37.

125. Mahmoud M, Hill A. Appendicitis in South Auckland, New Zealand. *New Zealand Medical Journal* 2006;119(1230).

126. Boardman B. *Fuel Poverty: from Cold Homes to Affordable Warmth*. London: Belhaven Press, 1991.

127. Berry M. Whose City? The Forgotten Tenant. *Journal of Sociology* 1977;13:53.

APPENDIX 1 PUBLISHED PAPERS

[pp 235-255

Telfar Barnard LF, Baker MG, Hales S, Howden-Chapman PL. Excess Winter Morbidity and Mortality: Do Housing and Socio-Economic Status Have an Effect? *Reviews on Environmental Health* 2008;23(3):203-221.

Abstract: *Objective*: To review the published research evidence on the links between excess winter mortality (EWM) or excess winter hospitalization (EWH) and housing quality or socioeconomic status (SES). *Design*: Systematic review. *Criteria*: Linked data on EWM or EWH and potential associations with housing quality or SES. *Results*: No consistent relations between SES and EWM or EWH. The results for housing quality are also inconsistent, with some studies showing a weak protective effect of home heating. *Conclusion*: Studies to date do not provide good evidence that housing quality or SES factors affect EWM and EWH. More research is needed, particularly studies using individual level housing and SES data. Controlled trials of interventions would be desirable.

Keywords: seasonal variation; morbidity; excess mortality; cold; literature review (PT)

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APPENDIX 2 LITERATURE REVIEW TABLE

Table A 2.1 Ecological Studies: Seasonal ratios/indices

Study and year	Location and time period	Subjects and size	Exposure measure	Outcome measure	Analysis and control for confounding	Main findings and interpretation
Rudge and Gilchrist, 2007[48] and 2005[49]	Newham Borough, London (UK), August 1993 – July 96	65+, 3373 hospitalisations, "about 25,000" total population	Winter; Fuel Poverty Risk Index Score; Townsend deprivation score (Both census enumeration district level)	Emergency respiratory hospital episode	Excess Winter Morbidity Ratio (EWMb), using Curwen's EWMR method (see p. 3) and various poisson-related distributions Controlled for sex, age, ethnicity and weather.	FPRI is a predictor for excess winter respiratory morbidity among Newham over-65s. EWMb for high FPR is 1.7 higher than ratio for non-high FPR. Townsend deprivation score is not a factor in increased risk of excess winter episodes.
Maheswaran et al., 2004[14]	South Yorkshire Coalfields Health Action Zone (UK), 1981-1999	45+, 146,481 deaths, 131,363 total population	Winter; Townsend deprivation score (Census enumeration district level)	Death; Cardiovascular death; respiratory death.	Curwen's EWMR Poisson regression analysis for significance. Notes age may be a confounder because of using 85+ age band.	No significant increase in EWM ratios for cardiovascular disease, respiratory disease or all other diseases with increasing socio-economic deprivation.
Maheswaran et al., 2004[14]	South Yorkshire Coalfields Health Action Zone (UK), 1981-1999	45+, 656,061 hospitalisations, 131,363 total population	Winter; Townsend deprivation score (Census enumeration district level)	Emergency respiratory hospital admissions.	Excess winter admissions ratio = (Dec to Jan)/ ((April to Nov + Feb to Mar)/5). Poisson regression analysis for significance Notes age may be a confounder because of using 85+ age band.	No significant increase in the excess winter emergency hospital admission ratio for respiratory disease with increasing deprivation.

Study and year	**Location and time period**	**Subjects and size**	**Exposure measure**	**Outcome measure**	**Analysis and control for confounding**	**Main findings and interpretation**
Wilkinson et al. 2004[45]	UK 1995-1998	75 yrs+, 119389 person years; 33326 people; 10123 deaths	Winter; Carstairs deprivation group. (Census enumeration district level)	Death	Curwen's EWMR Poisson regression with interaction terms Controlled for temperature, influenza, and influenza vaccination.	No Carstairs deprivation group gradient in EWM ratios
Lawlor et al., 2002[60]	South West Region (UK) 1994-1998	279 513 deaths (all); 1169 wards.	Winter; Townsend deprivation (electoral ward level)	Death	Curwen's EWMR Discounts temperature variation between wards as confounder.	No association between EWM ratios and Townsend deprivation score.
Aylin et al., 2001[50]	Great Britain (UK), 1986-1996	1682687 (winter) 2825223 (other) deaths 65+ years	Winter; Rain; Wind; Sunshine hours; English House Condition Survey variables; Carstairs deprivation score (both electoral ward level)	Death: – all cause, - coronary heart disease, - stroke, - respiratory diseases	Curwen's EWMR Poisson regression analysis Confounders not discussed	No association between Carstairs deprivation index and all cause or coronary EWM ratio. Borderline significant *lower* EWM with *increasing* deprivation for EWM from respiratory disease (OR=0.976, 95% CI 0.953-1.000) Lack of central heating associated with a higher risk of dying in winter (OR = 1.016, 95% CI 1.009-1.022
Watkins et al. 2001[21]	Stockport (UK), 1990-1992	All Stockport residents (Census) 284200 persons	Winter; ACORN housing type (postcode level)	"Finished Consultant Episode" (FCE) for ischaemic heart disease.	Nov to Feb May to August Significance tests not done because results contrary to those expected. Confounders not discussed	Winter excess FCEs greater in more affluent areas.

Study and year	Location and time period	Subjects and size	Exposure measure	Outcome measure	Analysis and control for confounding	Main findings and interpretation
Wilkinson et al., 2001[47]	England (UK), 1986-1996	People living in postcodes with EHCS surveyed dwelling (179234 deaths); 21273 dwellings	Winter; Housing tenure, Age of property, Dampness, Central heating, SAP energy rating, Low indoor temperature (postcode level)	Death from cardiovascular disease	Curwen's EWMI Technical details not included; available on request. Controlled for SES.	Magnitude of EWM greater in people living in dwellings predicted to be poorly heated. % rise in deaths in winter greater in dwellings with low energy-efficiency ratings, and in dwellings predicted to have low indoor temperatures during cold periods. Gradient of EWM risk with age of property - risk greatest in dwellings built before 1850, lowest in dwellings built after 1980. Trend removed by controlling for index of indoor temperature, but not by controlling for central heating.
Lawlor et al. 2000[56]	Bradford, (UK), 1994-1998	1198 excess winter deaths = 24.5% of total. Bradford overall population not given.	Winter; 10 socio-economic "Super Profile groups" (Census enumeration district level)	Death	Curwen's EWMI, tested for trend using χ^2 Age-standardised Accounted for influenza effect; may be confounded by presence of nursing homes in some group areas.	No significant trend in EWM across Super Profile groups (χ^2 trend = 0.24, p> 0.05). Two Super Profile groups, 'Thriving greys' and 'Hard-pressed families', appear to have significantly higher EWDI than Bradford as a whole (p = 0.05 and p < 0.05, respectively) No association between EWM and deprivation at enumeration district level.

Study and year	**Location and time period**	**Subjects and size**	**Exposure measure**	**Outcome measure**	**Analysis and control for confounding**	**Main findings and interpretation**
Shah et al. 1999[46]	Croydon, London, (UK), 1990-1995	All deaths (17744)	Winter, Townsend score, by quintile. (electoral ward level)	Death	Curwen's EWMR Ratios and Townsend scores assessed using Kendall's rank correlation. Controlled for residential/nursing homes. Useful discussion of potential confounders. Quotes Mackenbach's finding that air pollution has little impact on temperature dependant variations in mortality.	No relationship between EWM and Townsend scores for all deaths (Kendall's c = -0.066, p=0.63), nor cardiovascular deaths, nor respiratory deaths.

Table A 2.2 Ecological Studies: Time series

Study and year	Location and time period	Subjects and size	Exposure measure	Outcome measure	Analysis and control for confounding	Main findings and interpretation
Gouveia et al. 2003[51]	Sao Paolo, Brazil, 1991-1994	All city deaths except ‘violent’ and one-month neonatal. 212,577 total deaths.	Temperature, Socio-economic position (SEP) by 5 factors: mean income, average education level, adequate sewerage system, percentage with piped water, crowding (district level).	Death – all cause, cardiovascular, respiratory, and other. All cause only for children.	“standard time-series methods … developed for air pollution studies” - Poisson generalised additive models (GAM) regression allowing for overdispersion was used to determine the relative risk (RR) of death associated with a 1°C change in mean temperature. Separate analysis for each SEP. Controlled for humidity, pollution, at city-wide level. Main possible confounder is size of study area units. While district may be an adequate proxy for SEP in Sao Paolo, air pollution may have variations within districts.	No modification of the mortality impact for all causes due to cold by SEP, nor for CVD or respiratory disease in adults and the elderly.

Study and year	Location and time period	Subjects and size	Exposure measure	Outcome measure	Analysis and control for confounding	Main findings and interpretation
Wilkinson et al., 2001[47]	England (UK), 1986-1996	Subset of people living in postcodes with EHCS surveyed dwelling (179234 deaths); 21273 dwellings	Predicted indoor temperature, based on six variables: household size, net income, region, building age, central heating presence, standardised heating costs (postcode level).	Death from cardiovascular disease	Modification of Schwartz et al.'s 1996 time series method[53] for measuring adverse health effects of air pollution (full description not given, available on request.) Controlled for SES.	Relationship between outdoor temperature and mortality steeper among residents of intrinsically cold homes than among those in warmer homes. For each degree C fall in outdoor temperature, the % rise in mortality was greater in those living in cold homes (the rise was about 2.8% per degree C in the coldest 10% of homes and 0.9% in the warmest 10% of homes.)
Gemmell et al. 2000[8]	Scotland (UK), 1981-1993	All deaths – number not given	Winter, outdoor temperature; Carstairs category ("area based" – level not given).	Death	Seasonal pattern estimated using Poisson regression on weekly data. Uses disease groupings to control for possible confounding between individual causes of death. Controlled for long-term and seasonal mortality trends, over-dispersion, and influenza epidemics.	No clear evidence of a relationship between socioeconomic status and seasonal mortality, however the extent of the fall in seasonal variation was greater in deprived areas than in affluent areas.
Shah and Peacock 1999[46]	Croydon, London (UK), 1990-1995	All deaths (17744)	Monthly average temperature; Townsend score, by quintile (electoral ward level).	Death	Multiple linear regression used to develop model of monthly ward mortality. Controlled for nursing and residential home residents.	No evidence of interaction between Townsend score and temperature in the model of ward mortality rates (p=0.73). Findings not affected by exclusion of deaths of nursing and residential home residents. (p=0.83)

Table A 2.3 Individual level (cohort) Studies: Seasonal ratios/indices

Study and year	Location and time period	Subjects and size	Exposure measure	Outcome measure	Analysis and control for confounding	Main findings and interpretation
Rau 2004[12]	USA, 1989-1998	Subset of 77 million deaths; 50+	Month; Education level (as proxy for socio-economic status)	Death	$\frac{\text{Deaths Jan to March}}{\text{Deaths Jul to Sept}}$ Confounders not discussed. Relationship between education and EWM could be confounded by geographical location.	Clear social gradient in seasonal mortality up to age 90. Greatest difference between people with a college degree or higher, and those with no formal education. People in the highest educational group had the lowest seasonal amplitude and vice versa. Little difference between men and women.
Rau 2004[12]	Denmark, 1980-1998	1.8 million people, 65+; 999,605 deaths	Month; Housing conditions, Wealth	Death, respiratory death	$\frac{\text{Deaths Jan to March}}{\text{Deaths Jul to Sept}}$ Confounders not discussed.	No social gradient in excess winter mortality, whether measured as highest completed education or wealth on the family level. No relationship between housing factors and EWM.
Wilkinson et al. 2004[45]	UK 1995-1998	75 yrs+, randomised interviewees invited from general practices; 4221 deaths	Winter; Self assessed difficulty making ends meet, Self-assessed difficulty keeping house warm.	Death	Curwen's EWMR Poisson regression with interaction terms Controlled for temperature, influenza, and influenza vaccination.	No relationship between self-reported difficulty making ends meet and EWM No relationship between self reported difficulty keeping house warm and EWM.
Wilkinson et al., 2001[47]	England (UK), 1986-1996	Subset of people living in postcodes with EHCS surveyed dwelling (37,700 deaths)	Winter; Head of household socioeconomic group.	Death from cardiovascular disease	Curwen's EWMI Technical details not included; available on request. Confounders not discussed for individual level data.	Professionals had the highest EWM rate and unskilled workers the lowest; however the trend across groups was not significant.

Study and year	**Location and time period**	**Subjects and size**	**Exposure measure**	**Outcome measure**	**Analysis and control for confounding**	**Main findings and interpretation**
Van Rossum et al. 2001[54]	UK 1967-1995	Whitehall study male civil servants (18,841 men, 8347 deaths with known cause.)	Winter; Employment grade 1967-70	Death	Highest monthly mortality rate November – March: lowest monthly mortality rate June-September. Poisson regression. Mentions air pollution as a climatic factor possibly contributing to EWM, but not as a confounder. Confounders not discussed.	No significant differences in seasonal fluctuations between two employment grades. However, employment grade in 1967 may not adequately reflect SES at time of death, particularly for deaths some 20 years later.

Table A 2.4 Individual level (cohort) Studies: Time series

Study and year	Location and time period	Subjects and size	Exposure measure	Outcome measure	Analysis and control for confounding	Main findings and interpretation
Donaldson and Keatinge, 2003[52]	England and Wales (UK), 1998-2000	Men and women 65-74 and 50-59. Between 896 and 66477 deaths in each age, sex and class group (total not given)	Temperature; Occupational class - 1 (professional) to 5 (unskilled)	Death	Daily mortality at 18° estimated by generalised linear modelling with Poisson distribution, of mortality on temperature, over the linear range 0°C to 18°C. Controlled for influenza.	Cold related mortality in 65-74 year olds generally higher in class 5 (unskilled) than class 1 (professions) men, or other classes, with little difference between men, and women or housewives, of any class. Cold related mortality generally low in class 5 men of working age (50–59) only, compared with men in other classes, and significantly compared with class 5 women or housewives. Infers work to have a beneficial effect independent of home environment and income, probably via internal heat production from manual labour.
Gemmell et al. 2000[8]	Scotland (UK), 1981-1993	All male deaths – number not given	Month; Occupation-based social class (Registrar General's social classes)	Death	Seasonal pattern estimated using Poisson regression on weekly data. Uses disease groupings to control for possible confounding between individual causes of death. Controlled for long-term and seasonal mortality trends, over-dispersion, and influenza epidemics.	Differences by class, but did not reach statistical significance. Differences in the ratio of weekly deaths to annual average deaths, for different classes, almost reached statistical significance only during the 4-week period covering late December/early January (P= 0.055). Possible selection bias as only recorded professions included (numbers not given).

APPENDIX 3 EXCLUDED ADMISSION NUMBERS

This Appendix lists the number of admissions excluded for each exclusion category, by year of admission.

Exclusion categories:

1. Non-publicly funded
2. Non-NZ-residents
3. Transfers and tranfer-like cases
4. Non-treatment events
5. Admissions related to pregnancy, birth and perinatal period
6. Non-acute admissions
7. Same-day discharges

Table A 3.1 Total, excluded, and included hospital admissions, by exclusion category and year, 1980-2006.

		Exclusion category							
Year	**Admissions**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Included**
1980	337802	0	1009	12208	18601	16186	110043	0	179755
1981	374552	0	1041	15809	20353	43882	111570	0	181897
1982	413843	0	912	19088	22740	71962	108294	0	190847
1983	420223	0	978	21075	23851	75066	108940	0	190313
1984	429562	0	1055	21696	26072	76600	107140	0	196999
1985	418374	0	1154	21470	27483	77781	96521	22	193943
1986	432340	0	1183	22014	29138	79958	99237	0	200810
1987	441732	0	1333	22518	30162	82949	102319	2844	199607
1988	605882	3	3030	23187	49056	90313	164910	15351	260032
1989	611501	3	3528	24054	46174	93647	173075	20761	250259
1990	639463	5	2433	23393	48180	97714	186760	25970	255008
1991	671258	5	5107	24682	59055	99913	207464	27285	247747
1992	737924	27	4466	27602	85476	97638	238354	32912	251449
1993	802429	39	5214	30809	98705	101072	267754	39269	259567
1994	828115	127	6503	32117	102919	105315	265343	44289	271502
1995	851919	5626	7601	33793	112256	137361	244426	38969	271887
1996	904811	37001	21449	33803	118423	151886	243402	36290	262557
1997	909516	18609	11599	33643	114676	151145	270472	38822	270550
1998	934605	25891	9861	38396	115866	151737	275027	44956	272871
1999	987769	35778	7672	42444	122039	157637	288053	52408	281738
2000	1067398	55801	8462	47754	131814	163710	304749	64981	290127
2001	1144203	78717	9033	52501	143493	161899	320868	77447	300245
2002	1162773	87272	16071	55133	150636	160224	316158	80999	296280
2003	1166718	83363	21485	52943	150462	163917	315907	81187	297454
2004	1097190	15341	28445	51372	141578	166528	310796	84503	298627
2005	1105356	10289	31917	48963	143543	165369	313221	94232	297822
2006	1121116	10157	32079	71439	135288	167019	309020	97412	298702

APPENDIX 4 EWH FOR DEMOGRAPHIC SUB-GROUPS

Table A 4.1 EWH 2000-2006 by age and ethnicity, standardised by gender, NZDep, rurality and annual average minimum temperature; and by age and gender, standardised by ethnicity, NZDep, rurality and annual average minimum temperature.

