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Factors Associated with Uptake of No-Cost Safety Modifications to Home Access Steps: Implications for Equity and Policy

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Abstract: (1) Background: Fall injuries in the home present a major health burden internationally for all age groups. One effective intervention to prevent falls is home modification, but safety is only increased if opportunities to install safety modifications are taken up. This study sought to identify factors that may lead to a higher uptake of no-cost home modifications when these are offered to people living in the community. (2) Methods: We studied 1283 houses in the New Zealand cities of New Plymouth and Wellington. Using logistic regression, we modelled the odds of uptake according to the number of access steps, the provider who was undertaking the modifications, occupant ethnicity, prior fall injury history, and age group. (3) Results: Homes with older residents (age 65+) had higher uptake rates (35% vs. 27% for other homes). Larger numbers of access steps were associated with higher uptake rates. There was indicative evidence that homes with Indigenous Māori occupants had a higher uptake of the modifications for one of the two providers, but not the other. (4) Conclusions: No-cost home safety modifications offered via cold calling are likely to have relatively low uptake rates but the households that do consent to the modifications may be those who are more likely to benefit from the concomitant increased safety.

Keywords: home modification; interventions; fall injuries; randomised controlled trial; indigenous health

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1. Background

Globally, unintentional falls in all settings caused around 18% of all injury deaths, three-quarters of a million deaths in 2019 [1]. Falls during 2019 in the US, UK, and Aotearoa New Zealand (NZ) caused an estimated 44,000, 9000, and 600 deaths, respectively [1], which is a rate of around 0.12–0.13 per thousand population. In NZ, over the period 2011–2018, there were around 658,000 medically treated falls annually (an annual rate of 134 per thousand population), and more than half of these occurred in the home [2].

In terms of injury mortality for NZ working-age adults, the rate for the 10th percentile of personal income (the group with the lowest income) has been estimated at around three times that of the 90th percentile (the highest income group), indicating a strong socioeconomic gradient in injury burden [3]. A study that assessed injury hazards in the home environment, which have a strong association with home injury rates [4,5], showed a consistent trend for higher numbers of hazards for increasing levels of socioeconomic deprivation [5].

Trials of home modification to prevent falls have shown considerable promise, particularly in NZ. The Home Injury Prevention Intervention (HIPI) found a reduction in home fall injury rates of 26% (95% CI 6–42%) [4] and the social benefits of injuries prevented were

estimated to be at least six times the costs of the intervention [6]. Māori, the Indigenous people of NZ, were colonised by British settlers in the late 18th century. The 1840 Treaty of Waitangi, signed by Māori chiefs and the British Crown was designed to protect Māori ownership of lands and natural resources. It was largely disregarded by the New Zealand Government for 100 years and Māori lost most of their lands and natural resources, and consequent socioeconomic and health inequities persist to this day [7]. Māori experience higher rates of injury-related ill health than non-Māori and have elevated rates of fall injuries [8]. In the Māori Home Injury Prevention Intervention (MHIPI), the same modifications as tested in the HIPI study showed an even greater benefit for the occupants of Māori homes: there were 31% fewer fall-related injuries in the modified households and for more specific falls in the areas of the home modified, there were 40% fewer injuries [9].

Measuring uptake has been identified as a key outcome for injury interventions, particularly for groups who may be at higher risk [10]. Related to uptake is the degree of compliance with home modification recommendations in the context of a trial. In an English study of people aged 65 plus in which a team involving an occupational therapist recommended or provided home modifications to prevent falls, the uptake rate of the modifications was low: on average, participants installed 17% of the recommended items [11]. Qualitative data indicated that a large proportion of the participants did not consider they would benefit from the safety features offered, which the researchers identified as the main reason for the low level of compliance with the recommendations [11]. Similar reasons for non-compliance were found in an Australian study where modifications were recommended for older people's homes [12]. In a New Zealand study involving home environment modifications for older people with visual impairment, the recommendation with the lowest compliance was to remove or secure floor coverings such as rugs or mats: 40% compliance after six months [13]. Follow-up interviews indicated that participants liked their rugs and mats despite the fall risk they posed, and were reluctant to remove them [13]. Where modifications cost money, income is also considered an important factor in the uptake of safety measures [14].

