Risk of rehospitalisation and death for vulnerable New Zealand children

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ABSTRACT

Objectives There is considerable need to improve the effectiveness of healthcare to reduce morbidity and mortality. Child hospitalisations are influenced by determinants of health, including the home environment. Our aims were: (1) To investigate whether children hospitalised with potentially avoidable conditions thought to be associated with the home have an increased risk of rehospitalisation and death, (2) To investigate whether children hospitalised with particular subgroups of potentially avoidable conditions have an increased risk of rehospitalisation and death, (3) To assess the usefulness of these subgroups for identifying at-risk children.

Design We used four existing groups of potentially avoidable conditions developed based on expert opinion: 1. the potentially avoidable hospitalisations (PAH) group, associated with social/environmental conditions, 2. the potentially avoidable hospitalisations attributable (at least in part) to the home environment (PAHHE) group, 3. the crowding group, and 4. the Ministry of Health (MoH) group. We analysed national New Zealand hospital discharge data (2000–2014). Rehospitalisation and death were described using Kaplan-Meier curves. Group effectiveness for identifying at-risk children was assessed using Cox proportional hazard models with children hospitalised for non-PAH conditions as comparison.

Results In total, 1425085 hospital admissions occurred, for 683115 unique children. Rehospitalisation was relatively common (71.0%). Death was rare (0.6%). All groups performed moderately well identifying at-risk children. Children with PAH have increased risk of rehospitalisation (adjusted HR (aHR):2.30–3.60) and death (aHR:3.07–10.44). PAH group had highest sensitivity (75.1%). The MoH group has the highest positive predictive value (rehospitalisation: 86.2%, death: 2.5%).

Conclusions Children in the MoH group are very likely to benefit from housing interventions. Rehospitalisation and early mortality are useful assessment measures. Rehospitalisation exerts a considerable burden, and child deaths are catastrophic.

INTRODUCTION

There is a considerable global need to improve the effectiveness of healthcare delivery and reduce childhood morbidity and mortality.[1 2] New Zealand (NZ) has well-described child poverty, and child hospitalisations have inequitable socioeconomic and ethnic distributions.[3 4] The underlying determinants of health (such as housing quality, nutrition, household crowding and access to effective healthcare) play a major part in influencing child health outcomes.[5–8] Failure to address the underlying causes of ill health results in children continuing to experience poor outcomes, with substantial costs to the individuals affected, their families, communities and the government sector.[9 10]

The hospital setting has long been used as a screening point to identify children who may be at risk of future harm. For example, emergency departments use screening tools that highlight specific patterns and types of injury presentation to prompt hospital staff to consider a non-accidental cause and to arrange for further investigation and referral.[11–13]

Hospital-based screening has the potential to reduce health inequities by identifying families who are in need of support.[14] Admission to hospital with a preventable disease or injury provides an obvious intervention point, as children are likely to return to the same high-risk environment when they are discharged. For example, NZ children admitted to hospital with respiratory infections have a high prevalence of exposure to adverse housing conditions, which are likely to increase their risk of future ill health.[15–20]

Health researchers and policymakers in NZ have previously identified groups of conditions that can be used as indicators of avoidable hospitalisation. Four such groups are examined in this study. The

potentially avoidable hospitalisations (PAH) group is designed to identify all potentially avoidable paediatric admissions, with the intention of quantifying the total burden of disease that could be prevented by policy measures addressing the underlying determinants of health.[21] The second group is designed to identify the subgroup of potentially avoidable hospitalisations attributable (at least in part) to the home environment (PAHHE).[1] The third group is designed to identify potentially avoidable hospitalisations due to household crowding (crowding).[22] The final group, currently in use by the NZ Ministry of Health (MoH), includes children with a set of infectious PAH conditions though to be associated with increased risk of acute rheumatic fever (ARF).[23] Details on how these groupings were determined may be seen in the Supplementary appendix. These groups are unique from others identified in the literature as all have been specifically designed for use in a NZ child population (most others concern adult populations, such as that developed by Jackson and Tobias).[24] Furthermore, these groups are designed to capture the effect of socioeconomic and environmental determinants of child health on hospital admissions.[1]

The aims of this study were as follows:

1. To investigate whether children hospitalised with potentially avoidable conditions thought to be associated with the home environment have an increased risk of rehospitalisation and death.
2. To investigate whether children hospitalised with particular subgroups of potentially avoidable conditions have a relatively greater increased risk of rehospitalisation and death.
3. To assess the usefulness of potentially avoidable condition subgroups for identifying at-risk children.