Age	NZ Euro	95%CI	Māori	95%CI	Pacific	95%CI		Female	95% CI	Male	95% CI
0	1.6364	(1.5812-1.6935)	1.8435	(1.7776-1.9118)	1.8842	(1.7875-1.9861)		1.7510	(1.6924-1.8116)	1.7405	(1.6914-1.7911)
1	1.4823	(1.4400-1.5258)	1.7936	(1.7396-1.8494)	1.9272	(1.8434-2.0148)		1.6716	(1.6252-1.7193)	1.6438	(1.6041-1.6845)
2	1.4456	(1.3947-1.4983)	1.4851	(1.4233-1.5495)	1.4184	(1.3316-1.5109)		1.5297	(1.4752-1.5862)	1.3873	(1.3426-1.4334)
3	1.2991	(1.2441-1.3566)	1.2539	(1.1854-1.3265)	1.3038	(1.1998-1.4169)		1.2976	(1.2390-1.3589)	1.2920	(1.2403-1.3458)
4	1.1804	(1.1231-1.2406)	1.1023	(1.0320-1.1774)	1.1480	(1.0388-1.2686)		1.1932	(1.1309-1.2588)	1.1276	(1.0754-1.1823)
5	1.0721	(1.0175-1.1297)	1.0071	(0.9383-1.0810)	1.0026	(0.8983-1.1191)		1.1015	(1.0403-1.1664)	1.0144	(0.9644-1.0670)
6	1.0233	(0.9695-1.0801)	0.9401	(0.8726-1.0129)	0.9671	(0.8638-1.0827)		1.0309	(0.9708-1.0948)	0.9590	(0.9105-1.0101)
7	0.9532	(0.9009-1.0086)	0.8917	(0.8240-0.9649)	0.9319	(0.8217-1.0569)		0.9518	(0.8935-1.0139)	0.9274	(0.8778-0.9798)
8	0.9536	(0.9012-1.0091)	0.8710	(0.8026-0.9454)	0.8128	(0.7099-0.9306)		0.9136	(0.8567-0.9742)	0.9056	(0.8559-0.9582)
9	1.0040	(0.9480-1.0633)	0.9229	(0.8513-1.0006)	0.7771	(0.6775-0.8913)		0.9920	(0.9303-1.0578)	0.9240	(0.8727-0.9783)
10	0.9695	(0.9157-1.0264)	0.8957	(0.8252-0.9723)	0.9364	(0.8176-1.0724)		0.9746	(0.9141-1.0391)	0.9161	(0.8650-0.9703)
11	0.9890	(0.9357-1.0452)	0.9732	(0.8987-1.0539)	0.8193	(0.7122-0.9425)		0.9862	(0.9260-1.0502)	0.9653	(0.9129-1.0206)
12	0.9748	(0.9230-1.0295)	0.8771	(0.8092-0.9507)	0.9603	(0.8411-1.0964)		0.9837	(0.9235-1.0478)	0.9294	(0.8798-0.9818)
13	1.0169	(0.9633-1.0734)	0.9505	(0.8760-1.0315)	0.9555	(0.8321-1.0973)		1.0126	(0.9487-1.0808)	0.9732	(0.9222-1.0270)
14	1.0063	(0.9541-1.0614)	1.0622	(0.9822-1.1488)	1.0654	(0.9201-1.2337)		1.0682	(1.0045-1.1359)	0.9775	(0.9253-1.0328)
15	1.0298	(0.9786-1.0837)	1.0387	(0.9602-1.1236)	1.0887	(0.9454-1.2538)		1.0523	(0.9936-1.1145)	1.0237	(0.9692-1.0811)
16	1.0466	(0.9968-1.0988)	1.0452	(0.9677-1.1289)	1.2850	(1.1222-1.4715)		1.0819	(1.0248-1.1422)	1.0404	(0.9862-1.0975)
17	1.0231	(0.9763-1.0722)	0.9975	(0.9252-1.0754)	1.1301	(0.9878-1.2930)		1.0388	(0.9856-1.0948)	1.0025	(0.9520-1.0556)
18	1.0689	(1.0213-1.1187)	1.0516	(0.9778-1.1310)	1.1922	(1.0459-1.3590)		1.0863	(1.0328-1.1425)	1.0530	(1.0015-1.1073)
19	0.9877	(0.9436-1.0339)	0.9823	(0.9128-1.0571)	1.1037	(0.9701-1.2558)		0.9854	(0.9367-1.0367)	0.9983	(0.9492-1.0499)
20	1.0367	(0.9903-1.0852)	0.9723	(0.9048-1.0450)	0.9151	(0.8012-1.0452)		1.0141	(0.9639-1.0669)	1.0100	(0.9608-1.0618)
21	1.0038	(0.9574-1.0525)	0.9767	(0.9080-1.0505)	1.1051	(0.9714-1.2572)		1.0169	(0.9649-1.0716)	0.9972	(0.9481-1.0488)
22	1.0310	(0.9820-1.0824)	1.0122	(0.9414-1.0884)	1.0048	(0.8818-1.1449)		0.9926	(0.9406-1.0475)	1.0352	(0.9836-1.0895)
23	1.0200	(0.9703-1.0723)	0.9534	(0.8828-1.0295)	1.0685	(0.9363-1.2194)		1.0385	(0.9839-1.0960)	0.9954	(0.9430-1.0506)
24	0.9487	(0.9007-0.9992)	1.0152	(0.9420-1.0941)	1.2090	(1.0673-1.3695)		1.0022	(0.9478-1.0598)	0.9865	(0.9349-1.0409)
25	1.0016	(0.9507-1.0552)	1.0251	(0.9493-1.1070)	1.0218	(0.8918-1.1706)		1.0028	(0.9482-1.0605)	1.0113	(0.9568-1.0689)
26	0.9642	(0.9151-1.0159)	1.0705	(0.9907-1.1567)	0.9311	(0.8147-1.0641)		1.0319	(0.9756-1.0915)	0.9449	(0.8935-0.9993)
27	1.0242	(0.9731-1.0780)	1.1017	(1.0202-1.1897)	1.0606	(0.9306-1.2088)		1.0778	(1.0209-1.1379)	1.0149	(0.9597-1.0731)
28	1.0273	(0.9765-1.0806)	1.0334	(0.9577-1.1151)	1.0200	(0.8907-1.1680)		1.0654	(1.0090-1.1248)	0.9903	(0.9371-1.0465)
29	0.9896	(0.9421-1.0396)	1.0490	(0.9727-1.1313)	1.0542	(0.9233-1.2036)		1.0685	(1.0136-1.1264)	0.9755	(0.9239-1.0300)
30	1.0188	(0.9715-1.0684)	1.0392	(0.9644-1.1198)	1.0921	(0.9579-1.2450)		1.0644	(1.0114-1.1203)	1.0011	(0.9492-1.0558)
31	0.9849	(0.9400-1.0319)	1.0086	(0.9348-1.0881)	0.9585	(0.8367-1.0980)		0.9789	(0.9300-1.0304)	1.0070	(0.9555-1.0612)
32	0.9650	(0.9212-1.0109)	1.0787	(1.0025-1.1607)	1.0649	(0.9319-1.2169)		1.0448	(0.9933-1.0990)	0.9592	(0.9109-1.0102)
33	0.9902	(0.9454-1.0371)	0.9599	(0.8895-1.0358)	0.9817	(0.8574-1.1239)		0.9849	(0.9361-1.0363)	0.9741	(0.9245-1.0264)
34	0.9659	(0.9229-1.0109)	1.0061	(0.9324-1.0855)	0.9910	(0.8652-1.1351)		0.9911	(0.9426-1.0420)	0.9716	(0.9225-1.0233)
35	1.0004	(0.9551-1.0478)	0.9894	(0.9162-1.0684)	1.0772	(0.9410-1.2330)		1.0029	(0.9534-1.0550)	1.0137	(0.9620-1.0681)
36	0.9646	(0.9204-1.0108)	1.0240	(0.9497-1.1040)	1.0231	(0.8898-1.1765)		1.0046	(0.9548-1.0569)	0.9474	(0.8988-0.9986)

Age	NZ Euro	95%CI	Māori	95%CI	Pacific	95%CI		Female	95% CI	Male	95% CI
37	0.9988	(0.9542-1.0456)	1.0755	(0.9967-1.1605)	0.8889	(0.7749-1.0196)		1.0364	(0.9853-1.0902)	0.9783	(0.9294-1.0298)
38	0.9660	(0.9227-1.0114)	1.0287	(0.9551-1.1081)	1.0447	(0.9104-1.1989)		1.0058	(0.9563-1.0579)	0.9752	(0.9270-1.0260)
39	0.9545	(0.9125-0.9984)	1.0870	(1.0098-1.1701)	1.0968	(0.9591-1.2542)		1.0086	(0.9601-1.0595)	0.9847	(0.9365-1.0353)
40	0.9447	(0.9039-0.9872)	0.9841	(0.9131-1.0605)	1.0103	(0.8818-1.1574)		0.9716	(0.9250-1.0206)	0.9499	(0.9040-0.9982)
41	0.9874	(0.9457-1.0310)	0.9870	(0.9146-1.0652)	1.0449	(0.9146-1.1937)		0.9841	(0.9370-1.0337)	0.9988	(0.9514-1.0486)
42	0.9868	(0.9448-1.0307)	0.9638	(0.8942-1.0388)	0.9426	(0.8185-1.0855)		1.0044	(0.9565-1.0547)	0.9499	(0.9041-0.9979)
43	0.9820	(0.9404-1.0254)	1.1204	(1.0412-1.2056)	1.0672	(0.9319-1.2221)		1.0128	(0.9648-1.0632)	1.0205	(0.9720-1.0714)
44	0.9876	(0.9462-1.0308)	0.9980	(0.9238-1.0782)	1.0910	(0.9484-1.2550)		1.0262	(0.9778-1.0771)	0.9884	(0.9413-1.0378)
45	0.9920	(0.9504-1.0354)	1.0325	(0.9562-1.1150)	1.1145	(0.9707-1.2795)		1.0253	(0.9763-1.0767)	0.9891	(0.9424-1.0382)
46	0.9850	(0.9440-1.0277)	0.9503	(0.8795-1.0268)	0.9731	(0.8438-1.1223)		0.9773	(0.9305-1.0264)	0.9888	(0.9422-1.0377)
47	0.9770	(0.9360-1.0198)	1.0372	(0.9597-1.1209)	1.1262	(0.9818-1.2919)		1.0069	(0.9580-1.0583)	0.9763	(0.9305-1.0244)
48	0.9910	(0.9502-1.0335)	1.0652	(0.9861-1.1505)	0.9652	(0.8379-1.1118)		1.0190	(0.9704-1.0701)	0.9774	(0.9320-1.0251)
49	1.0032	(0.9619-1.0464)	1.1003	(1.0169-1.1906)	0.9768	(0.8523-1.1194)		1.0003	(0.9522-1.0509)	1.0265	(0.9787-1.0767)
50	0.9465	(0.9079-0.9868)	1.0326	(0.9539-1.1179)	1.0584	(0.9244-1.2118)		0.9790	(0.9320-1.0283)	0.9750	(0.9304-1.0217)
51	1.0081	(0.9676-1.0503)	1.0664	(0.9872-1.1519)	1.1495	(1.0028-1.3176)		1.0422	(0.9935-1.0933)	1.0092	(0.9631-1.0575)
52	0.9505	(0.9123-0.9903)	1.0858	(1.0054-1.1727)	1.1498	(1.0075-1.3122)		0.9768	(0.9306-1.0252)	0.9963	(0.9513-1.0433)
53	1.0155	(0.9758-1.0568)	1.0551	(0.9758-1.1408)	0.9957	(0.8677-1.1427)		1.0087	(0.9617-1.0580)	1.0226	(0.9772-1.0701)
54	0.9753	(0.9378-1.0144)	1.1761	(1.0857-1.2740)	1.0996	(0.9610-1.2583)		1.0392	(0.9913-1.0895)	0.9756	(0.9324-1.0209)
55	0.9778	(0.9400-1.0171)	1.1136	(1.0290-1.2052)	0.9958	(0.8687-1.1414)		1.0333	(0.9857-1.0833)	0.9949	(0.9510-1.0409)
56	1.0154	(0.9767-1.0557)	0.9812	(0.9049-1.0640)	1.0415	(0.9072-1.1956)		1.0439	(0.9958-1.0944)	0.9825	(0.9392-1.0277)
57	1.0107	(0.9724-1.0505)	1.1232	(1.0354-1.2184)	1.0678	(0.9304-1.2254)		1.0276	(0.9804-1.0771)	1.0257	(0.9809-1.0726)
58	1.0334	(0.9939-1.0745)	1.0091	(0.9301-1.0947)	1.0874	(0.9490-1.2461)		1.0572	(1.0083-1.1085)	1.0034	(0.9593-1.0494)
59	1.0327	(0.9943-1.0726)	1.0357	(0.9553-1.1228)	0.9673	(0.8371-1.1177)		1.0649	(1.0163-1.1159)	1.0043	(0.9610-1.0497)
60	1.0377	(0.9992-1.0776)	1.0837	(1.0008-1.1734)	1.0741	(0.9352-1.2337)		1.0502	(1.0025-1.1002)	1.0359	(0.9917-1.0822)
61	1.0308	(0.9928-1.0702)	1.0806	(0.9957-1.1728)	1.1270	(0.9811-1.2945)		1.0911	(1.0420-1.1425)	1.0107	(0.9672-1.0562)
62	1.0281	(0.9905-1.0672)	1.1841	(1.0944-1.2811)	1.1689	(1.0119-1.3502)		1.0738	(1.0251-1.1248)	1.0271	(0.9839-1.0723)
63	1.0446	(1.0070-1.0836)	1.0599	(0.9772-1.1496)	1.1317	(0.9858-1.2992)		1.0682	(1.0204-1.1183)	1.0411	(0.9975-1.0866)
64	0.9927	(0.9571-1.0296)	1.1029	(1.0181-1.1949)	1.1911	(1.0397-1.3645)		1.0307	(0.9847-1.0788)	1.0230	(0.9806-1.0673)
65	1.0278	(0.9913-1.0656)	1.1158	(1.0291-1.2098)	1.1030	(0.9597-1.2677)		1.0518	(1.0052-1.1007)	1.0318	(0.9890-1.0763)
66	1.0160	(0.9800-1.0534)	1.0971	(1.0106-1.1911)	0.9625	(0.8337-1.1112)		1.0471	(1.0007-1.0957)	1.0048	(0.9629-1.0485)
67	1.0494	(1.0128-1.0873)	1.0488	(0.9647-1.1403)	0.9759	(0.8444-1.1279)		1.0295	(0.9840-1.0772)	1.0536	(1.0104-1.0986)
68	1.0258	(0.9906-1.0622)	1.1184	(1.0286-1.2160)	1.1460	(0.9988-1.3149)		1.0868	(1.0401-1.1356)	1.0117	(0.9704-1.0547)
69	1.0391	(1.0045-1.0750)	1.1140	(1.0244-1.2115)	1.0819	(0.9292-1.2597)		1.0497	(1.0050-1.0965)	1.0425	(1.0011-1.0855)
70	1.0620	(1.0279-1.0973)	1.1468	(1.0512-1.2510)	1.1762	(1.0188-1.3578)		1.0823	(1.0372-1.1293)	1.0675	(1.0265-1.1102)
71	1.0671	(1.0343-1.1009)	1.0040	(0.9163-1.1002)	1.0517	(0.9078-1.2184)		1.0656	(1.0228-1.1101)	1.0576	(1.0180-1.0987)
72	1.0816	(1.0491-1.1152)	1.0558	(0.9649-1.1554)	1.0757	(0.9235-1.2530)		1.0908	(1.0481-1.1353)	1.0656	(1.0261-1.1067)
73	1.1108	(1.0785-1.1441)	0.9934	(0.9013-1.0949)	1.1903	(1.0186-1.3908)		1.0805	(1.0390-1.1236)	1.1089	(1.0686-1.1507)
74	1.0590	(1.0289-1.0899)	1.1494	(1.0419-1.2680)	1.1873	(1.0227-1.3785)		1.0310	(0.9921-1.0714)	1.0998	(1.0607-1.1403)
75	1.1091	(1.0784-1.1408)	1.1832	(1.0698-1.3088)	1.1035	(0.9406-1.2945)		1.1041	(1.0636-1.1461)	1.1324	(1.0924-1.1738)
76	1.1091	(1.0789-1.1402)	1.1541	(1.0379-1.2834)	1.3333	(1.1382-1.5619)		1.1159	(1.0759-1.1574)	1.1226	(1.0831-1.1636)
77	1.0941	(1.0645-1.1245)	1.1529	(1.0311-1.2891)	1.1087	(0.9450-1.3009)		1.0796	(1.0413-1.1193)	1.1128	(1.0735-1.1535)
78	1.0954	(1.0660-1.1257)	1.0938	(0.9741-1.2282)	1.1360	(0.9585-1.3463)		1.0812	(1.0435-1.1202)	1.1090	(1.0693-1.1502)
79	1.1141	(1.0845-1.1445)	1.2588	(1.1166-1.4191)	1.2075	(1.0148-1.4368)		1.1004	(1.0627-1.1395)	1.1366	(1.0958-1.1790)

Age	NZ Euro	95%CI	Māori	95%CI	Pacific	95%CI		Female	95% CI	Male	95% CI
80	1.0887	(1.0597-1.1185)	1.3149	(1.1650-1.4841)	1.0604	(0.8872-1.2675)		1.1194	(1.0814-1.1587)	1.0653	(1.0263-1.1058)
81	1.1376	(1.1069-1.1692)	1.0790	(0.9325-1.2485)	1.3671	(1.1173-1.6727)		1.1297	(1.0910-1.1698)	1.1472	(1.1037-1.1924)
82	1.0999	(1.0697-1.1310)	0.9863	(0.8392-1.1592)	1.3714	(1.0880-1.7286)		1.0875	(1.0499-1.1266)	1.1192	(1.0748-1.1654)
83	1.1181	(1.0869-1.1502)	1.0855	(0.9197-1.2811)	1.2125	(0.9700-1.5157)		1.0843	(1.0466-1.1234)	1.1512	(1.1039-1.2006)
84	1.1175	(1.0854-1.1506)	1.0742	(0.8939-1.2909)	1.2422	(0.9725-1.5868)		1.1163	(1.0765-1.1576)	1.1182	(1.0706-1.1680)
85	1.1271	(1.0936-1.1615)	1.1482	(0.9453-1.3947)	0.9685	(0.7233-1.2967)		1.1262	(1.0850-1.1690)	1.1305	(1.0800-1.1834)
86	1.1200	(1.0849-1.1562)	1.0200	(0.8296-1.2541)	1.3648	(0.9955-1.8711)		1.1119	(1.0696-1.1559)	1.1328	(1.0781-1.1903)
87	1.1393	(1.1022-1.1777)	1.3656	(1.0906-1.7098)	0.9366	(0.6779-1.2942)		1.1305	(1.0861-1.1768)	1.1609	(1.1016-1.2234)
88	1.1601	(1.1200-1.2016)	1.1550	(0.9017-1.4794)	1.8982	(1.3290-2.7112)		1.1708	(1.1224-1.2214)	1.1480	(1.0849-1.2148)
89	1.1471	(1.1050-1.1908)	1.0966	(0.8390-1.4334)	1.7554	(1.1706-2.6322)		1.1311	(1.0813-1.1832)	1.1928	(1.1236-1.2664)
90	1.2058	(1.1578-1.2559)	1.2097	(0.8705-1.6810)	0.7203	(0.3820-1.3582)		1.1718	(1.1158-1.2306)	1.2646	(1.1834-1.3513)
91	1.1376	(1.0862-1.1914)	1.3768	(0.9567-1.9814)	3.1029	(1.7164-5.6095)		1.1389	(1.0789-1.2022)	1.1959	(1.1051-1.2942)
92	1.1557	(1.0983-1.2161)	1.3480	(0.8116-2.2390)	1.5611	(0.8425-2.8927)		1.1289	(1.0638-1.1981)	1.2336	(1.1286-1.3483)
93	1.2066	(1.1376-1.2799)	2.5270	(1.5658-4.0785)	1.1082	(0.5116-2.4007)		1.2093	(1.1305-1.2936)	1.2137	(1.0913-1.3498)
94	1.2378	(1.1567-1.3247)	0.4604	(0.1895-1.1185)	0.9067	(0.3150-2.6096)		1.2383	(1.1458-1.3383)	1.2409	(1.0999-1.4001)
95	1.1969	(1.1037-1.2979)	1.8136	(0.7703-4.2704)	1.4507	(0.5835-3.6066)		1.1808	(1.0769-1.2947)	1.2495	(1.0775-1.4489)
96	1.2569	(1.1407-1.3848)	1.1970	(0.4351-3.2935)	1.1399	(0.3337-3.8938)		1.2158	(1.0893-1.3570)	1.3764	(1.1530-1.6431)
97	1.0890	(0.9664-1.2272)	1.7101	(0.5747-5.0883)	3.9896	(0.7307-21.7817)		1.0738	(0.9406-1.2259)	1.2907	(1.0269-1.6223)
98	1.1352	(0.9803-1.3146)	3.3250	(0.7946-13.9131)	.	(.-.)		1.1434	(0.9726-1.3441)	1.1288	(0.8471-1.5041)
99	1.1390	(0.9578-1.3545)	0.9975	(0.0904-11.0004)	1.3298	(0.2222-7.9586)		1.1595	(0.9588-1.4024)	1.2412	(0.8891-1.7326)
100	1.3810	(1.1089-1.7198)	0.4987	(0.0557-4.4622)	.	(.-.)		1.4176	(1.1138-1.8042)	1.3298	(0.8617-2.0524)

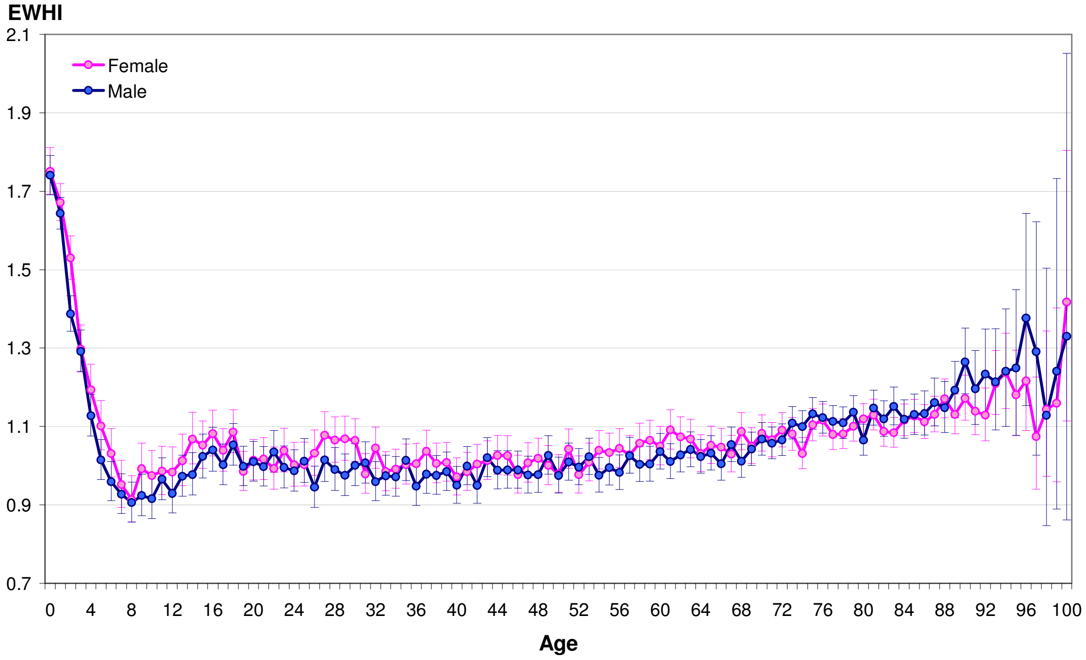

Figure A 4.1 Winter:non-winter all-cause hospitalisation incidence rate ratios by sex and year of age, 2000-2006 (adjusted for ethnicity, NZDep decile, rurality and annual average minimum temperature), with percentage of total hospitalisations by year of age.