In a review of studies on child safety, Kendrick and colleagues considered that it was important to measure the effects of interventions on particular groups so that policies and practices could be designed to reduce inequalities [15]. However, the studies they reviewed failed to show different safety effects according to child age, ethnic group, or parental unemployment [15]. For interventions aimed at increasing home safety practices and/or the use of home safety equipment, uptake rates were increased for stair gates amongst families living in non-owner-occupied accommodations and for window locks amongst families with male children [15].

Cultural beliefs around injury occurrence can also affect uptake, particularly if these beliefs relate to the preventability of injury. One study of older Chinese people found that a fatalistic view of injury was common, where injury occurrence was regarded as something that was fated to happen [16]. Related more particularly to uptake, the importance of good relationships with providers of safety features or safety advice has also been emphasised in qualitative research on an injury prevention programme for Māori [17].

Given our socioeconomic gradient in injury, higher injury risks posed by lower-income housing, and factors leading to differential uptake rates, it is likely that home safety interventions that present few barriers to uptake, particularly financial barriers, will address some aspects of inequity [18].

For this reason, our safety on steps (SOS) study tested a fall prevention intervention that involved home safety modifications installed at no cost to the participants. To inform the potential future provision of home modification safety programmes, with an eye on equity effects, the analysis presented here looks at potential factors behind differential uptake rates of safety modifications in the SOS study. A priori, we considered that such factors might relate to the perceived degree of need for the features. Hence, we estimated associations between the modification rate and the age group and ethnicity of the residents, how many access steps the house had, and any prior history of fall injuries. We consid-

ered that residents' ethnicity could be related to the uptake of modifications by different providers, as Māori may have a greater degree of trust in Māori providers of services and distrust of others [19].

2. Materials and Methods

2.1. Protocol for Recruiting Houses

The study population was homes in the Wellington Region and New Plymouth with flights of at least four access steps from the street to the front door and no handrail for at least some of these steps (see Figure 1 for an example). Areas from which houses were recruited for the study were identified from knowledge of the topography of the cities. Streets in flat areas of the cities were excluded as accessways to homes in these areas generally do not involve more than three steps. Research assistants visited streets in these areas and created a sampling frame for the study by listing all houses with visible accessways and eligible steps. They recorded the number of access steps from the street to the house, as well as how they were configured (number of flights) and whether there were any handrails for the steps. These observations were made from the street, so some houses with accessways not visible from the street were excluded from the study. There was a small number of houses for which the number of steps was clearly within the scope of the study, but the precise number was difficult to ascertain. This situation led to missing values for the field "number of access steps" for 1% of the sample (see Table 1). Also excluded were accessways that served multiple dwellings. This latter exclusion was to avoid negotiations with several parties to get consent for the modifications offered.

Figure 1. An example of home access steps that were part of the study.

The participants in the study did not consent to participate prior to randomisation. Instead, qualifying addresses were identified and those subsequently randomised to the intervention group were approached to gain consent for the modifications to be installed.

Table 1. Households included in the study: n; proportion of total houses; proportion having modifications done according to match to injury claims data; geographical area; older resident in injury data; fall history of occupants; access steps to home; Māori occupant or not in injury data.

Classification	Level	n Houses	Proportion of Total Houses	Proportion That Were Modified
Overall		1283	100%	29%
Match to injury data?	No	216	17%	27%
	Yes	1067	83%	29%
Area	New Plymouth	355	28%	34%
	Wellington	928	72%	27%
Older resident 65+	No match to injury data	216	17%	27%
	None	717	56%	27%
	At least one	350	27%	35%
Fall injury history (prior 2 years)	None *	802	63%	28%
	At least one	481	37%	30%
Number of access steps	Missing data **	16	1%	25%
	4–5 steps	325	25%	27%
	6–10 steps	579	45%	27%
	11–15 steps	249	19%	31%
	16+ steps	114	9%	39%
Māori occupants	No match to injury data	216	17%	27%
	None	767	60%	29%
	At least one	300	23%	30%

* includes addresses not matched to injury claims data. ** missing data arose from steps that could not be counted accurately from the street.