METHODS
Data and ethics
Full ethics approval was obtained from the University of Otago Ethics Committee (No. HD15/046).

We obtained national hospitalisation and mortality data for the 15-year period 2000–2014 from the NZ National Minimum Dataset (NMDS). The NMDS is a national collection of public and private hospital discharge information.[25]

The encrypted National Health Index (NHI) number was used to identify and link individual patients' hospitalisations over time. No entries lacked encrypted NHI numbers; consequently, all patients' first hospitalisations could be distinguished from later ones.

All computations were performed using the R language and environment for statistical computing (version 3.2.2).[26] All survival analyses were performed using the 'survival' R library (Therneau TM: Survival: A package for Survival Analysis in S, version 2.38, 2015). Bootstrap procedures were performed using the authors' own code.

Condition groupings
▶ The *PAH group* was developed by a panel of child health experts to monitor PAH in NZ.
▶ The PAH group includes a subset of conditions (the *PAHHE group*) which might be avoided by 'Central and local government policies which ensured that families with children had access to high quality housing and a safe physical environment…'[1]
▶ The *crowding group* is a set of selected PAH conditions associated with household crowding. Diseases selected for inclusion were based on a systematic literature review that identified groups of infectious diseases associated

with exposure to household crowding, mainly respiratory and enteric infections.[22] The crowding group was further refined, based on previously published literature.[27] Asthma is included on the basis that many episodes are triggered by respiratory infections.[28]
▶ *MoH* group, which targets selected infectious PAH conditions thought to be associated with ARF and streptococcal infections, based on expert opinion.[23] It is the narrowest of the four groups.

Conditions in each of the PAHHE, crowding and MoH subgroups were selected for further investigation (table 1) using hospital discharge data. Only children hospitalised with the conditions listed while aged 1 to 15 years old were eligible for inclusion. Children aged <1 year old were excluded from the analysis due to the unique disease susceptibility patterns that affect this age group.[29] The total number of child hospitalisations for each group and condition from 2000 to 2014 was noted. Hospitalisations occurring within 30 days of last discharge were considered to be a single event (ie, not counted as rehospitalisations).

Statistical methods
We calculated whether children ever hospitalised with diseases in the PAH, PAHHE, crowding and MoH groups were more likely to be rehospitalised for any cause or die in the study period. As a comparison group, we used all hospitalised children who had never been admitted with a PAH condition.

We used Kaplan-Meier curves to describe the percentage of children who were rehospitalised or died within 5502 days (15 years) post hospitalisation (ie, died before 1 January 2015). Observations were right censored at the end of the study period. HRs were produced using the Cox proportional hazards model to describe the multivariable risk. Where there were multiple readmissions for one individual, the 95% CI and variances were calculated with a cluster resampling procedure (the cluster bootstrap); otherwise, standard variance estimates were used (ie, for death). HRs were adjusted for age, sex, ethnicity and deprivation to reduce confounding. Unadjusted and adjusted HRs (HR and aHR) were estimated using the Cox proportional hazards model to describe the univariable and multivariable risk. We tested the proportional hazards assumption using Grambsch and Therneau's global goodness-of-fit test, which tests the assumption that the regression coefficient β does not change over time. Survival by single year of age was also calculated.

The prioritised ethnicity classification system identifies individuals belonging to more than one ethnic group and allocates them to a single ethnic group based on a prioritised order of Māori, Pacific and other. For example, a person who identifies as Māori and European will be classified as Māori only.[30]

The New Zealand Index of Deprivation classification system is an index of deprivation that measures the level of socioeconomic deprivation for people in each small area.[31] Deciles 1–2 represent people living in the least deprived areas and deciles 9–10 represent people living in the most deprived areas.