Table A 4.2 Rates of all-cause hospitalisation in winter and non-winter months for ages 0-4 years, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				Winter:non-winter ratio (95% CI)		Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value		
	Winter		Non-winter		Unadjusted (cohort analysis)				
All	106.3	(58,450)	69.3	(76,213)	1.5331	(1.5167-1.5497)			
Age (years)									
0	258.1	(15,004)	145.0	(17,153)	1.7799	(1.7413-1.8192)	1.00	Baseline	
1	172.8	(20,616)	104.3	(24,838)	1.6561	(1.6258-1.6870)	**0.9329**	**(0.9065-0.9599)**	**0.000**
2	92.9	(11,239)	64.1	(15,470)	1.4492	(1.4144-1.4848)	**0.8166**	**(0.7903-0.8437)**	**0.000**
3	54.7	(6,776)	42.3	(10,442)	1.2944	(1.2554-1.3345)	**0.7298**	**(0.7028-0.7577)**	**0.000**
4	37.7	(4,815)	32.6	(8,310)	1.1558	(1.1154-1.1975)	**0.6521**	**(0.6264-0.6799)**	**0.000**
0-4 (continuous)					0.8949	(0.8871-0.9027)	**0.8956**	**(0.8879-0.9035)**	**0.000**
Gender									
Male	117.2	(33,032)	77.4	(43,600)	1.5146	(1.4931-1.5364)	1.00	Baseline	
Female	94.8	(25,418)	60.8	(32,613)	1.5579	(1.5326-1.5837)	**1.0290**	**(1.0069-1.0516)**	**0.010**
Ethnicity[‡]									
NZ European	81.3	(44,696)	56.2	(61,764)	1.4137	(1.3972-1.4304)	1.00	Baseline	
Māori	180.5	(99,190)	112.5	(123,617)	1.5124	(1.5006-1.5242)	**1.1002**	**(1.0710-1.1303)**	**0.000**
Pacific	168.0	(92,318)	101.0	(111,012)	1.5679	(1.5551-1.5808)	**1.1513**	**(1.1112-1.1928)**	**0.000**
Asian	49.1	(26,987)	35.1	(38,557)	1.3811	(1.3603-1.4023)	0.9799	(0.9243-1.0387)	0.494
Other	58.1	(31,927)	40.2	(44,150)	1.4218	(1.4020-1.4419)	1.0115	(0.9226-1.1090)	0.807
Unknown	30.1	(16,566)	21.8	(23,941)	1.3727	(1.3461-1.3998)	0.9920	(0.8775-1.1213)	0.898
NZDep01/06									
1-3	70.4	(8,905)	49.2	(12,458)	1.4297	(1.3914-1.4692)	1.00	Baseline	
4-7	92.0	(18,359)	61.5	(24,513)	1.4971	(1.4687-1.5260)	1.0230	(0.9891-1.0581)	0.186
8-10	139.2	(31,186)	87.6	(39,242)	1.5883	(1.5648-1.6120)	**1.0443**	**(1.0093-1.0804)**	**0.013**
1-10 (Continuous)					1.0160	(1.0119-1.0201)	**1.0062**	**(1.0017-1.0107)**	**0.007**
Rurality									
Main Urban	106.6	(43,044)	69.6	(56,169)	1.5320	(1.5129-1.5514)	1.00	Baseline	
Secondary	105.8	(3,989)	68.6	(5,173)	1.5417	(1.4794-1.6067)	0.9988	0.9547-1.0449)	0.958
Minor	120.2	(5,932)	75.7	(7,471)	1.5868	(1.5336-1.6418)	1.0217	0.9839-1.0610)	0.264
Rural Centre	105.5	(1,417)	70.6	(1,893)	1.4946	(1.3952-1.6011)	0.9679	(0.9017-1.0390)	0.368
Other rural	88.9	(4,068)	60.2	(5,505)	1.4770	(1.4184-1.5381)	0.9873	(0.9441-1.0323)	0.574
Other	0	(0)	42.8	(2)	-	-	-	-	-
Mean min. temp.					0.9967	(0.9918-1.0016)	**0.9890**	**(0.9832-0.9948)**	**0.000**

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

[‡] Morbidity rates and winter:non-winter ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

Table A 4.3 Rates of all-cause hospitalisation in winter and non-winter months for ages 65+ years, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years*[*]* (No of hospitalisations)		**Winter:non-winter ratio (95% CI) Unadjusted (cohort analysis)**	**Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value**
	Winter	**Non-winter**		
All	172.1 (204425)	156.2 (370121)	1.1016 (1.0957-1.1076)	
Age (years)				
65-69	101.6 (31420)	97.7 (60257)	1.0400 (1.0259-1.0542)	1.00 Baseline
70-74	144.8 (39234)	134.7 (72798)	1.0749 (1.0618-1.0882)	**1.0343 (1.0144-1.0535) 0.000**
75-79	200.0 (45885)	180.3 (82525)	1.1090 (1.0964-1.1218)	**1.0680 (1.0491-1.0872) 0.000**
80-84	252.4 (42572)	227.0 (76373)	1.1117 (1.0986-1.1249)	**1.0717 (1.0524-1.0913) 0.000**
85-89	278.9 (29583)	244.9 (51814)	1.1389 (1.1228-1.1553)	**1.0990 (1.0774-1.1210) 0.000**
90-94	207.5 (12873)	174.6 (21607)	1.1880 (1.1624-1.2142)	**1.1476 (1.1183-1.1776) 0.000**
95+	67.8 (2858)	56.4 (4747)	1.2008 (1.1463-1.2578)	**1.1612 (1.1060-1.2193) 0.000**
65-100 (continuous)			1.0033 (1.0028-1.0038)	**1.0038 (1.0032-1.0332) 0.000**
Gender				
Male	178.1 (95266)	161.5 (172284)	1.1029 (1.0943-1.1117)	1.00 Baseline
Female	167.0 (109159)	151.7 (197837)	1.1004 (1.0923-1.1086)	0.9906 (0.9799-1.0014) 0.089
Ethnicity[‡]				
NZ European	222.9 (172216)	202.2 (311582)	1.1023 (1.0971-1.1076)	1.00 Baseline
Māori	322.9 (12815)	286.9 (22714)	1.1257 (1.1212-1.1301)	1.0209 (0.9972-1.0452) 0.084
Pacific	200.0 (5097)	171.1 (8701)	1.1684 (1.1625-1.1743)	**1.0385 (1.0015-1.0768) 0.041**
Asian	141.7 (3649)	128.9 (6621)	1.0992 (1.0927-1.1058)	0.9981 (0.9537-1.0445) 0.935
Other	26.9 (5356)	24.9 (9907)	1.0784 (1.0638-1.0932)	0.9729 (0.9387-1.0083) 0.132
Unknown	33.0 (4143)	30.8 (7707)	1.0721 (1.0591-1.0854)	0.9692 (0.9320-1.0078) 0.116
NZDep01/06				
1-3	151.1 (41505)	139.2 (76245)	1.0857 (1.0728-1.0987)	1.00 Baseline
4-7	170.3 (86413)	155.0 (156926)	1.0983 (1.0892-1.1075)	1.0128 (0.9979-1.0278) 0.092
8-10	188.2 (76507)	168.9 (136950)	1.1142 (1.1044-1.1241)	**1.0243 (1.0086-1.0402) 0.002**
1-10 (Continuous)			1.0036 (1.0016-1.0057)	**1.0034 (1.0013-1.0055) 0.002**
Rurality				
Main Urban	170.9 (145907)	154.8 (263751)	1.1033 (1.0963-1.1104)	1.00 Baseline
Secondary	191.5 (19983)	173.7 (36152)	1.1025 (1.0837-1.1217)	1.0044 (0.9849-1.0242) 0.660
Minor	187.3 (24535)	169.5 (44308)	1.1044 (1.0873-1.1218)	1.0007 (0.9834-1.0184) 0.935
Rural Centre	129.5 (4202)	125.1 (8097)	1.0351 (0.9973-1.0744)	**0.9423 (0.9070-0.9789) 0.002**
Other rural	146.7 (9792)	133.7 (17796)	1.0975 (1.0708-1.1249)	1.0063 (0.9805-1.0328) 0.635
Other	61.6 (6)	87.4 (17)	0.7064 (0.2785-1.7915)	0.6547 (0.2582-1.6603) 0.372
Mean min. temp.			1.0022 (0.9998-1.0046)	1.0020 (0.9992-1.0047) 0.161

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

[‡] Morbidity rates and winter:non-winter ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

Table A 4.4 Rates of all-cause hospitalisation in winter and non-winter months for Māori, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				Winter:non-winter ratio (95% CI)		Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value		
	Winter		Non-winter		Unadjusted (cohort analysis)				
All	88.0	(91650)	78.1	(162444)	1.1256	(1.1165-1.1347)			
Age (years)									
0-4	183.9	(20432)	114.0	(25321)	1.6129	(1.5834-1.6429)	**1.4628**	**(1.4235-1.5033)**	**0.000**
5-14	36.3	(9136)	38.6	(19398)	0.9394	(0.9163-0.9630)	**0.8521**	**(0.8253-0.8798)**	**0.000**
15-29	57.2	(15410)	56.1	(30149)	1.0195	(0.9999-1.0394)	**0.9240**	**(0.8985-0.9502)**	**0.000**
30-59	85.1	(29611)	82.0	(56894)	1.0381	(1.0236-1.0527)	**0.9403**	**(0.9176-0.9637)**	**0.000**
60-79	268.7	(14927)	243.5	(26993)	1.1034	(1.0815-1.1257)	1.0000	Baseline	
80+	344.3	(2134)	298.3	(3689)	1.1541	(1.0942-1.2172)	1.0451	(0.9873-1.1064)	0.129
Gender									
Male	92.1	(46425)	82.3	(82747)	1.1193	(1.1067-1.1321)	1.00		
Female	84.1	(45225)	74.2	(79697)	1.1321	(1.1191-1.1452)	**1.0217**	**(1.0053-1.0394)**	**0.000**
NZDep01/06									
1-3	71.3	(6031)	63.8	(10778	1.1165	(1.0819-1.1522)	1	Baseline	
4-7	81.8	(23393)	73.3	(41822)	1.1159	(1.0982-1.1339)	0.9974	(0.9627-1.0333)	0.885
8-10	92.7	(62226)	82.0	(109844)	1.1301	(1.1191-1.1413)	1.0048	(0.9718-1.0389)	0.779
1-10 (Continuous)					1.0025	(0.9990-1.0060)	1.0014	(0.9978-1.0050)	0.454
Rurality									
Main Urban	88.4	(60019)	78.4	(106225)	1.1272	(1.1160-1.1386)	1.0000	Baseline	
Secondary	86.0	(6830)	75.4	(11949)	1.1404	(1.1070-1.1748)	1.0150	(0.9827-1.0486)	0.366
Minor	92.6	(14341)	82.2	(25390)	1.1267	(1.1039-1.1500)	0.9998	(0.9768-1.0233)	0.987
Rural Centre	80.5	(3358)	72.9	(6066)	1.1044	(1.0588-1.1520)	0.9863	(0.9442-1.0304)	0.538
Other rural	81.9	(7099)	74.1	(12808)	1.1058	(1.0742-1.1384)	0.9877	(0.9574-1.0190)	0.438
Other	35.9	(3)	35.9	(6)	1.0006	(0.2503-4.0004)	0.9454	(0.2355-3.7723)	0.933
Mean min. temp.					1.0025	(0.9980-1.0071)	1.0028	(0.9979-1.0076)	0.261

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

Table A4. 1 Rates of all-cause hospitalisation in winter and non-winter months for Pacific peoples, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				Winter:non-winter ratio (95% CI)		Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value		
	Winter		Non-winter		Unadjusted (cohort analysis)				
All	62.7	(34017)	53.3	(91722)	1.1759	(1.1603-1.1918)			
Age (years)									
0-4	169.9	(9688)	101.7	(11584)	1.6697	(1.6252-1.7153)	**1.4903**	**(1.4280-1.5553)**	**0.000**
5-14	25.9	(3338)	28.1	(7220)	0.9221	(0.8850-0.9607)	**0.8233**	**(0.7810-0.8679)**	**0.000**
15-29	37.5	(5064)	34.9	(9397)	1.0749	(1.0388-1.1122)	0.9588	(0.9143-1.0055)	0.083
30-59	50.9	(9370)	49.1	(18029)	1.0366	(1.0110-1.0628)	**0.9243**	**(0.8868-0.9634)**	**0.000**
60-79	167.1	(5481)	149.1	(9759)	1.1204	(1.0839-1.1581)	1.0000	Baseline	
80+	224.3	(1076)	179.3	(1716)	1.2510	(1.1592-1.3501)	**1.1173**	**(1.0282-1.2141)**	**0.009**
Gender									
Male	68.1	(17846)	58.3	(30470)	1.1683	(1.1469-1.1901)	1.0000	Baseline	
Female	57.6	(16171)	48.6	(27235)	1.1844	(1.1616-1.3077)	1.0249	(0.9977-1.0528)	0.073
NZDep01/06									
1-3	52.9	(1973)	46.7	(3471)	1.1339	(1.0729-1.1983)	1.0000	Baseline	
4-7	57.5	(6794)	49.7	(11713)	1.1569	(1.1228-1.1920)	1.0052	(0.9438-1.0707)	0.872
8-10	65.2	(25250)	55.0	(42521)	1.1846	(1.1663-1.2032)	1.0163	(0.9590-1.0769)	0.585
1-10 (Continuous)					1.0053	(0.9993-1.0113)	1.0020	(0.9960-1.0081)	0.515
Rurality									
Main Urban	63.0	(32477)	53.5	(55069)	1.1764	(1.1604-1.1926)	1.0000	Baseline	
Secondary	58.6	(753)	47.9	(1230)	1.2218	(1.1159-1.3378)	1.0162	(0.9231-1.1186)	0.743
Minor	67.4	(492)	54.5	(794)	1.2360	(1.1046-1.3831)	1.0407	(0.9281-1.1670)	0.494
Rural Centre	47.5	(99)	56.1	(233)	0.8476	(0.6700-1.0723)	**0.7319**	**(0.5766-0.9290)**	**0.010**
Other rural	39.7	(196)	38.5	(379)	1.0318	(0.8684-1.2260)	0.8800	(0.7371-1.0508)	0.158
Other	-	(0)	-	(0)	-		-	-	-
Mean min. temp.					0.9932	(0.9834-1.0032)	0.9911	(0.9802-1.0020)	0.110

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

Table A 4.5 Rates of all-cause hospitalisation in winter and non-winter months for NZ Europeans, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)		Winter:non-winter ratio (95% CI) Unadjusted (cohort analysis)	Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value
	Winter	Non-winter		
All	71.7 (371226)	67.1 (693340)	1.0680 (1.0638-1.0723)	
Age (years)				
0-4	81.6 (24943)	56.4 (34483)	1.4464 (1.4230-1.4701)	**1.3584 (1.3344-1.3828) 0.000**
5-14	25.5 (19026)	25.6 (38065)	0.9969 (0.9797-1.0144)	**0.9363 (0.9188-0.9540) 0.000**
15-29	37.6 (36257)	37.0 (71305)	1.0142 (1.0014-1.0271)	**0.9508 (0.9371-0.9648) 0.000**
30-59	44.0 (94741)	44.5 (191288)	0.9878 (0.9802-0.9955)	**0.9266 (0.9168-0.9364) 0.000**
60-79	151.9 (115939)	142.4 (216784)	1.0666 (1.0590-1.0742)	1.0000 Baseline
80+	332.1 (80320)	293.2 (141415)	1.1327 (1.1230-1.1426)	**1.0600 (1.0481-1.0720) 0.000**
Gender				
Male	76.8 (183625)	72.3 (344946)	1.0619 (1.0559-1.0679)	1.0000 Baseline
Female	67.3 (187601)	62.7 (384394)	1.0741 (1.0681-1.0802)	**1.0098 (1.0017-1.0179) 0.017**
NZDep01/06				
1-3	59.3 (84979)	56.0 (159893)	1.0602 (1.0514-1.0691)	1.0000 Baseline
4-7	72.1 (158520)	67.8 (297286)	1.0636 (1.0572-1.0701)	1.0007 (0.9902-1.0112) 0.903
8-10	82.6 (127727)	76.6 (236161)	1.0789 (1.0715-1.0862)	**1.0144 (1.0032-1.0257) 0.011**
1-10 (Continuous)			1.0025 (1.0010-1.0040)	**1.0022 (1.0007-1.0037) 0.005**
Rurality				
Main Urban	72.6 (261851)	67.9 (488501)	1.0693 (1.0642-1.0743)	1.0000 Baseline
Secondary	79.5 (34025)	74.4 (63505)	1.0688 (1.0548-1.0829)	0.9943 (0.9798-1.0091) 0.451
Minor	78.1 (41319)	72.4 (76392)	1.0789 (1.0661-1.0919)	1.0049 (0.9917-1.0184) 0.467
Rural Centre	59.6 (8670)	57.1 (16572)	1.0435 (1.0168-1.0710)	0.9791 (0.9534-1.0055) 0.120
Other rural	54.0 (25349)	51.6 (48349)	1.0459 (1.0301-1.0619)	0.9888 (0.5347-1.0052) 0.180
Other	43.2 (12)	37.8 (21)	1.1406 (0.5612-2.3181)	1.0866 (0.9925-2.2085) 0.818
Mean min. temp.			0.9987 (0.9969-1.0005)	**0.9980 (0.9960-1.0000) 0.045**