Houses randomised to the treatment group were sent letters describing the study, along with phone numbers and email addresses so that households could contact the community trusts, which employed builders to carry out the modifications to the access steps. A website address was also provided so that potential participants could give permission for the modifications or decline to participate online. Surveyors visited addresses that had neither consented nor declined to participate after receiving the letter. Of the 1283 intervention group addresses approached by mail and/or visits, 372 (around 30%) consented to have the modifications done, consisting of the installation of handrails and high-visibility slip-resistant edgings on the steps. These were a subset of the modifications tested in two randomised controlled trials and found to reduce home fall injuries by around a quarter [4,9].

The community trusts who recruited participants and installed the modifications were WISE-Better Homes in New Plymouth and the Sustainability Trust in Wellington. Both have a principal business that involves retrofitting insulation in the mainly stand-alone wooden dwellings that predominate in NZ. WISE-Better Homes was set up to provide employment and training for the unemployed and has its office and workshop in one of the most socio-economically deprived areas of New Plymouth. It employs many Māori and had a Māori CEO at the time of the study. The Sustainability Trust describes itself as a "social enterprise that supports sustainable living" and is based in central Wellington, with a staff of around 50 as well as many volunteers.

2.2. Match to Injury Data

New Zealand has a national no-fault personal injury insurer, the Accident Compensation Corporation (ACC). ACC covers most of the treatment costs for injuries (regardless of fault) provided by doctors, dentists, physiotherapists, specialists, counsellors, and other

health professionals and also covers 80% of lost earnings apart from the first week absent from work. Where the co-payment provided by ACC is insufficient to cover the costs of treatment, the patient pays an additional surcharge.

ACC provided anonymised data on home injury claims for the current analysis. These data were matched by the address of the claimant to our list of addresses in the study. The address data were then stripped from the file provided to us, leaving a list of injury claims along with key matched information on the homes studied (including the number of steps to the house, etc.). Information from these matched injury data was used for the current analysis to infer three key factors regarding the homes studied: the injury claim history of the homes; whether an occupant may be aged 65 and over; whether a current or recently past occupant self-identified as Māori. The protocol for making these inferences is described in the next subsection.

2.3. Analysis

Household-level information about whether any occupants were older (age 65+) or Māori was inferred from a match made between the addresses included in the study and the home addresses of claimants for treatment for an injury occurring at home made to ACC over a 16.5-year period from January 2004 to June 2020. Only 17% of the 1283 addresses in the study failed to match to the claims data for home injuries over that period. In NZ, people qualify for national superannuation from the age of 65, which is a rationale for using this age group to categorise households. Of all addresses in the study, 27% were identified as having an "older resident 65+". For these addresses, there had been at least one ACC claim over the period studied for a person listing this address as their home and with a birth date that would have put them at age 65 plus as of the beginning of March 2016. This date was the median date at which interventions were carried out. The 17% of study addresses without a match to claims data were considered as having missing data for this classification (see Table 1).

A similar protocol was used to code addresses as having a Māori occupant or not. People seeking treatment for injury self-identify their ethnicity. If any claimant for home injury over the 16.5-year period specified above identified as Māori, the address was classified for the purpose of the analysis as having a Māori occupant. Missing values were assigned if there were no matched home claims. All other addresses were classified as not having a Māori occupant. The potential degree of misclassification of these aspects is discussed below.

We fitted a logistic model estimating the adjusted odds that a household was successfully approached and agreed to have the free safety modifications applied to their access steps. The explanatory variables used were all the available household classifying variables, along with any first-order interactions of these variables whose coefficients were estimated to be different from zero with $p < 0.1$.