Screening effectiveness and efficiency
We used a standard screening approach to assess the effectiveness of the four disease groups. The sensitivity, specificity and positive predictive value (PPV) for detecting patients, who subsequently developed the condition of interest (rehospitalisation, death), were calculated using the Kaplan-Meier estimates at 5502 days. The number of children needed to screen (NNS) in order to prevent one rehospitalisation or death (assuming a perfect

Table 1 Conditions included in the PAH, PAHHE, crowding and MoH groups and association with social/environmental variables

Condition	ICD codes	Associated social/environmental variables[1]	PAH group	PAHHE group	Crowding group	MoH group
Acute bronchiolitis	J21	Social policy Housing/physical environment Ethnic disparities	Yes	Yes	Yes	Yes
Acute rheumatic fever	I00–I02	Social policy Housing/physical environment Access to primary care Ethnic disparities	Yes	Yes	Yes	Yes
Bacterial meningitis	G00, G01	Housing/physical environment Ethnic disparities	Yes	Yes	Yes	Yes
Bacterial/unspecified pneumonia	J13–J16, J18	Social policy Housing/physical environment Access to primary care Ethnic disparities	Yes	Yes	Yes	Yes
Bronchiectasis	J47	Social policy Housing/physical environment Access to primary care Ethnic disparities	Yes	Yes	Yes	Yes
Sepsis due to group A streptococcus	A400	Housing/physical environment[22]	Yes	No	Yes	Yes
Meningococcal disease (includes meningococcal meningitis)	A39	Social policy Housing/physical environment Ethnic disparities	Yes	Yes	Yes	Yes
Viral/other/unspecified meningitis	A87, G02, G03	Social policy Ethnic disparities	Yes	No	Yes	Yes
Viral pneumonia	J12, J100, J110	Social policy Housing/physical environment	Yes	Yes	Yes	Yes
Acute nephritic syndrome	N00, N05	Housing/physical environment[42]	Yes	No	No	Yes
Acute upper respiratory tract infection excluding croup	J00–J03, J06	Housing/physical environment Access to primary care	Yes	Yes	Yes	No
Asthma	J45, J46	Social policy Housing/physical environment Access to primary care Ethnic disparities	Yes	Yes	Yes	No
Croup, acute laryngitis, tracheitis	J04 J050	Access to primary care	Yes	No	Yes	No
Dermatitis/eczema	L20–L30	Social policy Access to primary care Ethnic disparities	Yes	No	No	No
Febrile convulsions	R560	Access to primary care Ethnic disparities	Yes	No	No	No
Gastroenteritis	A00–A09, R11, K529	Access to primary care Health promotion	Yes	No	Yes	No
Nutritional deficiency	E40–E64, D50–D53	Social policy Access to primary care Health promotion	Yes	No	No	No
Otitis media	H65–H67	Social policy Housing/physical environment Access to primary care Ethnic disparities	Yes	Yes	Yes	No
Skin infection	L00–L05, L08, L980, J340, H010, H000	Social policy Housing/physical environment Access to primary care Health promotion Ethnic disparities	Yes	Yes	No	No
Tuberculosis	A15-A19	Social policy Housing/physical environment Ethnic disparities	Yes	Yes	Yes	No
Vaccine preventable diseases (tetanus neonatorum, congenital rubella, tetanus, diphtheria, pertussis, polio, hepatitis B, measles, rubella, mumps)	P350, A33, A34, A35, A36, A37, A80, B16, B180, B181, B05, B06, B26, M014	Social policy Access to primary care Health promotion	Yes	No	No	No
Viral infection of unspecified site	B34	Housing/physical environment Access to primary care	Yes	Yes	No	No

Table 1 Continued

Condition	ICD codes	Associated social/environmental variables[1]	PAH group	PAHHE group	Crowding group	MoH group
Constipation	K590	Access to primary care	Yes	No	No	No
Dental (dental caries, pulp, periodontal)	K02, K04, K05	Social policy Access to primary care Health promotion	Yes	No	No	No
Gastro-oesophageal reflux	K21	Access to primary care	Yes	No	No	No
Osteomyelitis	M86	Ethnic disparities	Yes	No	No	No
Rheumatic heart disease	I05–I099	Social policy Access to primary care Ethnic disparities	Yes	No	No	No