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

Table A 4.6 Rates of respiratory (ICD Chapter 10) hospitalisation in winter and non-winter months for ages 0-4 years, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				Winter:non-winter ratio (95% CI)		Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value		
	Winter		Non-winter		Unadjusted (cohort analysis)				
All	56.7	(31161)	23.9	(26316)	2.3671	(2.3286-2.4063)			
Age (years)									
0	157.3	(9139)	49.8	(5890)	3.1573	(2.0556-3.2624)	1	Baseline	
1	100.1	(11942)	40.2	(9561)	2.4922	(2.4261-2.5601)	**0.7920**	**(0.7592-0.8263)**	**0.000**
2	44.4	(5365)	22.7	(5469)	1.9568	(1.8845-2.0319)	**0.6217**	**(0.5915-0.6535)**	**0.000**
3	23.6	(2925)	12.8	(3163)	1.8446	(1.7541-1.9397)	**0.5863**	**(0.5521-0.6225)**	**0.000**
4	14.0	(1790)	8.8	(2233)	1.5989	1.5026-1.7015)	**0.5084**	**(0.4739-0.5454)**	**0.000**
0-4 (continuous)					0.8426	(0.8314-0.8539)	**0.8432**	**(0.8320-0.8545)**	**0.000**
Gender									
Male	63.1	(17783)	28.3	(15919)	2.2333	(2.1860-2.2815)	1	Baseline	
Female	49.9	(13378)	19.4	(10397)	2.5721	(2.5070-2.6389)	**1.1507**	**(1.1129-1.1898)**	**0.000**
Ethnicity									
NZ European	36.3	(11102)	15.4	(9405)	2.3604	(2.2964-2.4261)	1	Baseline	
Māori	111.1	(12413)	47.9	(10637)	2.3326	(2.2729-2.3938)	0.9607	(0.9220-1.0011)	0.056
Pacific	109.0	(6219)	43.5	(4951)	2.5078	(2.4159-2.6031)	1.0294	(0.9768-1.0848)	0.279
Asian	20.6	(889)	9.4	(816)	2.1811	(1.9834-2.3985)	0.9169	(0.8297-1.0134)	0.089
Other	23.3	(349)	11.1	(333)	2.0926	(1.8008-2.4316)	0.8922	(0.7657-1.0397)	0.144
Unknown	10.6	(189)	4.9	(174)	2.1670	(1.7638-2.6625)	0.9686	(0.7868-1.1924)	0.764
NZDep01/06									
1-3	32.5	(4106)	14.5	(3662)	2.2427	(2.1450-2.3449)	1	Baseline	
4-7	45.7	(9112)	19.7	(7851)	2.3200	(2.2510-2.3910)	1.0380	(0.9829-1.0963)	0.180
8-10	80.1	(17943)	33.1	(14803)	2.3671	(2.3704-2.4758)	**1.0774**	**(1.0207-1.1373)**	**0.007**
1-10 (Continuous)					1.0109	(1.0043-1.0175)	**1.0096**	**(1.0025-1.0167)**	**0.008**
Rurality									
Main Urban	57.2	(23099)	24.2	(19496)	2.3687	(2.3240-2.4143)	1	Baseline	
Secondary	53.0	(1996)	23.3	(1757)	2.2714	(2.1303-2.4218)	0.9761	(0.9100-1.0469)	0.498
Minor	67.5	(3327)	27.1	(2670)	2.4903	(2.3666-2.6204)	1.0598	(1.0014-1.1216)	0.044
Rural Centre	54.3	(729)	25.8	(690)	2.1096	(1.9010-2.3410)	0.9101	(0.8176-1.0131)	0.085
Other rural	43.9	(2010)	18.6	(1703)	2.3591	(2.2116-2.5164)	1.0463	(0.9748-1.1231)	0.210
Other	-	-	-	-	-	-	-	-	-
Mean min. temp.					1.0073	(0.9999-1.0148)	1.0061	(0.9969-1.0153)	0.194

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

Table A 4.7 Rates of respiratory (ICD Chapter 10) hospitalisation in winter and non-winter months for ages 65+ years, ratio of rates and relative change in winter:non-winter ratios for potential modifying factors; 2000-2006 (using NHI cohort).

	Rate per 1000 person years[*] (No of hospitalisations)				Winter:non-winter ratio (95% CI)		Winter:non-winter ratio relative to reference category (95% CI)[†] , p-value		
	Winter		Non-winter		Unadjusted (cohort analysis)				
All	30.1	(35770)	18.7	(44198)	1.6142	(1.5918-1.6364)			
Age (years)									
65-69	18.2	(5634)	11.6	(7155)	1.5704	(1.5166-1.6262)	1	Baseline	
70-74	27.2	(7361)	17.2	(9308)	1.5773	(1.5298-1.6263)	1.0007	(0.9553-1.0482)	0.977
75-79	36.8	(8436)	23.0	(10501)	1.6024	(1.5571-1.6490)	1.0102	(0.9655-1.0570)	0.660
80-84	45.6	(7180)	26.8	(8995)	1.5920	(1.5433-1.6490)	0.9961	(0.9503-1.0441)	0.871
85-89	44.2	(4686)	26.4	(5583)	1.6744	(1.6106-1.7406)	1.0421	(0.9886-1.0984)	0.125
90-94	31.9	(1980)	17.5	(2167)	1.8221	(1.7144-1.9365)	**1.1320**	**(1.0547-1.2149)**	**0.001**
95+	11.7	(493)	5.8	(489)	2.0108	(1.7743-2.2787)	**1.2550**	**(1.1009-1.4307)**	**0.001**
65-100 (continuous)					1.0030	(1.0017-1.0043)	**1.0023**	**(1.0009-1.0038)**	**0.002**
Gender									
Male	33.4	(17869)	21.9	(23305)	1.5294	(1.4999-1.5595)			
Female	27.4	(17901)	16.0	(20893)	1.7088	(1.6750-1.7432)	**1.1110**	**(1.0801-1.1428)**	**0.000**
Ethnicity[‡]									
NZ European	37.0	(43969)	22.7	(53683)	1.6336	(1.6131-1.6543)	1	Baseline	
Māori	84.8	(100783)	57.5	(136116)	1.4767	(1.4647-1.4888)	**0.9119**	**(0.8673-0.9588)**	**0.000**
Pacific	58.6	(69622)	34.3	(81165)	1.7108	(1.6936-1.7282)	1.0190	(0.9453-1.0985)	0.622
Asian	25.1	(29840)	15.4	(36445	1.6331	(1.6083-1.6583)	0.9917	(0.8772-1.1212)	0.894
Other	4.5	(5362)	2.7	(6450)	1.6581	(1.5991-1.7193)	1.0180	(0.9253-1.1200)	0.715
Unknown	5.2	(6192)	3.4	(8062)	1.5319	(1.4820-1.5835)	0.9439	(0.8493-1.0490)	0.284
NZDep01/06									
1-3	22.9	(6297)	14.7	(8058)	1.5586	(1.5080-1.6108)	1	Baseline	
4-7	28.6	(14528)	17.8	(18004)	1.6095	(1.5747-1.6450)	1.0293	(0.9889-1.0713)	0.157
8-10	36.8	(14945)	22.4	(18136)	1.6436	(1.6084-1.6796)	**1.0604**	**(1.0178-1.1048)**	**0.005**
1-10 (Continuous)					1.0070	(1.0016-1.0125)	**1.0084**	**(1.0028-1.0140)**	**0.003**
Rurality									
Main Urban	29.9	(25515)	18.5	(31573)	1.6118	(1.5854-1.6386)	1	Baseline	
Secondary	32.9	(3433)	19.9	(4141)	1.6536	(1.5805-1.7302)	1.0146	(0.9640-1.0679)	0.578
Minor	34.4	(4510)	20.8	(5437)	1.6545	(1.5904-1.7211)	1.0230	(0.9786-1.0693)	0.315
Rural Centre	21.9	(710)	14.6	(946)	1.4970	(1.3582-1.6500)	0.9404	(0.8513-1.0389)	0.227
Other rural	24.0	(1600)	15.8	(2100)	1.5197	(1.4240-1.6218)	0.9733	(0.9091-1.0420)	0.437
Other	20.6	(2)	5.1	(1)	4.0026	(0.3630-44.1399)	2.6355	(0.2389-29.0735)	0.429
Mean min. temp.					0.9951	(0.9889-1.0012)	0.9954	(0.9883-1.0026)	0.210

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[*] These rates may be underestimates given differences between NHI total count (overestimate) and census count (underestimate)

[†] Adjusted for all listed covariates (but age rather than age group, and NZDep decile rather than tertile, where appropriate) and winter interaction terms.

[‡] Morbidity rates and winter:non-winter ratios have been age-standardised to account for different population structures for different ethnicities. RRRs have not been age-standardised, as they have already been adjusted for the winter*age interaction.

Table A 4.8 Rates of all-cause hospitalisation in winter and non-winter months by Territorial Authority, ratio of rates and winter:non-winter ratios relative to baseline; 2000-2006 (using NHI cohort).

		Rate per 1000 person years (No. of hospitalisations)		Winter: non-winter ratio (95% CI)		Winter: non-winter ratio relative to reference		
Number	Territorial Authority	Winter	Non-winter	Unadjusted (cohort analysis)		category (95% CI), p-value		
1	Far North	67.3 (9139)	60.0 (16266)	1.1193	(1.0913-1.1481)	1.0241	(0.9912-1.0580)	0.153
2	Whangarei	69.4 (12656)	63.6 (23106)	1.0920	(1.0692-1.1153)	1.0037	(0.9789-1.0291)	0.774
3	Kaipara	60.9 (2538)	58.0 (4820)	1.0496	(1.0004-1.1012)	0.9772	(0.9276-1.0294)	0.385
4	Rodney	55.3 (9211)	53.9 (17911)	1.0306	(1.0069-1.0548)	**0.9555**	**(0.9287-0.9831)**	**0.002**
5	North Shore City	41.3 (21007)	39.0 (39579)	1.0584	(1.0416-1.0754)	0.9873	(0.9673-1.0077)	0.222
6	Waitakere City	49.2 (21065)	45.2 (38607)	1.0896	(1.0726-1.1067)	0.9985	(0.9783-1.0193)	0.889
7	Auckland City	42.6 (47604)	39.1 (87108)	1.0904	(1.0785-1.1025)	1.0000	Baseline	
8	Manukau City	50.7 (42474)	45.7 (76474)	1.1100	(1.0975-1.1227)	0.9901	(0.9735-1.0069)	0.245
9	Papakura	67.5 (7956)	61.9 (14545)	1.0901	(1.0609-1.1201)	0.9863	(0.9573-1.0163)	0.367
10	Franklin	53.1 (6988)	49.8 (13069)	1.0665	(1.0360-1.0978)	0.9788	(0.9442-1.0145)	0.241
11	Thames-Coromandel	60.7 (4026)	57.4 (7602)	1.0561	(1.0165-1.0972)	0.9875	(0.9454-1.0315)	0.572
12	Hauraki	60.5 (2566)	58.9 (4984)	1.0253	(0.9776-1.0752)	**0.9486**	**(0.9008-0.9991)**	**0.046**
13	Waikato	59.8 (5654)	54.8 (10335)	1.0911	(1.0564-1.1271)	0.9992	(0.9641-1.0355)	0.965
15	Matamata-Piako	54.6 (2863)	50.0 (5233)	1.0936	(1.0514-1.1374)	1.0122	(0.9633-1.0635)	0.632
16	Hamilton City	59.9 (18121)	55.1 (33231)	1.0905	(1.0714-1.1099)	1.0007	(0.9794-1.0225)	0.946
17	Waipa	56.8 (5741)	53.0 (10685)	1.0740	(1.0401-1.1089)	0.9937	(0.9603-1.0283)	0.718
18	Otorohanga	65.4 (1072)	59.4 (1943)	1.0996	(1.0206-1.1847)	1.0168	(0.9412-1.0983)	0.673
19	South Waikato	52.5 (3082)	48.5 (5672)	1.0842	(1.0377-1.1327)	0.9865	(0.9388-1.0367)	0.592
20	Waitomo	69.1 (1685)	63.2 (3071)	1.0942	(1.0311-1.1612)	1.0020	(0.9412-1.0667)	0.951
21	Taupo	52.6 (4138)	49.3 (7730)	1.0618	(1.0233-1.1018)	0.9772	(0.9350-1.0212)	0.305
22	Western Bay of Plenty	60.3 (5793)	55.2 (10585)	1.0905	(1.0566-1.1256)	1.0135	(0.9770-1.0513)	0.475
23	Tauranga	72.5 (14012)	66.9 (25785)	1.0849	(1.0653-1.1048)	0.9983	(0.9749-1.0224)	0.891
24	Rotorua	66.3 (11991)	60.8 (21929)	1.0902	(1.0662-1.1148)	0.9938	(0.9687-1.0194)	0.630
25	Whakatane	75.7 (6895)	70.3 (12769)	1.0779	(1.0468-1.1099)	0.9863	(0.9505-1.0233)	0.462
26	Kawerau	80.7 (1539)	73.4 (2790)	1.1004	(1.0341-1.1710)	0.9907	(0.9272-1.0585)	0.782
27	Opotiki	78.9 (1795)	75.9 (3447)	1.0405	(0.9829-1.1015)	**0.9390**	**(0.8836-0.9978)**	**0.042**
28	Gisborne	79.7 (9031)	70.4 (15918)	1.1322	(1.1034-1.1618)	1.0277	(0.9982-1.0582)	0.066
29	Wairoa	67.6 (1426)	61.3 (2579)	1.1004	(1.0315-1.1738)	1.0013	(0.9355-1.0717)	0.971
30	Hastings	64.8 (9966)	58.5 (17945)	1.1089	(1.0840-1.1344)	1.0071	(0.9798-1.0351)	0.615
31	Napier City	60.7 (8909)	56.2 (16452)	1.0799	(1.0524-1.1081)	0.9942	(0.9664-1.0229)	0.690
32	Central Hawke's Bay	57.6 (1771)	53.6 (3284)	1.0746	(1.0143-1.1385)	1.0043	(0.9448-1.0675)	0.891
33	New Plymouth	66.8 (11747)	61.4 (21546)	1.0878	(1.0637-1.1125)	1.0099	(0.9843-1.0363)	0.452
34	Stratford	57.0 (1269)	57.2 (2541)	0.9962	(0.9313-1.0656)	**0.9281**	**(0.8650-0.9958)**	**0.038**
35	South Taranaki	61.9 (4158)	56.7 (7589)	1.0921	(1.0516-1.1342)	1.0101	(0.9676-1.0544)	0.648
36	Ruapehu	80.4 (2712)	71.3 (4794)	1.1292	(1.0773-1.1836)	1.0334	(0.9816-1.0878)	0.210
37	Wanganui	75.9 (8670)	70.1 (15965)	1.0832	(1.0553-1.1119)	0.9958	(0.9674-1.0250)	0.777
38	Rangitikei	60.6 (2204)	56.2 (4079)	1.0780	(1.0236-1.1353)	0.9974	(0.9436-1.0543)	0.927
39	Manawatu	51.0 (3106)	47.8 (5804)	1.0665	(1.0210-1.1140)	0.9884	(0.9411-1.0381)	0.640
40	Palmerston North City	46.5 (9267)	43.5 (17282)	1.0692	(1.0426-1.0965)	0.9880	(0.9608-1.0159)	0.394
41	Tararua	54.6 (2386)	52.7 (4601)	1.0337	(0.9838-1.0861)	0.9587	(0.9089-1.0111)	0.120
42	Horowhenua	63.3 (4940)	57.6 (8966)	1.0995	(1.0620-1.1384)	1.0048	(0.9637-1.0478)	0.821
43	Kapiti Coast	55.0 (5869)	52.1 (11093)	1.0545	(1.0218-1.0883)	0.9722	(0.9398-1.0057)	0.103
44	Porirua City	44.9 (5934)	41.0 (10788)	1.0976	(1.0634-1.1329)	0.9876	(0.9546-1.0217)	0.470
45	Upper Hutt City	54.8 (5323)	50.7 (9814)	1.0816	(1.0463-1.1182)	1.0054	(0.9704-1.0415)	0.767
46	Lower Hutt City	54.9 (14077)	50.6 (25888)	1.0852	(1.0634-1.1074)	0.9968	(0.9736-1.0206)	0.788
47	Wellington City	32.8 (15550)	30.9 (29190)	1.0600	(1.0398-1.0805)	0.9897	(0.9675-1.0124)	0.372
48	Masterton	65.5 (3933)	61.9 (7418)	1.0568	(1.0167-1.0985)	0.9727	(0.9280-1.0194)	0.247

49	Carterton	60.6 (993)	54.7 (1787)	1.1075 (1.0249-1.1968)	1.0392 (0.9590-1.1262)	0.348
50	South Wairarapa	59.5 (1243)	53.0 (2208)	1.1115 (1.0377-1.1907)	1.0431 (0.9702-1.1214)	0.253
51	Tasman	44.7 (4469)	41.2 (8220)	1.0846 (1.0459-1.1249)	1.0190 (0.9796-1.0601)	0.349
52	Nelson City	45.2 (4878)	42.9 (9235)	1.0530 (1.0184-1.0888)	0.9807 (0.9454-1.0174)	0.299
53	Marlborough	56.0 (5711)	52.8 (10732)	1.0608 (1.0273-1.0954)	0.9930 (0.9540-1.0335)	0.730
54	Kaikoura	60.1 (474)	54.0 (849)	1.1132 (0.9949-1.2456)	1.0376 (0.9257-1.1632)	0.526
55	Buller	64.9 (1591)	57.4 (2805)	1.1323 (1.0647-1.2041)	1.0516 (0.9856-1.1221)	0.128
56	Grey	71.3 (2413)	65.6 (4431)	1.0867 (1.0341-1.1419)	1.0083 (0.9538-1.0660)	0.770
57	Westland	61.1 (1215)	54.7 (2168)	1.1166 (1.0409-1.1978)	1.0464 (0.9728-1.1257)	0.223
58	Hurunui	54.1 (1098)	52.5 (2127)	1.0429 (0.9738-1.1169)	0.9740 (0.9029-1.0507)	0.495
59	Waimakariri	54.4 (3622)	51.2 (6804)	1.0596 (1.0247-1.0956)	0.9934 (0.9515-1.0372)	0.765
60	Christchurch City	55.9 (45338)	51.7 (83638)	1.0802 (1.0683-1.0922)	1.0031 (0.9869-1.0196)	0.710
61	Banks Peninsula	47.8 (223)	45.3 (422)	0.9960 (0.8661-1.1454)	0.9951 (0.8456-1.1711)	0.953
62	Selwyn	46.5 (2721)	43.5 (5071)	1.0743 (1.0259-1.1250)	1.0164 (0.9667-1.0686)	0.526
63	Ashburton	70.2 (4497)	65.0 (8306)	1.0796 (1.0411-1.1195)	1.0080 (0.9648-1.0532)	0.721
64	Timaru	64.0 (6897)	59.5 (12794)	1.0758 (1.0448-1.1078)	1.0041 (0.9673-1.0422)	0.831
65	Mackenzie	42.0 (401)	38.0 (724)	1.1131 (0.9855-1.2572)	1.0494 (0.9274-1.1875)	0.444
66	Waimate	60.0 (941)	55.9 (1749)	1.0732 (0.9914-1.1616)	0.9989 (0.9205-1.0840)	0.980
67	Chatham Islands	63.6 (24)	39.8 (30)	1.3309 (0.9547-1.8554)	1.4969 (0.8747-2.5617)	0.141
68	Waitaki	67.4 (3728)	61.7 (6802)	1.0935 (1.0508-1.1381)	1.0227 (0.9758-1.0719)	0.348
69	Central Otago	62.2 (2564)	57.8 (4757)	1.0750 (1.0246-1.1278)	1.0125 (0.9612-1.0665)	0.640
70	Queenstown-Lakes	47.5 (2122)	41.0 (3655)	1.1531 (1.0940-1.2153)	**1.0923 (1.0310-1.1572)**	**0.003**
71	Dunedin City	47.7 (18773)	44.5 (34939)	1.0724 (1.0535-1.0916)	1.0019 (0.9808-1.0234)	0.862
72	Clutha	44.8 (1892)	42.6 (3589)	1.0508 (0.9939-1.1109)	0.9870 (0.9305-1.0470)	0.665
73	Southland	45.0 (2662)	43.3 (5108)	1.0393 (0.9918-1.0890)	0.9790 (0.9306-1.0299)	0.411
74	Gore	34.6 (1189)	32.5 (2230)	1.0628 (0.9906-1.1403)	0.9859 (0.9145-1.0628)	0.711
75	Invercargill City	61.2 (8371)	56.6 (15439)	1.0814 (1.0531-1.1106)	1.0008 (0.9721-1.0304)	0.956