3. Results

As shown in Table 1, overall 29% of the 1283 homes approached agreed to have modifications done (last column) and there was a higher modification rate in New Plymouth (34%) than in Wellington (27%). There was an "older resident 65+" identified in 27% of addresses and a Māori occupant (at some time during the past 16.5 years) in 23% of homes. Homes with older residents had a higher rate of modification (35% vs. 27% for other homes). The largest difference in the modification rate was according to the number of steps leading to the front door from the street. For those homes with the most steps (16 or more), 39% agreed to have modifications done compared to 27% for homes with 10 or fewer steps.

We fitted a binary logistic model using PROC LOGISTIC in SAS version 9.4 to estimate the adjusted odds that modifications were carried out associated with household characteristics, shown in Table 2. For the logistic model, the outcome (uptake) was set to 1 for homes with modifications done and 0 otherwise. Household characteristics that were

included in this model are listed in Table 1. Only households with a match to injury data were studied as these data provided some information on past and current occupants' ages, ethnicity, and household-level fall history. Also excluded were houses whose steps could not be accurately counted. There were 1055 observations used in the model after excluding missing values. The final model took the form:

$$\text{Uptake} = (\text{older resident}) + (\text{prior fall injury}) + (\text{number of steps}) + (\text{Māori resident}) + (\text{city}) + (\text{Māori resident}) \times (\text{city}) \quad (1)$$

Table 2. Adjusted odds ratios of uptake of the safety intervention according to household characteristics.

Factor	Adjusted Odds Ratios (95% CI)
Resident age 65+ vs. no resident age 65+	1.56 (1.17, 2.07)
Fall injury in household vs. no fall injury in prior 2 years	1.10 (0.84, 1.45)
6–10 steps vs. 4–5 steps	1.05 (0.75, 1.46)
11–15 steps vs. 4–5 steps	1.23 (0.82, 1.83)
16+ steps vs. 4–5 steps	1.96 (1.21, 3.18)
Māori in New Plymouth vs. non-Māori in New Plymouth	1.60 (0.94, 2.74)
Māori in Wellington vs. non-Māori in Wellington	0.91 (0.63, 1.31)

Table 2 shows the adjusted odds ratios of uptake of the safety intervention associated with levels of the factors shown, derived from model (1). The Hosmer and Lemeshow Goodness-of-Fit test indicated no evidence that the fit was poor ($p = 0.37$). Statistically significant ($p < 0.05$) odds ratios were estimated for two factors: resident age 65+; and number of steps. The last two rows show odds ratios arising from an interaction between the region (Wellington or New Plymouth) and whether there was at least one identified Māori in the household. These represent the relative odds of successful modification of a home with at least one identified Māori occupant vs. other homes for each of New Plymouth and Wellington separately. The estimates from this interaction are consistent with the provider in New Plymouth having differentially greater success with Māori households, although the interaction was not statistically significant at the 0.05 level ($p = 0.08$).

4. Discussion

When a protocol of cold calling was used to offer safety modifications to homes, our results indicate that it is likely that those with greater need for the modifications were more likely to have them installed. There was a strong association with the age group, with a more than 50% increased uptake for households where the matched injury data indicated there may be a resident aged 65 plus. There was, however, no statistically significant association with prior history of falls injuries (in the previous two years) once age, ethnicity and number of access steps were controlled for. Households with more steps were generally more likely to have the modifications done and there was evidence of a dose-response relationship, with higher uptake rates with larger numbers of steps.

The package of repairs trialled in this study could feasibly be rolled out on a large scale, subsidised to some degree by the central government. An example of such a programme to address deficiencies in housing quality is the Warm Up New Zealand: Heat Smart Programme [20]. This intervention was designed to address aspects of the poor thermal performance (insulation and heating) of NZ housing generally by retrofitting government-subsidised insulation and heating systems. One of the purposes of the current analysis was to look at likely uptake rates for a housing improvement scheme that focused on improving safety. The fact that the uptake rates analysed in the current study were higher where there were likely to be greater safety benefits would support a rationale for a general rollout as a means to reduce home fall rates.