1As identified by Anderson *et al*. (2012) unless otherwise cited.
ICD, International Classification of Diseases; MoH, Ministry of Health; PAH,potentially avoidable hospitalisation; PAHHE, potentially avoidable hospitalisations attributable (at least in part) to the home environment.

intervention could be implemented every time) was calculated as a means of estimating efficiency, as total number of children in the group of interest divided by the number rehospitalised/dying over the study period. The cluster bootstrap technique was used to calculate the standard error (SE) and 95% confidence intervals (CI) to indicate the variability of this test. As the NNS is mathematically equivalent to 1/PPV, the SE of the NNS was calculated from the SE of the PPV using the delta method.

RESULTS
Total hospitalisations and deaths
Over the period 2000–2014, a total of 1425 085 hospitalisations occurred for a total of 683 115 children in the 1-15 year old age group. Of these, 619 667 hospitalisations occurred for 390 220 children in the PAH group and 1469 deaths. In the PAHHE group, 275 818 children experienced 413 316 admissions and 1180 deaths. Slightly fewer admissions, 365 249 occurred for 243 791 children in the crowding group, with 1140 deaths. The smallest group, the MoH group, included 67 918 children, with 88 712 admissions and 805 deaths.

Rehospitalisations
Overall, 71% of all hospitalised children were readmitted. Children hospitalised, but never for a PAH condition, demonstrated a much lower risk of being readmitted (compared with children admitted for PAH conditions), with 56.3% rehospitalised. Children hospitalised with diseases in the MoH group had the highest risk of rehospitalisation, with 86.2% rehospitalised at 5502 days following the initial admission. Similarly, there were elevated risks of rehospitalisation in children hospitalised with diseases in the PAHHE group (80.3% rehospitalised) and the crowding group (80.3% rehospitalised). Table 2 describes the risk of rehospitalisation for any cause following hospitalisation in each of the four groups using children who were hospitalised with a non-PAH condition as the comparison group.

Figure 1 describes the Kaplan-Meier curve for rehospitalisation, following initialhospitalisation for a condition in each group.

Mortality
Overall, 0.6% of all hospitalised children died during the study period. Children hospitalised, but never admitted for a PAH condition, demonstrated the highest survival rate, with 99.7% surviving. Children hospitalised with conditions in the MoH group demonstrated the poorest survival. At 5502 days post hospitalisation, 97.6% (95% CI: 97.2% to 98.0%) of children hospitalised in the MoH group remained alive (aHR: 10.4), as did 99.1% (95% CI: 99.0% to 99.2%) of children hospitalised in the crowding group (HR: 4.00) and 99.2% (95% CI: 99.1% to 99.3%) hospitalised in the PAHHE group (HR: 3.31). By comparison, 99.3% (95% CI: 99.2% to 99.3%) of children hospitalised for a PAH condition survived (HR: 3.07, Figure 2, table 3).

The proportional hazards assumption was tested and did not hold by group. We therefore fitted spline smoothed curves to the standardised Schoenfeld residuals for covariates in each model using the Therneau and Grambsch's Z test for global goodness of fit, available in the R survival library (p for all models<0.001). Visual inspection showed the assumption was largely true for age at diagnosis, ethnicity, deprivation and sex. For the main exposure, however (hospitalisation for housing-related disease), the assumption did not hold, with β declining over time. Grambsch and Therneau suggest that smoothed Schoenfeld residuals provide a good estimate of the true form of β(t) when there is a large sample size. This effectively extended the Cox model, allowing β to change with time, without specifying the form of

Table 2 HRs describing risk of rehospitalisation or death for any cause following admission with a condition in the PAH, PAHHE, crowding and MoH groups compared with children hospitalised for a non-PAH condition

Hospital admission group	Rehospitalisation risk	Unadjusted HR (95% CI)	Adjusted* HR (95% CI)
Non-PAH	56.3%	1.00 (reference)	1.00 (reference)
PAH	78.0%	2.19 (2.17 to 2.21)	2.31 (2.29 to 3.34)
PAHHE	80.3%	2.41 (2.40 to 2.43)	2.49 (2.48 to 2.52)
Crowding	80.3%	2.47 (2.45 to 2.49)	2.58 (2.56 to 2.61)
MoH	86.2%	3.35 (3.31 to 3.39)	3.60 (3.55 to 3.66)