Table A 4.9 **Rates of all-cause hospitalisation in winter and non-winter months by District Health Board area, ratio of rates and winter:non-winter ratios relative to baseline; 2000-2006 (using NHI cohort).**

Number	District Health Board	Rate per 1000 person years (No. of hospitalisations)		Winter: non-winter ratio (95% CI) Unadjusted (cohort analysis)	Winter: non-winter ratio relative to reference category (95% CI), p-value	
		Winter	Non-winter			
11	Northland	67.6 (24332)	61.6 (44191)	1.0983 (1.0813-1.1156)	1.0103 (0.9896-1.0313)	0.332
21	Waitemata	46.5 (51283)	43.6 (96095)	1.0645 (1.0532-1.0760)	0.9861 (0.9707-1.0017)	0.080
22	Auckland	42.6 (47605)	39.1 (87111)	1.0901 (1.0780-1.1024)		
23	Counties Manakau	52.8 (57419)	48.0 (104100)	1.1003 (1.0891-1.1116)	0.9885 (0.9732-1.0039)	0.144
31	Waikato	60.1 (46883)	55.5 (86406)	1.0824 (1.0703-1.0947)	0.9988 (0.9823-1.0156)	0.889
42	Lakes	62.2 (16129)	57.3 (29659)	1.0847 (1.0641-1.1057)	0.9918 (0.9693-1.0148)	0.482
47	Bay of Plenty	71.2 (30034)	65.7 (55376)	1.0819 (1.0668-1.0972)	0.9964 (0.9779-1.0153)	0.708
51	Tairawhiti	79.7 (9031)	70.5 (15918)	1.1318 (1.1030-1.1614)	**1.0296 (1.0001-1.0599)**	**0.049**
61	Hawkes Bay	62.6 (22096)	57.3 (40290)	1.0939 (1.0761-1.1120)	1.0027 (0.9825-1.0234)	0.794
71	Taranaki	64.8 (17174)	59.9 (31676)	1.0813 (1.0614-1.1016)	1.0052 (0.9829-1.0280)	0.651
81	Midcentral	51.8 (20649)	48.2 (38322)	1.0748 (1.0568-1.0931)	0.9934 (0.9726-1.0147)	0.541
82	Whanganui	70.9 (11513)	65.4 (21188)	1.0837 (1.0594-1.1086)	0.9986 (0.9732-1.0247)	0.916
91	Capital and Coast	38.0 (26403)	35.6 (49402)	1.0661 (1.0503-1.0821)	0.9842 (0.9659-1.0029)	0.097
92	Hutt	54.9 (19400)	50.7 (35702)	1.0839 (1.0651-1.1030)	0.9993 (0.9785-1.0204)	0.944
93	Wairarapa	63.4 (6169)	58.8 (11413)	1.0783 (1.0454-1.1122)	1.0013 (0.9672-1.0366)	0.941
101	Nelson Marlborough	48.6 (15058)	45.6 (28187)	1.0656 (1.0448-1.0869)	0.9989 (0.9757-1.0225)	0.924
111	West Coast	66.7 (5219)	60.3 (9404)	1.1070 (1.0702-1.1451)	1.0348 (0.9972-1.0738)	0.070
121	Canterbury	56.1 (57973)	52.0 (107217)	1.0786 (1.0678-1.0896)	1.0041 (0.9888-1.0197)	0.600
123	Sth Canterbury	62.0 (8239)	57.6 (15267)	1.0764 (1.0480-1.1056)	1.0102 (0.9796-1.0418)	0.517
131	Otago	50.9 (27744)	47.2 (51352)	1.0777 (1.0621-1.0935)	1.0102 (0.9913-1.0295)	0.292
141	Southland	51.8 (13557)	48.2 (25167)	1.0745 (1.0523-1.0972)	1.0019 (0.9779-1.0264)	0.880

APPENDIX 5 RATES BY ICD-10 DISEASE CODE

This Appendix lists absolute EWH and EWHI by ICD-10 disease code.

It begins with a list of New Zealand's highest impact winter illnesses, i.e. those ICD-10 codes which have:

- 100+ total annual admissions
- EWHI≥ 1.05
- Either absolute EWH≥100, or EWHI≥1.08

The codes are sorted by total absolute EWH for the period 2000-2006: improvements in EWHI would have the greatest population health benefits and hospital cost savings for disease codes at the top of the table.

EWHIs greater than 2 have been listed in bold (winter rate two or more times higher than non-winter rate).

Separate tables are listed for the entire population (Table A 5.1), Māori (Table A 5.2), and Pacific Peoples (Table A 5.3). Lastly, a full table of EWHIs for each ICD-10 code is provided (Table A 5.4)

Table A 5.1 Highest impact ICD-10 codes (to three digits) for the entire New Zealand population, with EWHI and absolute EWH 1 February 2000 – 31 January 2006.

ICD-10 CODE	DESCRIPTION	EWHI	ABSOLUTE EWH
J18	Pneumonia, organism unspecified	1.78	12547.6
J21	**Acute bronchiolitis**	**3.47**	**10941.0**
J44	Other COPD	1.68	10224.0
J22	Unspec'd acute lower resp. infection	1.92	4472.8
I50	Heart failure	1.30	3728.2
J06	**Multiple acute upper resp. infections**	**2.02**	**3644.6**
J45	Asthma	1.31	3372.0
B34	Viral infection, unspec'd site	1.44	2926.4
I21	Acute myocardial infarction	1.13	2493.0
A08	Viral and other intestinal infections	1.61	1809.8
A09	Infectious diarrhoea/gastroenteritis	1.31	1045.2
J05	Acute obstructive laryngitis/epiglottitis	1.88	929.9
J20	**Acute bronchitis**	**2.26**	**886.4**
J12	**Viral pneumonia, nec**	**4.09**	**834.7**
J40	**Bronchitis, unspecified**	**2.26**	**821.6**
J10	**Influenza, other virus**	**13.06**	**792.3**
J13	**Streptococcus pneumoniae**	**2.12**	**682.2**
I48	Atrial fibrillation/flutter	1.06	625.0
S72	Femur fracture	1.07	588.3
H66	Suppurative and unspec'd otitis media	1.92	586.1
R56	Convulsions, nec	1.17	584.8
R55	Syncope and collapse	1.07	564.7
J11	**Influenza, unidentified virus**	**5.36**	**564.6**
R04	Haemorrhage, respiratory passages	1.31	488.8
A39	Meningococcal infection	1.76	475.7
I63	Cerebral infarction	1.07	461.9
J47	Bronchiectasis	1.38	414.3
J15	Bacterial Pneumonia	1.47	409.9
J14	Pneumonia, Haemophlus influenzae	1.91	356.9
I64	Stroke, not spec'd	1.09	343.1
J98	Other respiratory disorders	1.37	265.9
I70	Atherosclerosis	1.22	244.2
M80	Osteoporosis, pathological fracture	1.41	218.9
K92	Other diseases, digestive	1.05	215.2
J46	Status asthmaticus	1.19	200.4
I61	Intracerebral haemorrhage	1.13	199.6
J96	Respiratory failure, nec	1.53	184.0
J69	Pnuemonitis due to solids/liquids	1.20	173.0
E10	Diabetes mellitus	1.06	163.0
R41	Other symptoms/signs, cognitive/awareness	1.12	146.3
I26	Pulmonary embolism	1.09	145.4
J90	Pleural effusion, nec	1.13	134.9
D69	Purpura/other haemorrhagic conditions	1.20	127.1
J39	Other diseases of upper resp. tract	1.50	110.4
I80	Phlebitis/thrombophlebitis	1.05	109.3
T68	**Hypothermia**	**2.84**	**106.8**
I97	Postproc. circulatory disorders, nec	1.22	105.6
A49	Bacterial infection, unspec'd site	1.29	104.9
A40	Streptococcal septicaemia	1.24	104.7
I25	Chronic IHD	1.12	103.5
I88	Nonspecific lymphadenitis	1.15	100.0
I71	Aortic aneurysm/dissection	1.12	95.8

ICD-10 CODE	DESCRIPTION	EWHI	ABSOLUTE EWH
J02	Acute pharyngitis	1.13	91.9
J01	Acute sinusitis	1.70	88.6
H65	Nonsuppurative otitis media	1.89	87.2
F05	Delirium, non-induced	1.14	84.3
N44	Torsion of testis	1.19	79.8
J04	Acute laryngitis/tracheitis	1.75	79.7
G97	Postproc. nervous system disorders, nec	1.31	78.7
J84	Other interstitial pulmonary	1.20	74.9
E84	Cystic fibrosis	1.16	70.2
G41	Status epilepticus	1.14	69.5
F12	M/B Disorder, cannabinoids	1.17	69.3
I74	Arterial embolism/thrombosis	1.20	64.1
R05	Cough	1.34	63.0
A07	Other protozoal intestinal	1.67	62.7
G00	Bacterial meningitis	1.25	59.8
M84	Disorders of continuity of bone	1.14	59.2
J32	Chronic sinusitis	1.21	56.7
J00	Acute nasopharyngitis	1.99	55.8
T88	Other surgical/medical complications, nec	1.14	55.8
N50	Other male genital organ disorders	1.30	55.0
F44	Dissociative disorders	1.15	52.5
D68	Other coagulation defects	1.09	52.4
K12	Stomatitis/related lesions	1.19	52.2
F19	M/B disorder, multiple drug use	1.15	51.5
H83	Inner ear, other	1.09	50.8
K72	Hepatic failure, nec	1.18	47.7
K55	Vascular disorders, intestine	1.08	45.0
K43	Ventral hernia	1.11	44.4
J95	Postproc. respiratory disorders, nec	1.13	42.5
S79	Other spec'd hip/thigh injuries	1.10	42.2
I22	Subsequent MI	1.14	42.1
L89	Decubitus ulcer	1.14	42.1
J43	Emphysema	1.23	42.0
I73	Other peripheral vascular	1.34	41.6
J81	Pulmonary oedema	1.19	39.4
F34	Persistent mood disorders	1.12	38.5
F53	M/B disorder, puerperium	1.30	36.6
I27	Other pulmonary heart	1.17	33.4
F45	Somatoform disorders	1.09	32.5
M75	Shoulder lesions	1.13	32.2
I30	Acute pericarditis	1.10	32.0
L20	Atopic dermatitis	1.18	31.0

Table A 5.2 Highest impact ICD-10 codes (to two digits) for New Zealand Māori, with EWHI and absolute EWH 1 February 2000 – 31 January 2006.

ICD-10 CODE	DESCRIPTION	EWHI	ABSOLUTE EWH
J44	Other COPD	1.58	4602.88
J21	**Acute bronchiolitis**	**3.04**	**3100.06**
J06	**Multiple acute upper resp. infections**	**2.03**	**1400.94**
A08	Viral and other intestinal infections	1.88	1089.91
I50	Heart failure	1.21	975.18
J18	**Pneumonia, organism unspecified**	**2.08**	**866.45**
J45	Asthma	1.24	647.00
H66	Suppurative and unspec'd otitis media	1.82	512.29
J22	**Unspec'd acute lower resp. infection**	**2.01**	**437.02**
J05	Acute obstructive laryngitis/epiglottitis	1.94	309.92
J11	**Influenza, unidentified virus**	**5.72**	**239.25**
J46	Status asthmaticus	1.10	237.81
J14	**Pneumonia, Haemophlus influenzae**	**2.04**	**207.26**
B34	Viral infection, unspec'd site	1.47	184.97
R51	Headache	1.16	181.98
J12	**Viral pneumonia, nec**	**4.59**	**181.92**
J13	**Streptococcus pneumoniae**	**2.02**	**177.61**
R04	Haemorrhage, respiratory passages	1.23	143.42
S73	Dislocation/sprain/strain of joint/ligaments of hip	1.15	135.96
J00	**Acute nasopharyngitis**	**2.64**	**124.14**
M10	Gout	1.11	114.59
K22	Other diseases of oesophagus	1.12	108.93
J69	Pnuemonitis due to solids/liquids	1.43	104.71
R06	Abnormalities of breathing	1.10	87.61
A09	Infectious diarrhoea/gastroenteritis	1.44	87.01
J15	Bacterial Pneumonia	1.65	66.15
J47	Bronchiectasis	1.58	64.36
I47	Paroxysmal tachycardia	1.13	61.05
J20	**Acute bronchitis**	**2.02**	**56.70**
I21	Acute myocardial infarction	1.13	54.03
J40	Bronchitis, unspecified	1.82	41.56
R56	Convulsions, nec	1.26	41.33
A39	Meningococcal infection	1.73	40.35
N44	Torsion of testis	1.09	37.93
J10	**Influenza, other virus**	**11.43**	**37.85**
J98	Other respiratory disorders	1.40	37.47
I48	Atrial fibrillation/flutter	1.09	33.65
T86	Failure and rejection of transplanted organs and tissues	1.48	32.78
A15	Respiratory TB, bacteriologically & histologically confirmed	1.42	29.33
L89	Decubitus ulcer	1.12	28.90
I00	Rheumatic fever without mention of heart involvement	1.37	27.27
H83	Inner ear, other	1.31	24.82
K40	Inguinal hernia	1.12	24.12
M54	Dorsalgia	1.10	23.54
C53	Malignant neoplasm of cervix uteri	1.35	23.35
M51	Other intervertebral disc disorders	1.14	22.81
M47	Spondylosis	1.29	22.36
R05	Cough	1.40	22.32
F34	Persistent mood disorders	1.21	21.37
F12	M/B Disorder, cannabinoids	1.21	20.61
N04	Nephrotic syndrome	1.29	19.82
E10	Diabetes mellitus	1.13	18.97
J32	Chronic sinusitis	1.47	18.27
I70	Atherosclerosis	1.24	17.29
M75	Shoulder lesions	1.51	16.80

ICD-10 CODE	DESCRIPTION	EWHI	ABSOLUTE EWH
A49	Bacterial infection, unspec'd site	1.35	16.69
H65	Nonsuppurative otitis media	1.87	16.69
J39	Other diseases of upper resp. tract	1.49	16.66
S83	Dislocation/sprain/strain of joints/ligaments of knee	1.17	15.82
C92	Myeloid leukaemia	1.09	14.91
S19	Other and unspecified injuries of neck	1.09	13.90
F19	M/B disorder, multiple drug use	1.18	13.70
N05	Unspecified nephritic syndrome	1.11	13.38
N18	Chronic renal failure	1.16	13.27
T88	Other surgical/medical complications, nec	1.10	12.91
N00	Acute nephritic syndrome	1.13	12.87
K81	Cholecystitis	1.16	12.29
S32	Fracture of lumbar spine and pelvis	1.10	12.28
F33	Recurrent depressive disorder	1.41	12.19
E83	Disorders of mineral metabolism	1.22	11.83
K12	Stomatitis/related lesions	1.11	11.35
S43	Dislocation/sprain/strain of joints/and ligaments of shoulder girdle	1.25	11.29
M60	Myositis	1.12	10.91
R31	Unspecified haematuria	1.34	10.75
N94	Pain/other conditions - female genital organs/menstrual cycle	1.25	10.30
F44	Dissociative disorders	1.44	10.24
I74	Arterial embolism/thrombosis	1.17	9.40
E16	Other disorders of pancreatic internal secretion	1.21	8.88
I71	Aortic aneurysm/dissection	1.17	8.81
I11	Hypertensive heart disease	1.13	8.40
A40	Streptococcal septicaemia	1.12	8.32
R63	Symptoms and signs concerning food and fluid intake	1.16	8.29
J02	Acute pharyngitis	1.15	8.20
G97	Postproc. nervous system disorders, nec	1.22	7.89
I31	Other diseases of pericardium	1.19	7.88
A56	Other sexually transmitted chlamydial diseases	1.08	7.87
H16	Keratitis	1.14	7.86
I01	Rheumatic fever with heart involvement	1.17	7.82
J90	Pleural effusion, nec	1.24	7.28
T46	Poisoning by agents primarily affecting the cardiovascular system	1.12	6.91
I83	Varicose veins of lower extremities	1.16	6.83
J96	Respiratory failure, nec	1.32	6.77
F06	Other mental disorders (brain damage/dysfunc., physical disease)	1.24	6.36
L20	Atopic dermatitis	1.20	5.82
D68	Other coagulation defects	1.13	5.80
S33	Dislocation/sprain/strain of joints/ligaments of lumbar spine/pelvis	1.09	5.41
C85	Other and unspecified types of non-Hodgkin's lymphoma	1.14	4.90
M32	Systemic lupus erythematosus	1.14	4.90
G81	Hemiplegia	1.10	4.88
C18	Malignant neoplasm of colon	1.12	4.39
K72	Hepatic failure, nec	1.16	3.88
T51	Toxic effect of alcohol	1.18	3.88

Table A 5.3 Highest impact ICD-10 codes (to two digits) for New Zealand resident Pacific Peoples, with EWHI and absolute EWH 1 February 2000 – 31 January 2006.

ICD-10 CODE	DESCRIPTION	EWHI	ABSOLUTE EWH
J18	**Pneumonia, organism unspecified**	**2.47**	**3070.91**
J21	**Acute bronchiolitis**	**3.10**	**2821.57**
J22	**Unspec'd acute lower resp. infection**	**2.11**	**551.05**
J06	**Multiple acute upper resp. infections**	**2.08**	**517.10**
J44	Other COPD	1.66	472.91
J45	Asthma	1.20	377.07
B34	Viral infection, unspec'd site	1.45	360.65
J12	**Viral pneumonia, nec**	**6.10**	**260.85**
A08	Viral and other intestinal infections	1.94	239.75
A09	Infectious diarrhoea/gastroenteritis	1.49	192.34
I50	Heart failure	1.21	166.72
J47	Bronchiectasis	1.52	137.23
A39	Meningococcal infection	1.77	127.51
J10	**Influenza, other virus**	**18.52**	**122.98**
J40	**Bronchitis, unspecified**	**2.27**	**115.73**
R56	Convulsions, nec	1.30	106.95
J05	**Acute obstructive laryngitis/epiglottitis**	**2.05**	**93.74**
R55	Syncope and collapse	1.22	80.94
H66	**Suppurative and unspec'd otitis media**	**2.12**	**79.29**
J20	**Acute bronchitis**	**2.02**	**71.30**
I21	Acute myocardial infarction	1.11	69.13
J98	Other respiratory disorders	1.80	64.26
J15	Bacterial Pneumonia	1.72	53.78
S82	Fracture of lower leg, including ankle	1.09	48.46
J13	Streptococcus pneumoniae	1.70	47.80
R04	Haemorrhage, respiratory passages	1.29	38.61
J14	Pneumonia, Haemophlus influenzae	1.92	35.39
G43	Migraine	1.40	33.25
K40	Inguinal hernia	1.36	31.25
K92	Other diseases, digestive	1.17	28.01
N45	Orchitis and epididymitis	1.42	23.34
C34	Malignant neoplasm of bronchus and lung	1.22	19.25
K56	Paralytic ileus and intestinal obstruction without hernia	1.13	18.57
K85	Acute pancreatitis	1.19	18.22
G45	Transient cerebral ischaemic attacks/related syndromes	1.13	18.10
K12	Stomatitis/related lesions	1.50	15.91
D69	Purpura/other haemorrhagic conditions	1.22	14.31
K37	Unspecified appendicitis	1.23	13.33
J96	Respiratory failure, nec	1.29	12.87
K72	Hepatic failure, nec	1.37	11.91
A49	Bacterial infection, unspec'd site	1.18	11.31
T23	Burn and corrosion of wrist and hand	1.25	10.87
A04	Other bacterial intestinal infections	1.16	10.80
E86	Volume Depletion	1.14	10.77
J46	Status asthmaticus	1.10	10.68
M79	Other soft tissue disorders, nec	1.10	10.21
S83	Dislocation, sprain and strain of joints and ligaments of knee	1.20	9.86
M32	Systemic lupus erythematosus	1.15	9.32
K91	Postprocedural disorders of digestive system, nec	1.19	8.86
I42	Cardiomyopathy	1.18	8.86
J69	Pnuemonitis due to solids/liquids	1.12	8.30
S63	Dislocation/sprain/strain of joints/ligaments at wrist/hand level	1.18	7.87
J90	Pleural effusion, nec	1.18	7.38
S32	Fracture of lumbar spine and pelvis	1.14	7.35

I95	Hypotension	1.08	7.24
D70	Agranulocytosis	1.12	6.83
T39	Poisoning by nonopioid analgesics/antipyretics/antirheumatics	1.10	6.81
I10	Essential (primary) hypertension	1.10	6.78
F43	Reaction to severe stress, and adjustment disorders	1.14	5.88
C16	Malignant neoplasm of stomach	1.10	5.82
I01	Rheumatic fever with heart involvement	1.09	5.81
S20	Superficial injury of thorax	1.09	2.90

Table A 5.4 EWHI and absolute EWH for the entire New Zealand population 1 February 2000 – 31 January 2006, by ICD-10 code (to two digits).