A limitation of the analysis is that we could not look at rates for addresses with different types of tenure as this information was not available. In a previous NZ study of retrofitted insulation installed without charge in older housing where an occupant was a community services card holder (which entitles a person to government assistance and subsidies), the uptake by landlords was disappointingly low, despite the potential for the value of the home to be improved at no cost [21]. It would not be surprising if landlords demonstrated a similar reluctance regarding free safety improvements. Although many landlords aim to provide safe and healthy housing for their tenants, the generally poor state of rental housing in NZ in comparison to owner-occupied housing [22], along with clearly identified links between poor housing quality and the burden of disease [23], has motivated regulatory change in the NZ rental housing market in the form of the Healthy Homes Guarantee Act [24]. Under this Act, landlords are required to improve their rental stock as necessary to meet certain minimum standards regarding insulation, heating, and draught stopping. Improvements in safety such as those tested in the current study were not specified in the Act.

A further limitation was the potential for misclassification, although the effects on our findings are likely to be minor. Missing data were treated differently when assessing prior fall injuries at the address. The absence of a match to the claims data also occurs if there were no injuries for which a claim was made over the 16.5-year period for which we had data. For this reason, households without any claims data for the previous two years were classified as having no fall injuries. A two-year period was used arbitrarily to represent recent injury history. Using this protocol, some addresses with an ACC claim that failed to be matched to our list of addresses (due to misspecification of address fields, for example) would have been misclassified as having had no history of injury claims. Our method of inferring the characteristics of occupants depended on various factors, including people's propensity to suffer a home injury and to seek medical treatment for the injury (resulting in a claim made under the ACC scheme). To check what proportion of addresses may have been correctly identified as having an older occupant or having an occupant identifying as Māori, we undertook some additional analysis of data collected previously in the HIPI study [4], for which details of the occupants were known. The claims data we matched to the HIPI addresses spanned 14.5 years (so two years shorter than in the current study) and the "true" occupancy details were known for a point in time that was mid-2010, some 5.5 years earlier than the median intervention date of the current study. Nevertheless, our analysis of these matched data does indicate how well the occupant data analysed in the current study may have represented those of the actual occupants. A match was made with the claims data for 84% of the HIPI addresses. For those HIPI addresses with an occupant aged 65 plus matched to claims data, 82% were correctly classified as such via the match with the claims data. For those HIPI addresses with a Māori occupant matched to claims data, 74% were correctly classified as such via the match with the claims data. Misclassification is likely to attenuate the odds ratios estimated, so the "true" odds ratios (in the theoretical situation where the characteristics were specified without misclassification) are likely to be higher than those estimated here.

In the current analysis, 28% of homes with non-missing claims data were defined to have at least one Māori occupant. According to the NZ General Social Survey 2018, the national estimate for households at a single point in time was 16% [25]. It is not possible to estimate from available data the proportion of houses nationally that had one or more Māori occupants over a longer period, but New Zealanders generally are quite mobile: around 16% overall had spent less than one year in a given address; the figure for Māori specifically is a little higher, at 20% [25]. Māori own their own home at a rate that is only around half that of NZ Europeans [26]. In NZ, compared to owner-occupied homes, rental homes are generally much less safe when injury hazards and safety features are considered [22]. In addition to generally less safe home environments, Māori have lower rates of healthcare access [27] following injury, which leads to poorer longer-term injury outcomes. These factors contribute to a greater injury burden for Māori. Policies addressing

the environmental health impacts of housing have been successful in addressing aspects of health inequities [28].

In the current study, although a similar proportion of addresses with Māori occupants were modified as those without an identified Māori occupant, there was indicative evidence from the interaction between provider and ethnicity ($p = 0.08$) implying that the provider in New Plymouth (WISE Better Homes) had differentially more success with Māori than with non-Māori. It can only be speculated from the current analysis whether this might be due to WISE Better Homes having a Māori CEO and many Māori in their workforce. Previous research has found that Māori may have a greater degree of trust in Māori providers of services [19]. In the USA, older people who were Black or Hispanic were found to have lower rates of fitment of modifications to prevent falls [29]. In light of our findings, it is possible that if providers of the modifications were from these specific groups, the uptake rate could improve.