*Adjusted for age, sex, ethnicity and deprivation.
MoH, Ministry of Health; PAH, potentially avoidable hospitalisation; PAHHE, potentially avoidable hospitalisations attributable (at least in part) to the home environment.
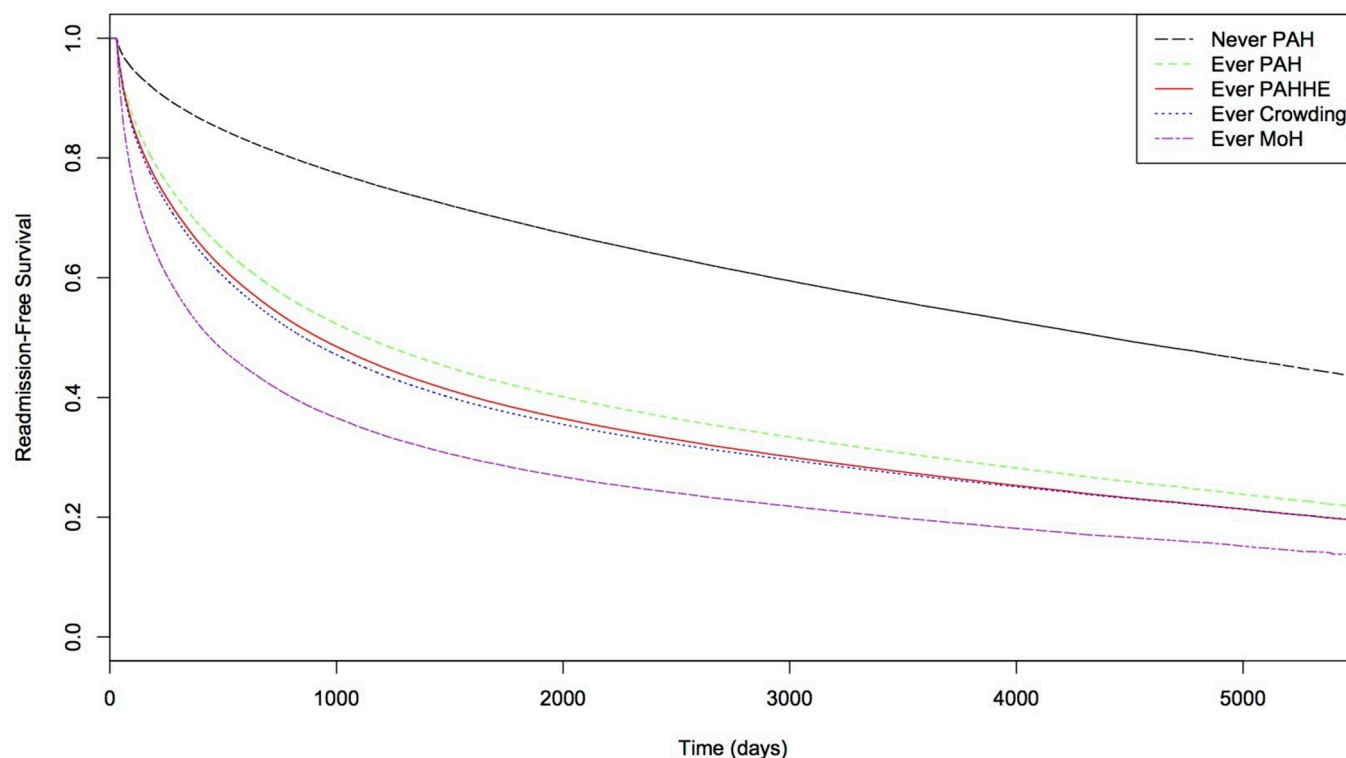
Figure 1 Rehospitalisations following hospitalisation for any cause (excluding PAH conditions), and rehospitalisation following admission for a condition in each disease group. MoH, Ministry of Health; PAH, potentially avoidable hospitalisation; PAHHE, potentially avoidable hospitalisations attributable (at least in part) to the home environment.

this relationship, with the naïve hazard ratios essentially representing 'average' effect (Supplementary appendix figure 1).