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
A00	1	1	1.99	0.5
A01	36	96	0.75	-12.1
A02	206	655	0.63	-122.5
A03	29	92	0.63	-17.1
A04	1590	3930	0.81	-380.8
A05	36	115	0.62	-21.7
A06	8	13	1.23	1.5
A07	156	186	1.67	62.7
A08	4780	5923	1.61	1809.8
A09	4391	6672	1.31	1045.2
A15	155	267	1.16	21.1
A16	89	164	1.08	6.8
A17	6	34	0.35	-11.0
A18	77	94	1.63	29.9
A19	6	25	0.48	-6.5
A23		2		-1.0
A24	2			2.0
A25		2		-1.0
A26	2	3	1.33	0.5
A27	116	252	0.92	-10.4
A28	8	18	0.89	-1.0
A30	1	5	0.40	-1.5
A31	35	69	1.01	0.4
A32	21	41	1.02	0.4
A35	2	12	0.33	-4.0
A36		1		-0.5
A37	325	696	0.93	-24.0
A38	49	120	0.81	-11.2
A39	1105	1255	1.76	475.7
A40	533	854	1.24	104.7
A41	3262	6854	0.95	-175.1
A42	5	12	0.83	-1.0
A43	9	6	2.99	6.0
A46	78	151	1.03	2.3
A48	67	100	1.34	16.9
A49	465	718	1.29	104.9
A50		3		-1.5
A51		6		-3.0
A52	6	9	1.33	1.5
A54	76	120	1.26	15.8
A56	205	423	0.97	-7.1
A58		1		-0.5
A59	8	26	0.61	-5.0
A60	50	98	1.02	0.9
A63	5	6	1.66	2.0
A64	2	4	1.00	0.0
A69	4	17	0.47	-4.5
A70		5		-2.5
A74	13	28	0.93	-1.0
A75	11	5	4.39	8.5
A77		3		-1.5
A78	1	1	1.99	0.5
A79	4	5	1.60	1.5
A81	9	13	1.38	2.5
A83		1		-0.5
A85	7	19	0.73	-2.5
A86	96	182	1.05	4.7
A87	901	2232	0.80	-218.3
A88	1			1.0
A89	2	1	3.99	1.5
A90	17	50	0.68	-8.1
A91		3		-1.5
A92		1		-0.5
A94	1			1.0
B00	332	765	0.87	-51.6
B01	386	938	0.82	-84.4
B02	473	1072	0.88	-64.6
B05	7	16	0.87	-1.0
B06	4	5	1.60	1.5
B07	2	4	1.00	0.0
B08	67	170	0.79	-18.2
B09	122	248	0.98	-2.4
B15	32	82	0.78	-9.1
B16	56	119	0.94	-3.7
B17	27	53	1.02	0.4
B18	66	165	0.80	-16.7
B19	50	126	0.79	-13.2
B20	6	14	0.85	-1.0
B21		1		-0.5
B22	7	12	1.16	1.0
B23	4	17	0.47	-4.5
B24		3		-1.5
B25	40	109	0.73	-14.7
B26	13	24	1.08	1.0
B27	402	823	0.97	-10.7
B30	9	23	0.78	-2.5
B33	21	41	1.02	0.4
B34	9625	13358	1.44	2926.4
B35	22	53	0.83	-4.6
B36	7	10	1.40	2.0
B37	195	364	1.07	12.5
B38		1		-0.5
B43		1		-0.5
B44	45	84	1.07	2.9
B45	3	18	0.33	-6.0
B46		4		-2.0
B47	1			1.0
B48	5	5	1.99	2.5
B49	4	7	1.14	0.5
B50	30	61	0.98	-0.6
B51	58	69	1.68	23.4
B52	3	3	1.99	1.5
B53	5	11	0.91	-0.5
B54	7	23	0.61	-4.5
B55		1		-0.5
B58	6	23	0.52	-5.5
B59	50	106	0.94	-3.2
B60	3	4	1.50	1.0
B65		2		-1.0
B66	1	1	1.99	0.5
B67	19	16	2.37	11.0
B69		7		-3.5
B74		1		-0.5
B75	3			3.0
B77		1		-0.5
B78	6	7	1.71	2.5
B79	2			2.0
B80	22	34	1.29	5.0
B81	1			1.0
B82	5	17	0.59	-3.5
B83	5	8	1.25	1.0
B85	6	6	1.99	3.0
B86	48	75	1.28	10.4
B87		2		-1.0
B88	1			1.0
B89		3		-1.5
B91		2		-1.0
B94		2		-1.0
B95	10	31	0.64	-5.5
B96	7	28	0.50	-7.0
B97	16	35	0.91	-1.6
B99	37	74	1.00	-0.1
C00	3	7	0.85	-0.5
C01	22	40	1.10	1.9
C02	24	34	1.41	7.0
C03	6	6	1.99	3.0
C04	12	20	1.20	2.0
C05	5	12	0.83	-1.0
C06	8	19	0.84	-1.5
C07	8	21	0.76	-2.5
C08	2	6	0.66	-1.0
C09	21	37	1.13	2.4
C10	8	20	0.80	-2.0
C11	45	82	1.09	3.9
C12	14	19	1.47	4.5
C13	8	36	0.44	-10.1
C14	6	17	0.70	-2.5
C15	401	806	0.99	-3.2
C16	517	1102	0.94	-35.6
C17	87	184	0.94	-5.3
C18	1529	3152	0.97	-51.6
C19	157	342	0.92	-14.5
C20	345	646	1.06	21.1
C21	41	105	0.78	-11.7
C22	234	504	0.93	-18.7
C23	37	98	0.75	-12.1
C24	79	139	1.13	9.3
C25	456	1017	0.89	-54.0
C26	40	76	1.05	1.9
C30	5	22	0.45	-6.0
C31	14	20	1.40	4.0
C32	50	109	0.91	-4.7
C33	7	10	1.40	2.0
C34	1879	3703	1.01	22.1
C37	14	17	1.64	5.5
C38	43	86	1.00	-0.1
C40	74	138	1.07	4.8
C41	56	135	0.83	-11.7
C43	71	135	1.05	3.3
C44	101	261	0.77	-29.9
C45	124	281	0.88	-16.9
C46	4	7	1.14	0.5
C47	6	11	1.09	0.5
C48	62	79	1.57	22.4
C49	88	173	1.01	1.2
C50	355	694	1.02	7.0
C51	11	30	0.73	-4.0
C52	10	24	0.83	-2.0
C53	137	257	1.06	8.1
C54	113	219	1.03	3.2
C55	20	49	0.81	-4.6
C56	274	584	0.94	-18.9
C57	7	13	1.07	0.5
C58	2	1	3.99	1.5
C60	3	10	0.60	-2.0
C61	482	1081	0.89	-60.1

	Admissions		EWHI	
ICD-10 Code	Winter	Non-winter	EWHI	Absolute
C62	77	164	0.94	-5.2
C63	1	7	0.28	-2.5
C64	213	475	0.89	-25.2
C65	10	13	1.53	3.5
C66	8	20	0.80	-2.0
C67	308	597	1.03	8.6
C68	3	7	0.85	-0.5
C69	12	27	0.89	-1.5
C70	13	20	1.30	3.0
C71	478	1085	0.88	-66.1
C72	10	21	0.95	-0.5
C73	37	77	0.96	-1.6
C74	18	49	0.73	-6.6
C75	16	19	1.68	6.5
C76	43	107	0.80	-10.7
C77	176	424	0.83	-36.6
C78	2198	4601	0.95	-109.3
C79	2437	4877	1.00	-8.7
C80	203	407	0.99	-1.1
C81	79	168	0.94	-5.2
C82	102	183	1.11	10.2
C83	400	840	0.95	-21.2
C84	58	116	1.00	-0.2
C85	362	765	0.94	-21.6
C88	30	75	0.80	-7.6
C90	412	877	0.94	-27.8
C91	475	948	1.00	-0.4
C92	413	853	0.97	-14.8
C93	6	20	0.60	-4.0
C94	21	34	1.23	4.0
C95	32	86	0.74	-11.1
C96	13	24	1.08	1.0
D00	7	13	1.07	0.5
D01	4	7	1.14	0.5
D02	5	7	1.42	1.5
D03	2	7	0.57	-1.5
D04	2	9	0.44	-2.5
D05	3	4	1.50	1.0
D06	7	17	0.82	-1.5
D07	2	4	1.00	0.0
D09	14	11	2.54	8.5
D10	2	7	0.57	-1.5
D11	3	3	1.99	1.5
D12	125	273	0.91	-11.9
D13	45	69	1.30	10.4
D14	1	14	0.14	-6.0
D15	7	22	0.63	-4.0
D16	15	23	1.30	3.5
D17	18	59	0.61	-11.6
D18	73	166	0.88	-10.2
D19	3	2	2.99	2.0
D20	4	9	0.89	-0.5
D21	5	15	0.66	-2.5
D22		3		-1.5
D23	7	14	1.00	0.0
D24	2	6	0.66	-1.0
D25	188	379	0.99	-2.1
D26	1	14	0.14	-6.0
D27	191	465	0.82	-42.2
D28	11	18	1.22	2.0
D29		2		-1.0
D30	7	9	1.55	2.5
D32	126	274	0.92	-11.4
D33	17	40	0.85	-3.1
D34	1	1	1.99	0.5
D35	58	109	1.06	3.3
D36	21	20	2.09	11.0
D37	127	299	0.85	-22.9
D38	49	94	1.04	1.9
D39	42	79	1.06	2.4
D40	2	12	0.33	-4.0
D41	24	57	0.84	-4.6
D42	14	22	1.27	3.0
D43	185	387	0.95	-9.1
D44	25	53	0.94	-1.6
D45	22	41	1.07	1.4
D46	370	752	0.98	-7.1
D47	100	194	1.03	2.7
D48	63	117	1.07	4.3
D50	1737	3318	1.04	73.1
D51	10	38	0.52	-9.1
D52	41	105	0.78	-11.7
D53	32	74	0.86	-5.1
D55	6	11	1.09	0.5
D56	16	28	1.14	2.0
D57	32	81	0.79	-8.6
D58	34	67	1.01	0.4
D59	164	307	1.07	10.0
D60	13	17	1.52	4.5
D61	171	388	0.88	-23.6
D62	58	128	0.90	-6.2
D63	1			1.0
D64	1280	2654	0.96	-50.9
D65	11	22	1.00	0.0
D66	92	171	1.07	6.2
D67	9	29	0.62	-5.5
D68	607	1106	1.09	52.4
D69	765	1272	1.20	127.1
D70	1233	2402	1.02	28.5
D71	4	5	1.60	1.5
D72	22	49	0.90	-2.6
D73	43	109	0.79	-11.7
D74	1	4	0.50	-1.0
D75	28	51	1.09	2.4
D76	15	21	1.42	4.5
D80	5	9	1.11	0.5
D81	3	6	1.00	0.0
D82	4	5	1.60	1.5
D83	2	12	0.33	-4.0
D84	9	10	1.79	4.0
D86	68	117	1.16	9.3
D89	5	15	0.66	-2.5
E01		1		-0.5
E03	71	135	1.05	3.3
E04	38	94	0.81	-9.1
E05	231	468	0.98	-3.7
E06	27	55	0.98	-0.6
E07	9	9	1.99	4.5
E10	3079	5815	1.06	163.0
E11	4805	9220	1.04	181.5
E13	60	94	1.27	12.9
E14	48	91	1.05	2.4
E15	9	22	0.82	-2.0
E16	229	467	0.98	-5.2
E20	6	4	2.99	4.0
E21	36	81	0.89	-4.6
E22	100	232	0.86	-16.3
E23	47	96	0.98	-1.1
E24	19	31	1.22	3.5
E25	6	13	0.92	-0.5
E26	10	8	2.49	6.0
E27	111	216	1.02	2.7
E28	33	75	0.88	-4.6
E29		1		-0.5
E31	3	3	1.99	1.5
E32	1			1.0
E34	13	16	1.62	5.0
E41	5	5	1.99	2.5
E43	11	9	2.44	6.5
E44		3		-1.5
E46	30	79	0.76	-9.6
E50	2	1	3.99	1.5
E51	16	54	0.59	-11.1
E53	16	28	1.14	2.0
E54	1	1	1.99	0.5
E55	15	18	1.66	6.0
E56	1	2	1.00	0.0
E58	3	2	2.99	2.0
E60		1		-0.5
E61	1	4	0.50	-1.0
E63	4	5	1.60	1.5
E65	2	2	1.99	1.0
E66	40	66	1.21	6.9
E67	1			1.0
E68	1			1.0
E70		7		-3.5
E71	1	11	0.18	-4.5
E72	10	25	0.80	-2.5
E73	15	20	1.50	5.0
E74	11	20	1.10	1.0
E75	6	11	1.09	0.5
E76	3	7	0.85	-0.5
E77	3	3	1.99	1.5
E78	10	19	1.05	0.5
E80	15	36	0.83	-3.1
E83	391	772	1.01	3.9
E84	519	895	1.16	70.2
E85	34	44	1.54	11.9
E86	1405	2823	0.99	-10.6
E87	1771	3824	0.92	-146.6
E88	33	75	0.88	-4.6
E89	28	61	0.92	-2.6
F00	1	6	0.33	-2.0
F01	185	380	0.97	-5.6
F02	1	4	0.50	-1.0
F03	420	781	1.07	28.4
F04	14	15	1.86	6.5
F05	677	1182	1.14	84.3
F06	162	303	1.07	10.1
F07	221	442	1.00	-0.6
F09	16	47	0.68	-7.6
F10	3151	6824	0.92	-271.0
F11	276	600	0.92	-24.9
F12	477	813	1.17	69.3
F13	90	160	1.12	9.8
F14		2		-1.0
F15	137	313	0.87	-20.0
F16	17	25	1.36	4.5
F17	1	3	0.66	-0.5
F18	15	40	0.75	-5.1
F19	385	665	1.15	51.5
F20	4769	9546	1.00	-18.0
F21	21	23	1.82	9.5
F22	260	588	0.88	-34.9
F23	536	1057	1.01	5.9
F24	6	10	1.20	1.0
F25	1389	2943	0.94	-86.8
F28	68	124	1.09	5.8

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
F29	659	1298	1.01	8.1
F30	190	421	0.90	-21.1
F31	3583	7541	0.95	-198.6
F32	2635	5392	0.97	-68.9
F33	802	1503	1.06	48.3
F34	373	667	1.12	38.5
F38	29	46	1.26	5.9
F39	57	117	0.97	-1.7
F40	24	48	1.00	-0.1
F41	683	1442	0.94	-40.1
F42	60	133	0.90	-6.7
F43	1469	3037	0.96	-54.0
F44	400	693	1.15	52.5
F45	376	685	1.09	32.5
F48	31	46	1.34	7.9
F50	181	411	0.88	-25.1
F51	6	15	0.80	-1.5
F52		3		-1.5
F53	157	240	1.30	36.6
F54	4	6	1.33	1.0
F55	17	18	1.88	8.0
F59		1		-0.5
F60	1020	2172	0.94	-69.2
F61	16	18	1.77	7.0
F62	1	7	0.28	-2.5
F63	20	48	0.83	-4.1
F64	4	6	1.33	1.0
F65	1	5	0.40	-1.5
F68	25	59	0.84	-4.6
F69	1	10	0.20	-4.0
F70	58	116	1.00	-0.2
F71	7	35	0.40	-10.6
F72	7	11	1.27	1.5
F73	1	6	0.33	-2.0
F78	2	2	1.99	1.0
F79	12	57	0.42	-16.6
F80	2	4	1.00	0.0
F81	1	2	1.00	0.0
F82		5		-2.5
F83	1	3	0.66	-0.5
F84	39	78	1.00	-0.1
F89	2	3	1.33	0.5
F90	21	32	1.31	5.0
F91	59	101	1.16	8.4
F92	2	7	0.57	-1.5
F93	7	6	2.33	4.0
F94	5	1	9.97	4.5
F95	9	21	0.85	-1.5
F98	20	45	0.89	-2.6
F99	64	126	1.01	0.8
G00	295	469	1.25	59.8
G03	237	531	0.89	-29.3
G04	90	194	0.93	-7.3
G06	80	140	1.14	9.8
G08	20	38	1.05	0.9
G09		1		-0.5
G10	19	46	0.82	-4.1
G11	20	43	0.93	-1.6
G12	97	193	1.00	0.2
G20	380	703	1.08	27.5
G21	51	86	1.18	7.9
G23	5	8	1.25	1.0
G24	65	107	1.21	11.3
G25	141	315	0.89	-17.0
G30	199	387	1.03	4.9
G31	79	168	0.94	-5.2

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
G35	291	598	0.97	-8.9
G36	4	6	1.33	1.0
G37	70	125	1.12	7.3
G40	3569	6898	1.03	109.9
G41	578	1014	1.14	69.5
G43	1865	3711	1.00	4.1
G44	412	904	0.91	-41.3
G45	4033	7980	1.01	31.3
G47	235	465	1.01	1.8
G50	102	208	0.98	-2.3
G51	208	411	1.01	1.9
G52	19	25	1.52	6.5
G54	56	94	1.19	8.9
G56	68	141	0.96	-2.7
G57	61	123	0.99	-0.7
G58	50	98	1.02	0.9
G60	6	10	1.20	1.0
G61	202	351	1.15	26.0
G62	75	166	0.90	-8.2
G64	1	1	1.99	0.5
G70	48	107	0.89	-5.7
G71	26	47	1.10	2.4
G72	53	132	0.80	-13.2
G80	25	54	0.92	-2.1
G81	454	848	1.07	28.8
G82	27	55	0.98	-0.6
G83	78	152	1.02	1.8
G90	60	106	1.13	6.8
G91	86	139	1.23	16.3
G92	2	10	0.40	-3.0
G93	316	635	0.99	-2.4
G95	134	244	1.10	11.6
G96	28	34	1.64	11.0
G97	336	513	1.31	78.7
G98	5	5	1.99	2.5
H00	239	495	0.96	-9.2
H01	16	19	1.68	6.5
H02	16	21	1.52	5.5
H04	71	152	0.93	-5.2
H05	107	213	1.00	0.2
H10	71	122	1.16	9.8
H11	13	22	1.18	2.0
H15	8	11	1.45	2.5
H16	287	578	0.99	-2.8
H17	1			1.0
H18	21	33	1.27	4.5
H20	48	75	1.28	10.4
H21	19	35	1.08	1.4
H25	5	7	1.42	1.5
H26	21	34	1.23	4.0
H27	5	11	0.91	-0.5
H30	5	9	1.11	0.5
H31	6	5	2.39	3.5
H33	367	973	0.75	-120.9
H34	20	43	0.93	-1.6
H35	28	54	1.03	0.9
H40	207	383	1.08	14.9
H43	14	40	0.70	-6.1
H44	65	124	1.05	2.8
H46	70	102	1.37	18.9
H47	16	41	0.78	-4.6
H49	87	135	1.29	19.3
H50	1	6	0.33	-2.0
H51	8	25	0.64	-4.5
H52	1	4	0.50	-1.0
H53	166	340	0.97	-4.5