The increasing uptake rate with increasing numbers of steps was an expected finding a priori. None of the access steps to houses in the study had handrails (this was a qualifying criterion for the study) and the perceived risk of falls on steps can be expected to increase as the number of steps increases. Participants may also have been motivated by the fact that installing longer handrails is more expensive, so having a more expensive modification installed at no cost to themselves may also have been an attractive factor. We did not interview participants to identify potential reasons behind uptake decisions, but other studies concluded that lack of uptake was related to a belief that there was little safety benefit from the safety features recommended [11].

The higher rate of modification for addresses with a resident age 65+ compared to addresses with no identified resident age 65+ is consistent with older people being differentially more motivated by the safety benefits of the intervention. However, as mentioned above, a limitation of the study is that we could not analyse the data according to tenure. As of the 2018 Census, around 44% of people in their 20s lived in a house they owned, and around 55% of people in their 30s. In comparison, 81% of people in the age group 65–74 lived in their own homes [26]. The likely higher rates of owner-occupation amongst the older people in this study could explain at least some of the higher rates of modification. Any participants renting would need their landlord to consent to the modifications and, as noted above, landlords have been a group with poor uptake of free insulation. It would not be surprising if they were similarly reluctant to take up an offer of free safety modifications.

Although our study is novel in assessing uptake rates for home modifications in relation to occupant characteristics, other studies have reported adherence (compliance) rates for participants already recruited into a home modification study. Adherence rates can be expected to be higher than the uptake rates we studied, all other things being equal, as the denominator of the compliance rate is the total number of people who have already provided informed consent to be part of the study. These participants will have some engagement with the stated study objectives, which include preventing fall injuries. A recent Cochrane review of environmental interventions for preventing falls amongst community-dwelling older people found seven studies reporting compliance rates of 76% to 91% in terms of adherence to at least one of the recommended modifications [30]. This review highlighted the importance of further research to understand how home modification programmes could be improved by awareness raising and participant-interventionist engagement [30]. A small Australian study of older female non-compliers with safety recommendations concluded that joint decision-making and negotiation with the providers or recommenders of modifications would support the uptake of safety modifications [31]. In terms of increasing initial recruitment rates for a fall prevention trial, enhanced publicity about an English trial was not found to be effective [32].

Factors leading to improved uptake rates of safety features have received little research attention internationally. In this context, our results have important implications regarding likely differential patterns of uptake in safety programmes, which in turn have equity

implications. Although our intervention was already provided without cost, so we could not study the impact of cost on uptake rates, other studies have concluded that home safety interventions that present few barriers to uptake, particularly financial barriers, will address some aspects of socioeconomic inequity [15]. Home modification to prevent falls in a similar setting has been shown to have a very high benefit-cost ratio found when uptake is close to 100% [6]. Our findings regarding the patterns of uptake for no-cost modifications suggest that higher uptake may occur amongst those with a higher risk of fall injuries, potentially increasing the cost-effectiveness of the intervention. Our results are consistent with findings internationally [33] that particular minority groups may be more willing to adopt safety measures if the providers of modifications are from these specific cultural groups. Where the groups concerned have higher injury rates, tailoring an intervention in this way is likely to address aspects of inequity.

5. Conclusions

The two strongest factors associated with the uptake of the free home modifications to access steps were having an occupant with age 65 or over and having a larger number of steps. A fall injury in the household during the previous two years was not a significant factor when other variables were controlled for. Nevertheless, the pattern of uptake of the safety modifications was consistent with greater levels of safety provided to those in greater need, which would be a worthwhile outcome from the point of view of a roll-out of such modifications more generally.

Although we could not examine this aspect in greater depth, our results support having Māori providers delivering the modifications as a way of increasing uptake by Māori, likely through a relationship of cultural resonance, reducing inequities in injury outcomes. An aspect of equity we could not examine here was the potential for rental housing occupants to miss out on the modifications because of the necessity to gain the cooperation of sometimes reluctant landlords. Experience from a New Zealand national roll-out of free insulation to lower-income households suggests that other policies, such as regulation, are necessary to compel landlords to provide safe housing conditions for their tenants.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data analysed are owned by ACC and the authors do not have permission to share them with other parties.

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