Increasing deprivation and Maori or Pacific ethnicity were associated with increased risk of readmission and mortality across
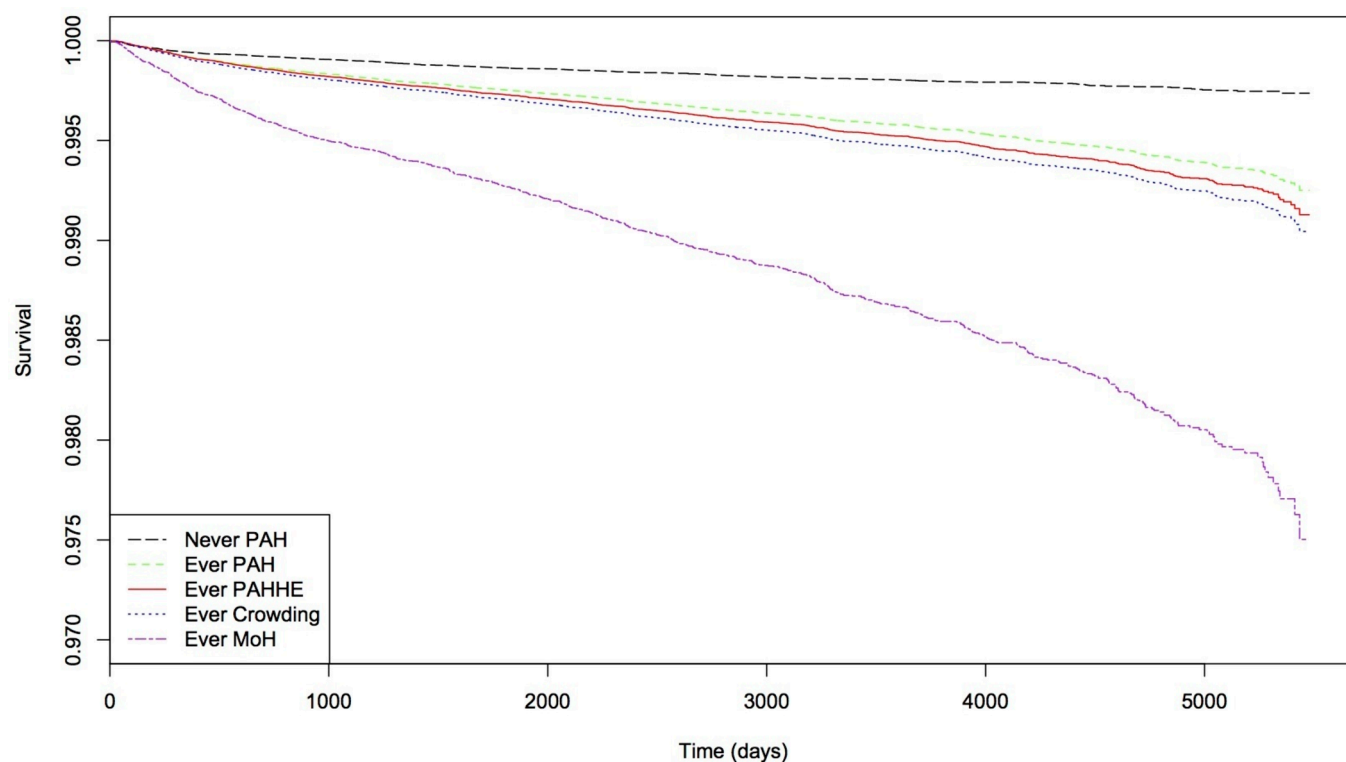

Figure 2 Patient survival following hospitalisation for all causes (excluding PAH conditions) and by group. MoH, Ministry of Health; PAH, potentially avoidable hospitalisation; PAHHE, potentially avoidable hospitalisations attributable (at least in part) to the home environment.