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
H54	24	60	0.80	-6.1
H55	10	22	0.91	-1.0
H57	44	128	0.69	-20.2
H59	83	135	1.23	15.3
H60	405	874	0.92	-33.3
H61	41	82	1.00	-0.1
H65	185	195	1.89	87.2
H66	1224	1272	1.92	586.1
H68		2		-1.0
H69	2	1	3.99	1.5
H70	90	134	1.34	22.8
H71	11	18	1.22	2.0
H72	14	15	1.86	6.5
H73	9	2	8.97	8.0
H74	8	16	1.00	0.0
H81	979	2077	0.94	-62.5
H83	619	1133	1.09	50.8
H90	56	105	1.06	3.3
H91	60	124	0.96	-2.2
H92	37	58	1.27	7.9
H93	31	59	1.05	1.4
H95	4	6	1.33	1.0
I00	151	244	1.23	28.6
I01	156	281	1.11	15.1
I02	17	41	0.83	-3.6
I05	60	100	1.20	9.9
I06	18	27	1.33	4.5
I07	17	51	0.66	-8.6
I08	151	286	1.05	7.6
I09	38	65	1.17	5.4
I10	987	1900	1.04	34.2
I11	205	350	1.17	29.5
I12	85	141	1.20	14.3
I13	27	56	0.96	-1.1
I15	40	79	1.01	0.4
I20	19332	38344	1.01	103.7
I21	21103	37111	1.13	2493.0
I22	335	584	1.14	42.1
I23	8	14	1.14	1.0
I24	247	440	1.12	26.4
I25	972	1732	1.12	103.5
I26	1719	3138	1.09	145.4
I27	230	392	1.17	33.4
I28	3	6	1.00	0.0
I30	357	648	1.10	32.0
I31	470	926	1.01	5.6
I33	295	660	0.89	-36.0
I34	136	247	1.10	12.1
I35	556	1097	1.01	5.9
I36	2	4	1.00	0.0
I37		3		-1.5
I38	28	33	1.69	11.5
I40	72	119	1.21	12.3
I42	410	771	1.06	23.4
I44	769	1560	0.98	-13.3
I45	174	345	1.01	1.0
I46	177	329	1.07	12.0
I47	2566	4975	1.03	71.2
I48	10861	20412	1.06	625.0
I49	1260	2764	0.91	-126.1
I50	16302	25074	1.30	3728.2
I51	131	209	1.25	26.2
I60	573	1088	1.05	27.4
I61	1699	2990	1.13	199.6
I62	426	940	0.90	-45.4
I63	6819	12677	1.07	461.9

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
I64	4062	7416	1.09	343.1
I65	147	372	0.79	-39.5
I66	132	246	1.07	8.6
I67	293	580	1.01	2.1
I69	8	21	0.76	-2.5
I70	1376	2257	1.22	244.2
I71	863	1530	1.12	95.8
I72	109	239	0.91	-10.9
I73	164	244	1.34	41.6
I74	387	644	1.20	64.1
I77	122	262	0.93	-9.4
I78	35	91	0.77	-10.6
I80	2388	4544	1.05	109.3
I81	16	37	0.86	-2.6
I82	170	305	1.11	17.1
I83	404	805	1.00	0.3
I84	647	1350	0.96	-30.0
I85	82	136	1.20	13.8
I86	26	41	1.26	5.4
I87	132	266	0.99	-1.4
I88	779	1354	1.15	100.0
I89	81	159	1.02	1.3
I95	2859	5915	0.96	-107.2
I97	577	940	1.22	105.6
I99	32	61	1.05	1.4
J00	112	112	1.99	55.8
J01	215	252	1.70	88.6
J02	818	1448	1.13	91.9
J03	2108	4203	1.00	0.3
J04	186	212	1.75	79.7
J05	1989	2112	1.88	929.9
J06	7213	7116	2.02	3644.6
J10	858	131	13.06	792.3
J11	694	258	5.36	564.6
J12	1105	539	4.09	834.7
J13	1293	1218	2.12	682.2
J14	747	778	1.91	356.9
J15	1290	1755	1.47	409.9
J16	45	57	1.57	16.4
J17	1			1.0
J18	28727	32264	1.78	12547.6
J20	1592	1407	2.26	886.4
J21	15371	8834	3.47	10941.0
J22	9326	9678	1.92	4472.8
J30	9	24	0.75	-3.0
J31	4	20	0.40	-6.0
J32	323	531	1.21	56.7
J33	10	21	0.95	-0.5
J34	232	475	0.97	-6.2
J35	194	374	1.03	6.5
J36	927	1818	1.02	15.3
J37	1	6	0.33	-2.0
J38	115	231	0.99	-0.8
J39	330	438	1.50	110.4
J40	1475	1303	2.26	821.6
J41	10	14	1.42	3.0
J42	41	73	1.12	4.4
J43	226	367	1.23	42.0
J44	25254	29972	1.68	10224.0
J45	14139	21471	1.31	3372.0
J46	1254	2101	1.19	200.4
J47	1497	2159	1.38	414.3
J61	14	19	1.47	4.5
J62	1	3	0.66	-0.5
J63		1		-0.5
J64		1		-0.5

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
J67	26	38	1.36	6.9
J68	14	38	0.73	-5.1
J69	1041	1731	1.20	173.0
J70	52	114	0.91	-5.2
J80	15	33	0.91	-1.5
J81	242	404	1.19	39.4
J82	18	38	0.94	-1.1
J84	441	730	1.20	74.9
J85	102	145	1.40	29.3
J86	169	304	1.11	16.6
J90	1203	2130	1.13	134.9
J91	1	4	0.50	-1.0
J92	10	16	1.25	2.0
J93	947	1977	0.96	-44.4
J94	51	113	0.90	-5.7
J95	373	659	1.13	42.5
J96	531	692	1.53	184.0
J98	979	1422	1.37	265.9
J99	1	11	0.18	-4.5
K00	4	5	1.60	1.5
K01	9	14	1.28	2.0
K02	47	93	1.01	0.4
K03	1			1.0
K04	414	1043	0.79	-109.0
K05	109	169	1.29	24.3
K06	16	16	1.99	8.0
K07	16	56	0.57	-12.1
K08	15	46	0.65	-8.1
K09	7	26	0.54	-6.0
K10	66	133	0.99	-0.7
K11	290	559	1.03	9.7
K12	329	552	1.19	52.2
K13	121	199	1.21	21.2
K14	45	83	1.08	3.4
K20	223	445	1.00	-0.2
K21	2232	4471	1.00	-10.1
K22	1177	2342	1.00	2.6
K25	1475	2962	0.99	-10.3
K26	1181	2334	1.01	10.6
K27	121	256	0.94	-7.4
K28	28	34	1.64	11.0
K29	2663	5482	0.97	-86.0
K30	232	473	0.98	-5.2
K31	339	675	1.00	0.5
K35	8136	16813	0.96	-295.2
K36	68	132	1.03	1.8
K37	993	1945	1.02	17.6
K38	268	586	0.91	-25.9
K40	1293	2423	1.06	77.9
K41	230	445	1.03	6.8
K42	448	868	1.03	12.7
K43	431	771	1.11	44.4
K44	168	280	1.20	27.6
K45	48	97	0.99	-0.6
K46	13	31	0.84	-2.5
K50	886	1946	0.91	-89.9
K51	521	972	1.07	33.6
K52	5620	12668	0.88	-732.6
K55	574	1055	1.08	45.0
K56	5717	11820	0.96	-210.4
K57	3520	7733	0.91	-357.9
K58	170	386	0.88	-23.6
K59	3701	7947	0.93	-284.2
K60	238	511	0.93	-18.3
K61	1994	4245	0.94	-134.7
K62	382	746	1.02	7.9

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
K63	338	650	1.04	12.0
K65	395	791	1.00	-1.7
K66	200	343	1.16	28.0
K70	407	907	0.89	-47.8
K71	78	167	0.93	-5.7
K72	314	531	1.18	47.7
K73	8	23	0.69	-3.5
K74	150	244	1.23	27.6
K75	219	479	0.91	-21.2
K76	132	293	0.90	-14.9
K80	6221	13516	0.92	-556.8
K81	799	1602	0.99	-4.4
K82	102	183	1.11	10.2
K83	682	1576	0.86	-108.3
K85	2145	4333	0.99	-27.9
K86	434	965	0.90	-49.9
K90	59	105	1.12	6.3
K91	1247	2423	1.03	31.9
K92	4244	8034	1.05	215.2
L00	46	102	0.90	-5.1
L01	225	495	0.91	-23.2
L02	6602	14967	0.88	-903.5
L03	12858	30603	0.84	-2488.4
L04	347	793	0.87	-50.7
L05	1254	2748	0.91	-124.0
L08	288	683	0.84	-54.5
L10	22	24	1.83	10.0
L11	1	1	1.99	0.5
L12	44	86	1.02	0.9
L13	9	20	0.90	-1.0
L20	200	337	1.18	31.0
L21	36	53	1.35	9.4
L22	24	35	1.37	6.4
L23	50	158	0.63	-29.2
L24	9	17	1.06	0.5
L25	34	57	1.19	5.4
L26	14	28	1.00	0.0
L27	341	710	0.96	-15.0
L28	15	25	1.20	2.5
L29	19	32	1.18	3.0
L30	778	1472	1.05	39.8
L40	138	233	1.18	21.2
L41	2	9	0.44	-2.5
L42	1	8	0.25	-3.0
L43	1			1.0
L44	1	8	0.25	-3.0
L50	409	837	0.97	-10.7
L51	158	343	0.92	-14.0
L52	36	64	1.12	3.9
L53	56	92	1.21	9.9
L55		34		-17.0
L56	1	9	0.22	-3.5
L57	3	8	0.75	-1.0
L58		1		-0.5
L59	5	5	1.99	2.5
L60	17	39	0.87	-2.6
L63	1	1	1.99	0.5
L66	1			1.0
L68		1		-0.5
L70	2	6	0.66	-1.0
L71	4	3	2.66	2.5
L72	142	329	0.86	-23.0
L73	45	145	0.62	-27.7
L74	2	4	1.00	0.0
L80	1	2	1.00	0.0
L81		6		-3.0

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
L82		2		-1.0
L84	2	8	0.50	-2.0
L85	5	10	1.00	0.0
L88	27	38	1.42	7.9
L89	349	612	1.14	42.1
L90	12	19	1.26	2.5
L91		5		-2.5
L92	24	48	1.00	-0.1
L93	3	10	0.60	-2.0
L94	4	6	1.33	1.0
L95	44	71	1.24	8.4
L97	1054	2064	1.02	19.0
L98	133	272	0.98	-3.4
M00	960	2095	0.91	-90.6
M02	28	51	1.09	2.4
M05	77	131	1.17	11.3
M06	243	493	0.98	-4.2
M08	57	103	1.10	5.3
M10	1481	2932	1.01	10.7
M11	129	252	1.02	2.6
M12	15	36	0.83	-3.1
M13	350	706	0.99	-4.0
M14		1		-0.5
M15	31	62	1.00	-0.1
M16	263	494	1.06	15.3
M17	189	346	1.09	15.5
M18	3	4	1.50	1.0
M19	70	140	1.00	-0.2
M20	11	25	0.88	-1.5
M21	16	49	0.65	-8.6
M22	9	21	0.85	-1.5
M23	57	107	1.06	3.3
M24	473	1070	0.88	-63.6
M25	1890	3669	1.03	50.1
M30	108	234	0.92	-9.3
M31	197	483	0.81	-45.2
M32	215	426	1.01	1.4
M33	44	78	1.12	4.9
M34	46	81	1.13	5.4
M35	166	387	0.86	-28.1
M40	1	15	0.13	-6.5
M41	19	33	1.15	2.5
M42	3	7	0.85	-0.5
M43	152	314	0.97	-5.5
M45	20	60	0.66	-10.1
M46	227	468	0.97	-7.7
M47	438	895	0.98	-10.8
M48	315	571	1.10	28.7
M49	1			1.0
M50	137	255	1.07	9.1
M51	1134	2225	1.02	18.2
M53	35	75	0.93	-2.6
M54	3275	6591	0.99	-30.2
M60	236	455	1.03	7.8
M61	3	5	1.20	0.5
M62	195	333	1.17	28.0
M65	272	532	1.02	5.2
M66	126	281	0.89	-14.9
M67	77	152	1.01	0.8
M70	860	2136	0.80	-211.1
M71	187	457	0.82	-42.2
M72	82	153	1.07	5.3
M75	290	514	1.13	32.2
M76	19	50	0.76	-6.1
M77	9	25	0.72	-3.5
M79	1718	3537	0.97	-55.7

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
M80	751	1061	1.41	218.9
M81	63	135	0.93	-4.7
M83	3	8	0.75	-1.0
M84	497	873	1.14	59.2
M85	30	51	1.17	4.4
M86	791	1792	0.88	-107.6
M87	65	108	1.20	10.8
M88	32	79	0.81	-7.6
M89	121	265	0.91	-11.9
M90	2			2.0
M91	22	54	0.81	-5.1
M92	3	11	0.54	-2.5
M93	293	726	0.80	-71.1
M94	350	657	1.06	20.5
M95	1			1.0
M96	99	189	1.04	4.2
N00	147	260	1.13	16.6
N01	4	22	0.36	-7.0
N02	57	127	0.90	-6.7
N03	16	30	1.06	1.0
N04	228	413	1.10	20.9
N05	216	411	1.05	9.9
N06	1	1	1.99	0.5
N10	600	1332	0.90	-68.0
N11	56	118	0.95	-3.2
N12	2386	5462	0.87	-353.0
N13	959	2177	0.88	-132.7
N14	5	11	0.91	-0.5
N15	42	109	0.77	-12.7
N17	1516	3082	0.98	-29.5
N18	634	1247	1.01	8.7
N19	75	144	1.04	2.8
N20	2401	5265	0.91	-239.2
N21	72	210	0.68	-33.3
N23	853	2001	0.85	-150.4
N25	28	48	1.16	3.9
N26	7	8	1.74	3.0
N28	148	270	1.09	12.6
N30	162	361	0.89	-19.0
N31	14	27	1.03	0.5
N32	165	346	0.95	-8.5
N34	18	38	0.94	-1.1
N35	60	109	1.10	5.3
N36	25	57	0.87	-3.6
N39	7649	16536	0.92	-643.3
N40	284	575	0.98	-4.3
N41	95	273	0.69	-41.9
N42	8	22	0.73	-3.0
N43	62	119	1.04	2.3
N44	501	840	1.19	79.8
N45	736	1380	1.06	44.0
N47	75	142	1.05	3.8
N48	163	339	0.96	-7.0
N49	181	396	0.91	-17.6
N50	238	365	1.30	55.0
N60	22	61	0.72	-8.6
N61	1365	2874	0.95	-76.2
N62	2	2	1.99	1.0
N63	19	37	1.02	0.4
N64	22	35	1.25	4.4
N70	343	698	0.98	-7.0
N71	95	212	0.89	-11.3
N72	9	26	0.69	-4.0
N73	987	2062	0.95	-47.0
N74		3		-1.5
N75	492	979	1.00	1.1

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
N76	507	988	1.02	11.5
N77		1		-0.5
N80	423	977	0.86	-66.9
N81	37	89	0.83	-7.6
N82	46	88	1.04	1.9
N83	1564	3351	0.93	-116.4
N84	27	84	0.64	-15.1
N85	31	72	0.86	-5.1
N86		2		-1.0
N87	1	8	0.25	-3.0
N88	13	32	0.81	-3.0
N89	28	51	1.09	2.4
N90	23	50	0.92	-2.1
N91	7	8	1.74	3.0
N92	704	1538	0.91	-67.3
N93	528	1026	1.03	13.5
N94	405	785	1.03	11.3
N95	93	202	0.92	-8.3
N96		1		-0.5
N97	4	11	0.73	-1.5
N98	112	242	0.92	-9.4
N99	456	935	0.97	-12.9
Q01		4		-2.0
Q02	1	5	0.40	-1.5
Q03	10	32	0.62	-6.0
Q04	15	34	0.88	-2.0
Q05	20	21	1.90	9.5
Q06	1	7	0.28	-2.5
Q07	13	24	1.08	1.0
Q10	1	3	0.66	-0.5
Q11		1		-0.5
Q12	2	2	1.99	1.0
Q13		1		-0.5
Q15	3	10	0.60	-2.0
Q16		2		-1.0
Q17		1		-0.5
Q18	27	67	0.80	-6.6
Q20	15	39	0.77	-4.6
Q21	93	177	1.05	4.2
Q22	11	18	1.22	2.0
Q23	9	38	0.47	-10.1
Q24	22	53	0.83	-4.6
Q25	30	68	0.88	-4.1
Q26	4	10	0.80	-1.0
Q27	15	29	1.03	0.5
Q28	23	44	1.04	0.9
Q30	5	12	0.83	-1.0
Q31	71	139	1.02	1.3
Q32	5	14	0.71	-2.0
Q33	6	14	0.85	-1.0
Q34	1	1	1.99	0.5
Q35	5	19	0.52	-4.5
Q36		1		-0.5
Q37	2	8	0.50	-2.0
Q38	7	18	0.78	-2.0
Q39	3	14	0.43	-4.0
Q40	91	181	1.00	0.2
Q41	7	14	1.00	0.0
Q42	5	13	0.77	-1.5
Q43	103	219	0.94	-6.8
Q44	21	53	0.79	-5.6
Q45	2	3	1.33	0.5
Q50	12	41	0.58	-8.6
Q51	3	5	1.20	0.5
Q52	10	16	1.25	2.0
Q53	16	35	0.91	-1.6

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
Q54	3	6	1.00	0.0
Q55	48	84	1.14	5.9
Q60	1	2	1.00	0.0
Q61	49	102	0.96	-2.1
Q62	12	34	0.70	-5.0
Q63	5	8	1.25	1.0
Q64	11	30	0.73	-4.0
Q65	10	11	1.81	4.5
Q66	9	10	1.79	4.0
Q67	1	6	0.33	-2.0
Q68		2		-1.0
Q69	1	2	1.00	0.0
Q72	1	2	1.00	0.0
Q74		4		-2.0
Q75	13	12	2.16	7.0
Q76	5	8	1.25	1.0
Q77		3		-1.5
Q78	7	19	0.73	-2.5
Q79	10	18	1.11	1.0
Q80	1	2	1.00	0.0
Q81		4		-2.0
Q82	8	23	0.69	-3.5
Q83	1			1.0
Q84	1	1	1.99	0.5
Q85	14	43	0.65	-7.6
Q87	17	42	0.81	-4.1
Q89	20	26	1.53	7.0
Q90	9	26	0.69	-4.0
Q91		4		-2.0
Q92		1		-0.5
Q93	2	11	0.36	-3.5
Q95	1	1	1.99	0.5
Q96		2		-1.0
Q98		1		-0.5
Q99	1			1.0
R00	1618	3416	0.94	-95.0
R01	11	18	1.22	2.0
R02	77	159	0.97	-2.7
R03	5	13	0.77	-1.5
R04	2083	3179	1.31	488.8
R05	250	373	1.34	63.0
R06	2172	4225	1.03	53.3
R07	21731	44294	0.98	-481.0
R09	317	615	1.03	8.6
R10	18209	38090	0.95	-891.9
R11	2536	5603	0.90	-273.7
R12	6	26	0.46	-7.0
R13	302	693	0.87	-45.5
R14	59	134	0.88	-8.2
R15	52	84	1.23	9.9
R16	33	62	1.06	1.9
R17	123	227	1.08	9.2
R18	213	459	0.93	-17.2
R19	323	643	1.00	0.6
R20	243	566	0.86	-40.8
R21	193	424	0.91	-19.6
R22	230	469	0.98	-5.2
R23	209	417	1.00	-0.1
R25	163	370	0.88	-22.5
R26	281	631	0.89	-35.4
R27	118	239	0.98	-1.9
R29	1003	1905	1.05	47.7
R30	17	36	0.94	-1.1
R31	733	1444	1.01	8.9
R32	39	59	1.32	9.4
R33	745	1658	0.90	-86.4

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
R34	6	12	1.00	0.0
R35	26	48	1.08	1.9
R39	20	37	1.08	1.4
R40	270	525	1.03	6.7
R41	1400	2500	1.12	146.3
R42	1328	2975	0.89	-163.9
R43	3	5	1.20	0.5
R44	78	131	1.19	12.3
R45	83	167	0.99	-0.7
R46	24	68	0.70	-10.1
R47	105	204	1.03	2.7
R48	3	2	2.99	2.0
R49	7	16	0.87	-1.0
R50	2284	5032	0.91	-239.4
R51	2669	5313	1.00	4.7
R52	68	111	1.22	12.3
R53	335	795	0.84	-63.7
R54	7	39	0.36	-12.6
R55	8199	15224	1.07	564.7
R56	4063	6936	1.17	584.8
R57	36	73	0.98	-0.6
R58	78	155	1.00	0.3
R59	207	453	0.91	-20.2
R60	148	403	0.73	-54.1
R61	18	61	0.59	-12.6
R62	225	398	1.13	25.4
R63	848	1655	1.02	18.1
R64	2	21	0.19	-8.5
R68	231	461	1.00	-0.2
R69	30	65	0.92	-2.6
R70	5	20	0.50	-5.0
R71		1		-0.5
R72		3		-1.5
R73	55	123	0.89	-6.7
R74	33	59	1.12	3.4
R76	4	4	1.99	2.0
R77	1	11	0.18	-4.5
R78		2		-1.0
R79	18	43	0.83	-3.6
R80	2	7	0.57	-1.5
R81	1	3	0.66	-0.5
R82	3	7	0.85	-0.5
R83		1		-0.5
R89		1		-0.5
R90	22	52	0.84	-4.1
R91	102	195	1.04	4.2
R92	1			1.0
R93	21	46	0.91	-2.1
R94	160	310	1.03	4.5
R95	14	21	1.33	3.5
R96	1			1.0
R99	1	10	0.20	-4.0
S00	990	2144	0.92	-85.1
S01	2857	6215	0.92	-259.6
S02	2637	5718	0.92	-230.4
S03	25	67	0.74	-8.6
S04	19	46	0.82	-4.1
S05	554	1141	0.97	-18.2
S06	3826	8457	0.90	-414.9
S07		1		-0.5
S08	16	47	0.68	-7.6
S09	1503	3515	0.85	-259.7
S10	79	231	0.68	-36.8
S11	96	218	0.88	-13.3
S12	467	1042	0.89	-55.5
S13	418	894	0.93	-30.3

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
S14	153	330	0.92	-12.5
S15	14	44	0.63	-8.1
S16	48	99	0.97	-1.6
S17	1	2	1.00	0.0
S19	381	703	1.08	28.5
S20	425	999	0.85	-76.0
S21	80	210	0.76	-25.3
S22	2162	4561	0.95	-125.2
S23	59	142	0.83	-12.2
S24	39	89	0.87	-5.6
S25	11	36	0.61	-7.1
S26	26	48	1.08	1.9
S27	670	1535	0.87	-99.8
S28	6	11	1.09	0.5
S29	205	414	0.99	-2.6
S30	642	1446	0.89	-83.1
S31	330	933	0.71	-137.9
S32	2407	4821	1.00	-10.6
S33	355	724	0.98	-8.1
S34	36	89	0.81	-8.6
S35	22	43	1.02	0.4
S36	664	1530	0.87	-103.2
S37	236	502	0.94	-15.7
S38	11	27	0.81	-2.5
S39	756	1647	0.92	-69.9
S40	92	246	0.75	-31.4
S41	111	388	0.57	-83.6
S42	3844	8948	0.86	-643.1
S43	469	903	1.04	16.2
S44	37	76	0.97	-1.1
S45	32	141	0.45	-38.7
S46	176	486	0.72	-67.7
S47	2	4	1.00	0.0
S48		2		-1.0
S49	102	195	1.04	4.2
S50	101	298	0.68	-48.4
S51	597	1817	0.66	-314.2
S52	7745	20097	0.77	-2333.0
S53	226	446	1.01	2.3
S54	115	364	0.63	-67.5
S55	74	241	0.61	-46.9
S56	395	1093	0.72	-153.1
S57	18	30	1.20	3.0
S58	6	11	1.09	0.5
S59	39	94	0.83	-8.1
S60	184	470	0.78	-51.7
S61	2684	5819	0.92	-234.0
S62	3421	6874	0.99	-26.1
S63	401	810	0.99	-5.2
S64	1085	2649	0.82	-243.4
S65	194	494	0.78	-53.7
S66	1966	4402	0.89	-241.5
S67	114	259	0.88	-15.9
S68	1225	2528	0.97	-42.7
S69	62	120	1.03	1.8
S70	458	937	0.97	-11.9
S71	223	604	0.74	-79.9
S72	9380	17532	1.07	588.3
S73	1382	2577	1.07	89.7
S74	10	24	0.83	-2.0
S75	14	51	0.55	-11.6
S76	232	468	0.99	-2.7
S77	6	21	0.57	-4.5
S78	1	5	0.40	-1.5
S79	480	873	1.10	42.2
S80	539	1184	0.91	-54.7

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
S81	1701	4296	0.79	-453.3
S82	8478	17278	0.98	-186.4
S83	528	1038	1.01	7.5
S84	29	86	0.67	-14.1
S85	37	91	0.81	-8.6
S86	957	2251	0.85	-171.8
S87	25	54	0.92	-2.1
S88	4	9	0.89	-0.5
S89	173	382	0.90	-18.6
S90	154	577	0.53	-135.3
S91	668	2395	0.56	-533.0
S92	1176	3202	0.73	-429.7
S93	260	665	0.78	-73.5
S94	19	68	0.56	-15.1
S95	10	28	0.71	-4.0
S96	173	608	0.57	-131.9
S97	28	80	0.70	-12.1
S98	42	156	0.54	-36.2
S99	76	155	0.98	-1.7
T00	13	32	0.81	-3.0
T01	8	24	0.66	-4.0
T02	2	9	0.44	-2.5
T03	7	19	0.73	-2.5
T04	8	5	3.19	5.5
T05	1	6	0.33	-2.0
T06	8	15	1.06	0.5
T07	1			1.0
T08	9	6	2.99	6.0
T09	145	285	1.01	2.1
T10	2			2.0
T11	31	89	0.69	-13.6
T13	62	180	0.69	-28.3
T14	82	146	1.12	8.8
T15	29	94	0.62	-18.1
T16	11	17	1.29	2.5
T17	301	682	0.88	-41.0
T18	679	1374	0.99	-10.0
T19	31	72	0.86	-5.1
T20	398	816	0.97	-11.2
T21	294	642	0.91	-27.9
T22	231	501	0.92	-20.2
T23	339	676	1.00	0.0
T24	305	639	0.95	-15.4
T25	181	343	1.05	9.0
T26	29	72	0.80	-7.1
T27	8	14	1.14	1.0
T28	34	48	1.41	9.9
T29	3	9	0.66	-1.5
T30		1		-0.5
T31		1		-0.5
T33	1			1.0
T34		2		-1.0
T35	5	5	1.99	2.5
T36	53	106	1.00	-0.2
T37	27	62	0.87	-4.1
T38	117	243	0.96	-4.9

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
T39	1856	3529	1.05	86.3
T40	488	928	1.05	22.6
T41	31	36	1.72	12.9
T42	1627	3487	0.93	-121.6
T43	1673	3531	0.94	-97.7
T44	175	332	1.05	8.5
T45	214	438	0.97	-5.6
T46	191	408	0.93	-13.6
T47	32	66	0.97	-1.1
T48	29	62	0.93	-2.1
T49	42	85	0.99	-0.6
T50	197	455	0.86	-31.2
T51	211	463	0.91	-21.2
T52	69	200	0.69	-31.3
T53	7	5	2.79	4.5
T54	53	145	0.73	-19.7
T55	14	38	0.73	-5.1
T56	44	76	1.15	5.9
T57	6	7	1.71	2.5
T58	177	301	1.17	26.1
T59	107	230	0.93	-8.3
T60	67	168	0.80	-17.2
T61	31	55	1.12	3.4
T62	80	249	0.64	-44.9
T63	77	651	0.24	-249.5
T65	57	119	0.96	-2.7
T66	4	9	0.89	-0.5
T67	4	66	0.12	-29.1
T68	165	116	2.84	106.8
T69	10	5	3.99	7.5
T70	14	69	0.40	-20.6
T71	83	196	0.84	-15.3
T73	7	18	0.78	-2.0
T74	18	35	1.03	0.4
T75	133	490	0.54	-112.7
T78	819	1831	0.89	-99.2
T79	351	910	0.77	-105.3
T80	167	342	0.97	-4.5
T81	8242	16600	0.99	-82.4
T82	1289	2541	1.01	14.8
T83	722	1474	0.98	-17.2
T84	1686	3746	0.90	-192.5
T85	1424	2921	0.97	-40.8
T86	346	657	1.05	16.5
T87	189	415	0.91	-19.1
T88	457	800	1.14	55.8
T89	76	158	0.96	-3.2
Z00	93	200	0.93	-7.3
Z01	10	21	0.95	-0.5
Z02	2	6	0.66	-1.0
Z03	409	887	0.92	-35.8
Z04	192	477	0.80	-47.2
Z08	12	17	1.41	3.5
Z09	34	73	0.93	-2.6
Z11	1	6	0.33	-2.0
Z12		5		-2.5

ICD-10 Code	Admissions		EWHI	
	Winter	Non-winter	EWHI	Absolute
Z13	4	5	1.60	1.5
Z20	6	21	0.57	-4.5
Z21	1	1	1.99	0.5
Z22	3	3	1.99	1.5
Z23		1		-0.5
Z24		1		-0.5
Z25		1		-0.5
Z26		2		-1.0
Z27	6	11	1.09	0.5
Z29	2	5	0.80	-0.5
Z40		2		-1.0
Z41		2		-1.0
Z42	11	22	1.00	0.0
Z43	82	159	1.03	2.3
Z44	1	7	0.28	-2.5
Z45	82	137	1.19	13.3
Z46	97	161	1.20	16.3
Z47	101	240	0.84	-19.4
Z48	193	403	0.96	-9.1
Z50	240	429	1.12	24.9
Z51	216	315	1.37	58.0
Z52	13	15	1.73	5.5
Z53	1	3	0.66	-0.5
Z54	161	365	0.88	-22.0
Z55		1		-0.5
Z56	2	2	1.99	1.0
Z57		1		-0.5
Z58	2	2	1.99	1.0
Z59	14	37	0.75	-4.6
Z60	28	62	0.90	-3.1
Z61	4	10	0.80	-1.0
Z62	2	3	1.33	0.5
Z63	31	77	0.80	-7.6
Z64		1		-0.5
Z65	5	14	0.71	-2.0
Z71	652	1232	1.06	34.2
Z72	8	10	1.60	3.0
Z73	19	23	1.65	7.5
Z74	48	85	1.13	5.4
Z75	22	71	0.62	-13.6
Z76	19	20	1.89	9.0
Z80		2		-1.0
Z81		1		-0.5
Z86		1		-0.5
Z90	1			1.0
Z91	6	13	0.92	-0.5

APPENDIX 6 DATA TABLES

Table A 6.1 Mean monthly hospitalisations, mean hospitalisations per 30-day month and mean hospitalisations per 30-day month per 100,000 population, 1980-2006.

Month	Mean monthly hospitalisations[*]	Mean hosps per 30-day month[†]	Mean hosps per 30-day month & 100,000 population[‡]
Jan	17875.19	17298.57	469.80
Feb	16674.33	17706.35	487.73
Mar	18626.56	18025.7	496.52
Apr	17874.93	17874.93	492.94
May	19081.85	18466.31	508.41
Jun	19096.07	19096.07	525.72
Jul	20188.93	19537.67	537.65
Aug	20413.59	19755.09	543.24
Sep	19203.22	19203.22	527.89
Oct	19212.89	18593.12	512.16
Nov	18513.41	18513.41	509.90
Dec	18719.67	18115.81	499.20

🟩 3 peak months	🟦 4th peak month
🟥 3 trough months	🟧 4th trough month

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[*] (Total hospitalisations in calendar month 1980-2006)/27.

[†] (Total hospitalisations in calendar month 1980-2006)/(number of month days 1980-2006)*30.

[‡]((Total hospitalisations in each calendar month for each year 1980-2006)/(number of days in given month in given year))/((Estimated population in given year/number of days in given year)*30).

Table A 6.2 Absolute EWH, absolute EWH per 100,000 and EWHI by year, 1980-2006.

Year	Absolute EWH	Absolute EWH per 100,000	EWHI
1980	2220	69	1.04
1981	961	30	1.02
1982	3567	110	1.06
1983	2826	86	1.04
1984	659	20	1.01
1985	448	13	1.01
1986	3938	118	1.06
1987	4886	145	1.07
1988	4138	122	1.06
1989	3756	110	1.06
1990	4405	128	1.07
1991	3969	114	1.06
1992	5819	165	1.09
1993	6303	176	1.09
1994	6679	184	1.09
1995	8326	227	1.11
1996	8141	218	1.11
1997	8571	227	1.11
1998	6872	180	1.09
1999	9761	255	1.12
2000	5827	151	1.07
2001	6954	179	1.08
2002	7455	189	1.09
2003	10034	250	1.12
2004	9057	223	1.10
2005	3317	81	1.04
2006	6877	166	1.07

APPENDIX 7 QV HOUSE TYPES

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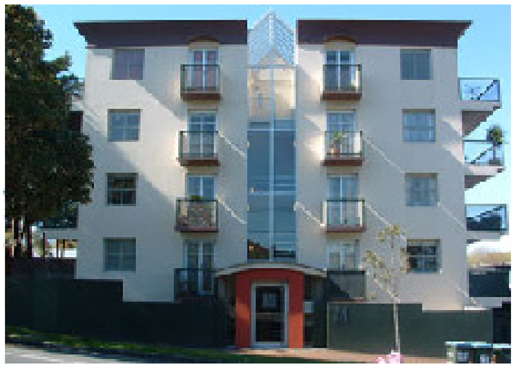
Manager, Data Solutions.

House Types are used by Valuers as a general way to characterising a house. They are not strictly defined or mutually exclusive and there can be overlaps between different house types. House type is chosen by the first Registered Valuer to inspect and value a property.



Apartment - generally built 1920s onwards - common entrance way, purpose built from the 1960s onwards, multi-storey blocks often with several apartments per floor. 5+ apartments per block. Apartments are normally joined on 2 walls.

Bach - any age - basic design, materials, layout, often small floor size, two bedrooms, and open plan, frequently extended in different styles and materials. Also called a crib in Southland.

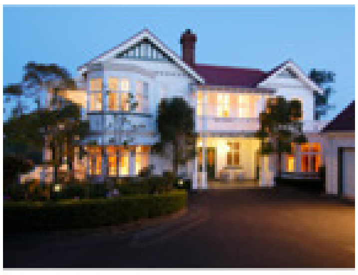
Contemporary - generally built 1970s onwards - modern, contemporary design, many roof breaks and pitches, high studs, grand entrance halls, often different angles walls, not uniform design. Often stucco, plaster walls. Building features are often associated with Weathertightness issues.

Cottage - generally built 1890-1900 door facing street, gable roof, veranda along front, single storey, weather clad, iron roof with two sloping slides

Pre-war bungalow - generally built 1920-1940s - House faces street - greater utility and less ostentatious, narrow weatherboard, iron roof, lower stud and gable, bay and boxed windows, verandas part of main roof. Timber joinery inside. Timber shingles.

Bungalow - post war - generally built 1950s onwards - 'standard' dwelling using average quality materials and design. Can have gable, Dutch gable or Hip roof lines. Often located for sunshine, not necessarily facing the street. Normally single storey, but sometime appears a dual storey if built over garage on sloping sections.

Quality Bungalow - generally built 1950s onwards - high quality materials, design, grand designs often with swimming pools, tennis courts etc, can often be two storeys, larger sections.



Quality Old - generally built 1920-1940s - Tudor and Georgian influences, English styles, large and grand, good quality materials, fixtures and fittings, usually 2 storey, weatherboards, stucco, brick and shingles, often in combination. Timber joinery. Sometimes referred to as "Arts and Crafts".

Spanish Bungalow - generally built 1930-1950 - Art Deco and Spanish styles, predominantly 30s and 40s built, horizontal lines feature in design, often curved walls, low pitched roofs, always stucco clad, and parapets around roof line.

State Rental - generally built late 1930s onwards - purpose build by the government for social housing, often simple materials and basic design but constructed well, often multiunit, weatherboard cladding, clay or concrete tile roofs.

Townhouse - generally built 1970s onwards - high site coverage, low maintenance sections, better quality than a Unit, can be detached or semi reattached, often separated by a garage. Normally two storey. Stucco plaster wall coverings; can be prone to weather tightness issues. Often crossleased.

Unit - generally built 1950s onwards - attached and semi detached, 1-3 bedrooms, small <100m2, basic design, open plan. Often cross leased.

Terraced Apartment - generally built 1990s onwards - medium to high quality fixtures and fittings, often 2-3 levels, 3-5 units in the complex, party walls between the apartments. These are NOT necessarily "flats". Often own entrance and garage with dwelling space above.

Villa - generally built 1900 - 1920s - door faces street, weatherboard, high stud, can be one or two storey, iron roof with four sides and single point, eaves, brackets, finial, fretwork common.

APPENDIX 8 “NO DATE” DWELLINGS

I checked information and aerial views (photographed in either 2004 or 2006) on the Wellington Council’s online rates database, for a sample of 185 out of 697 Wellington “No date” addresses. Of these 185:

- 69 aerial views showed an empty section;
- 9 aerial views showed either newly or partly completed dwellings;
- 14 appeared to be recent subdivisions, either of land, or of a single building into more than one title;
- one rates record noted the site was being prepared for future development;
- 17 were on the commercial rating scale,
- 2 were noted as “non-rateable”;
- 3 showed council or university land;
- 25 had more than one inhabitable building on the site; and
- 45 had no notable features on the rates record or aerial view.

In this sample, around half of the “No Date” age dwellings – the empty sections and the newly completed dwellings - are very recently built. If the sample is representative of the whole country, this finding could explain why the “No Date” hospitalisation rate is so close to the 2000s category. Another, smaller, number would appear to have no date assigned, because there is more than one dwelling onsite; if these buildings are of different ages (as their rooflines generally indicate) it would not be possible for QV to assign a construction date for the property.

QV Data-sourced differences between “Date” and “No Date” properties:

- Where the housing record had wall or roof construction materials listed, a much higher percentage of walls and roofs were listed as “mixed materials” in “No Date” than in dated dwellings;

- A much higher proportion of “no date” properties had 0m^2 floor area, and 0m^2 building-site coverage. However, if 0m^2 properties were excluded, “no date” properties had a higher median building-site coverage than “date” properties.
- Histograms for land area and for capital value showed differences in curves which would also support the hypothesis that where an address was matched but no date was assigned, the property would appear to be more likely to be either a recent construction or to have more than one separate dwelling. If they are primarily the former, it would explain why their hospitalisation rate would be so similar to the rate for 2000s dwellings.