Table 3 HRs describing risk of death for any cause following hospitalisation in the PAH, PAHHE, crowding and MoH groups compared with children hospitalised for a non-PAH condition

Hospital admission group	Survival (%)	Unadjusted HR (95% CI)	Adjusted HR (95% CI)
Non-PAH	99.7	1.00 (reference)	1.00 (reference)
PAH	99.3	2.23 (2.01 to 2.47)	3.07 (2.74 to 3.43)
PAHHE	99.2	2.45 (2.20 to 2.72)	3.31 (2.94 to 3.71)
Crowding	99.1	2.66 (2.39 to 2.96)	4.00 (3.55 to 4.50)
MoH	97.6	7.03 (6.27 to 7.87)	10.44 (9.18 to 11.86)

*Adjusted for age, sex, ethnicity and deprivation.
MoH, Ministry of Health; PAH, potentially avoidable hospitalisation; PAHHE, potentially avoidable hospitalisations attributable (at least in part) to the home environment.

all groups. Age showed a non-linear relationship with readmission and death risk, with a minimum risk reached at age 5–6 years before risk increased again. Most of the difference between the unadjusted and adjusted models is due to the inclusion of age. For readmissions only, an interaction between ethnicity and deprivation was significant in that Maori or Pacific ethnicity decreased the effect of deprivation, and this was included in the relevant models. All of these variables had much less effect than those for housing related admissions.

Effectiveness analysis

The following table summarises the performance of four groups using a range of screening performance measures (table 4).

For the rehospitalisation outcome, which is relatively common, three of the groups (PAH, PAHHE, crowding) were all able to detect more than half of the children who were subsequently readmitted (sensitivity 55.0%–75.1%). The MoH criteria identified a much lower proportion (sensitivity of 20.2%), but the likelihood of children hospitalised in this group being readmitted was higher (PPV of 86.2%). The NNS to hypothetically prevent one rehospitalisation was 1.2 for all three subgroups and 1.3 for the PAH group overall. Given the large sample sizes, all CIs were smaller than rounding errors, ie. <±0.5%.

When investigating mortality, the hospitalisation groups had sensitivities varying from 48% to 76%. The MoH group demonstrated the highest PPV, but this was still very low at 2.5% (as would be expected for a rare outcome). The NNS to hypothetically prevent one child's death was 40.2 for the MoH group, 111.7 for the Crowding group, 121.6 for the PAHHE group and for the PAH group overall was 131.9. The statistics were all normally distributed as demonstrated by plotting normal QQ plots of the bootstrap residuals.

DISCUSSION

Main findings

Children hospitalised for conditions that are considered potentially avoidable are more likely to be readmitted to hospital and die compared with children admitted for other conditions. After children are hospitalised with one of the PAH conditions, they are likely to return to situations where factors promoting illness are still present. These factors include housing conditions, such as crowding and cold, damp, mouldy indoor environments. It is also possible that there is less provision of effective treatment and social support for children with conditions included in the PAH group than provided to children with other conditions. We successfully explored four disease groups which identified potentially avoidable conditions, a number of which were influenced by the home, crowding and the physical environment.

This study showed that the screening performances of these different disease groupings varied markedly. The PAHHE and crowding groups identified the largest proportion of children who subsequently had adverse outcomes, but the trade-off was a lower PPV. The MoH group on the other hand identified fewer poor health outcomes but had significantly higher PPV and consequently could be seen as more efficient for screening purposes, particularly if resources for follow-up are limited. As a result, it also provided the lowest NNS to prevent a hypothetical death (NNS: 41.7 children).

The MoH group identifies children at relatively high risk of future morbidity and early death. These children are very likely to benefit from housing interventions to reduce future morbidity and mortality, as all of the conditions included in the MoH group are also considered to be associated with crowding and/or the home environment. While acute nephritic syndrome is included in the MoH group but not in PAHHE or crowding,

Table 4 Screening effectiveness and efficiency analysis

Rehospitalisation	Sensitivity (%)	Specificity (%)	PPV (%)	NNS (95% CI)
Non-PAH	24.9	52.2	56.3	1.8 (1.8 to 1.8)
PAH	75.1	47.8	78.0	1.3 (1.3 to 1.3)
PAHHE	60.0	64.0	80.3	1.2 (1.2 to 1.2)
Crowding	55.0	67.0	80.3	1.2 (1.2 to 1.2)
MoH	20.2	92.0	86.2	1.2 (1.2 to 1.2)
Death				
Non-PAH	24.3	57.0	0.3	373.1 (346.8 to 399.4)
PAH	75.7	42.9	0.7	131.9 (125.1 to 139.7)
PAHHE	67.1	59.7	0.9	121.6 (114.7 to 128.5)
Crowding	65.0	64.4	1.0	111.7 (105.2 to 118.2)
MoH	47.9	90.2	2.5	40.2 (33.9 to 46.5)

MoH, Ministry of Health; NNS, needed to screen; PAH, potentially avoidable hospitalisation; PAHHE, potentially avoidable hospitalisations attributable (at least in part) to the home environment; PPV, positive predictive value.

it has recently been shown to be associated with low socioeconomic status.[32–35]

Interventions that alleviate the effects of poor housing and socioeconomic deprivation are likely to have far-reaching effects, impacting positively on child health and benefiting society as a whole.[36 37] Such interventions are likely to be multisectorial. Rehospitalisation is a useful outcome to assess the success of such interventions. As child mortality is rare, it may not be so useful as an outcome measure when evaluating successes of intervention programmes; however, it is a catastrophic event and warrants effective prevention.

Strengths and limitations

A major strength of this study is the ability to investigate rehospitalisation in a complete national population. The NZ hospitalisation dataset includes a unique person identifier (the NHI) which can be used to track individuals over time.

One limitation concerns the association of diseases included in the PAHHE and other groups with poor quality housing.[1] While the PAHHE group was developed by child health experts, the extent to which housing influences the rates of these diseases has not been accurately quantified. Furthermore, as our comparison group is children who have been hospitalised (although not for PAH conditions), our analyses may underestimate the true risk of rehospitalisation and mortality because the comparison group has already experienced worse health outcomes than the never-hospitalised child population. The effectiveness of each group to predict rehospitalisation and death in this age group may thus be different to that reported.

Implications

There are two major implications from this work. The first concerns screening. Children hospitalised for conditions considered potentially avoidable have a markedly higher risk of rehospitalisation and death than children hospitalised for other conditions. Screening can provide health service operators (eg, district health boards) with an opportunity to identify children at increased risk of future admissions, and take action to improve their home circumstances.[12 13 38 39]

These findings also support the need for a multisectoral approach to reducing child health inequities. Housing is an important and clearly modifiable worldwide determinant of child health. The ability of the NZ government sector to effectively deliver housing interventions on a large scale has been clearly demonstrated. The Healthy Housing Programme in Auckland reduced rates of paediatric infectious disease hospitalisations by one-third,[40] and the Warm Up New Zealand: Heat Smart programme, which provided free insulation to over 300 000 homes, produced an estimated net benefit of nearly NZ $1 billion.[41] If a perfect intervention which entirely removed the excess rehospitalisation risk did exist, and it had been applied to all children hospitalised with PAH conditions (ie, 43.5% of all hospitalised children) over the study period, then a total of 103 090 admissions and 347 deaths would not have occurred. The effects of childhood poverty emerge through poorer social, educational and health outcomes.[6] Such effects can last a lifetime, as seen by the increased risk of cardiovascular disease in adulthood.[5] Childhood poverty results an increased burden on the healthcare system, as well as on other government and community agencies.[5 6 9] We recommend future research and policy focuses on developing effective housing-related interventions with the aim of reducing the burden of ARF and rheumatic heart disease, and alleviating poverty, improving health equity and enabling social justice throughout society. Such work is likely to be important in all countries where there is significant child poverty.

Hospitalisations for conditions in the MoH group were strongly associated with rehospitalisation and death, and this striking finding warrants further investigation to identify morbidity and mortality risks specific to these conditions. There is potential to target effective housing interventions towards children hospitalised with conditions in the MoH group in order to help prevent future morbidity and mortality.

Conclusion

Future child hospitalisations and deaths may be avoided though appropriate interventions. Large-scale housing interventions may reduce the burden of preventable diseases considerably, if judiciously targeted at vulnerable populations. Scoping for such a programme should begin with an emphasis on incorporating well-integrated referral pathways, and delivering timely intervention to people in need. Useful outcome measures should be pre-identified in order to periodically assess the programme's success. Rates identified in this study may be useful as baseline statistics.

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