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ABSTRACT 1

Accidental Hypothermia In New Zealand: Who freezes to death? An analysis of Coronial and Ministry of Health data

I have analysed NZ Coronial data of (closed) coronial cases of death during a 10-year period (2007-2016) where the cause was Accidental Hypothermia by:

- age
- gender
- location (geographical and whether indoors or outdoors)
- whether engaging in recreational activity
- time interval between presumed death and being found
- any involvement of Search and Rescue
- whether any trauma was involved
- contributing causes of death:
 1. physical medical conditions
 2. dementia
 3. mental health issues (acute or chronic)
 4. alcohol or substance involvement (acute or chronic)
 5. whether the decedent was of no fixed abode
- whether the patient could potentially have been saved by implementing current best practice in management of accidental hypothermia

Results are different from overseas, including a higher proportion of young healthy people dying in NZ. (That is, more “saveable”)

Using statistical data from the Ministry of Health I calculated:

- Incidence of hospitalization / 100 000 people/year
- Mortality of patients admitted to hospital in percent
- Incidence of deaths in population /100 000/ year
- Number of people dying outside hospital annually

Comparing these to international research findings it appears that accidental hypothermia deaths are under recognized in NZ.

From this analysis it is reasonable to suggest that the number of preventable hypothermia deaths annually *could* be roughly the same as annual preventable drownings.

However, further research is required to confirm this.

My other, free-standing, abstract submission suggests what we can do to save these lives.

Accidental Hypothermia in New Zealand: Part 1 : Who freezes to death?

Part 1: Baseline of harm by Accidental Hypothermia in New Zealand

In Part 2 : What can we do to save lives? I will make recommendations for a range of initiatives to introduce contemporary, quality care for accidental hypothermia patients in New Zealand. Optimisation of pre-hospital care, destination policies and in-hospital management practices will deliver better overall care. Cost savings will be made in the form of improved resource utilisation and shorter hospital stays and better patient outcomes .

Method:

I would like to thank the Injuries Prevention Unit (IPU) at the University of Otago for generously supplying me with their Injury Statistics database data and for their encouragement for my project.

I also contacted the Ministry of Health but they reassured me that they do not have any additional information over and above what the IPU have.

I contacted ACC on numerous occasions and requested data in line with what they make available for researchers but my request was denied and I was told to make an Official Information Act request but at this stage I have not done so.

I would also like to take this opportunity to extend my thanks to the Coronial Information Office who was most helpful, encouraging and keen to help out .

1) Incidence of hospitalization / 100 000 people/year

Incidence of hospitalization in different countries:

New Zealand in 1994: 6.9/ 100 000 ¹

In their 1994 paper Taylor, Griffiths and Cotter identified hypothermia hospitalisations to be 6.9 per 100,000 per year during the years 1979- 1986. They included domestic (what I have called indoors) and nonresidential (what I have called outdoors) cases but their data differs from mine in a couple of ways: They have included neonates, I have excluded neonates. They used data from the NHSC (national Health statistics Centre) using ICD coding and manual searchig.

I have used data supplied by the Injuries Prevention Unit which is the identical data to that of the Ministry of Health.

Neonatal hypothermia made up (1165 / 1815 =) 64.2 % of the hospitalisations.

Thus excluding the neonatal case load, the remaining hospital admissions (domestic and nondomestic) 650 in 7 years in a population of 3.3 million in 1986 which comes to **2.8 / 100 000** , thus this is the figure we should compare to my current figures

The authors comment that it is possible that the real incidence of hypotheria is vastly underdiagnosed in hospital admissions in NZ , **up to a factor of 60 fold in the elderly population.**

UK: Hospital admissions in 2012:1876. Population of 63 million in 2012 results in and incidence of 2.85 /100 000 ²

The information from the UK NHS Information Centre was analysed by the Daily Telegraph newspaper and it was noted that the incidence of hospital admissions due to hypothermia in 2010/2011 compared to in 2006/2007 had more than doubled in those aged over 60 (from 633 to 1369) , had increased by 54% for those aged 15-59 and increased by 22% in those aged 14 and under.

Sweden in 2016: Hospitalization 3.4/ 100 000 ³

Brändström, Johansson, Giesbrecht, Ångquist and Haney carried out a retrospective analysis of hospital records from the 4 northern most counties in Sweden between 2000 and 2007. In the group with accidental hypothermia the youngest patient was 4 and the oldest was 97.

44 out of 474 ie 9% of the patients had become cold indoors) either by a door left open or inadequate heating. The incidence for hypothermia with hospitalisation was 3.4/100 000 and was increasing year on year but this might have been due t increased recognition due to a large public education drive by the Swedish National Board of Health and Welfare.

Finland 1.37/100 000 ⁵

Pirnes and Ala-Kokko carried out a retrospective cohort study on patients with accidental hypothermia admitted to Oulu University Hospital in Finland over a 5 year periods. There were 374 Deaths between 2008- 2012) in a population of 5471753.Average 75 deaths / year (excluding neonatal and patients younger than age 18 years old)

Poland 5.05 /100 000 ⁴

“Accidental hypothermia in Poland – estimation of prevalence, diagnostic methods and treatment”

This article has a very good discussion about the challenges of collecting reliable data and the great variations in data collected in various countries.

The incidence of hospital admissions depend on several different things:

How many people are exposed to cold,wheter indoors or outdoors,

If their (core) temperature is measured on admission

If they are assigned the correct code when they arrive in hospital (ICD10-T68)

Or if they are pronounced life extinct before they are taken to hospital.I will discuss this further later on.

The incidence in Finland is 1.37

My NZ 2016 data calculation arrives at a figure 1.45

NZ 1994 2.8

UK 2.85

Sweden 3.4

Poland 5.05

If these incidences are averaged out they become 2.82, ie very similar to the UK currently and to NZ in 1994.

With a population of 4.8 million in NZ now it would extrapolate to 135 admissions each year, ie roughly twice what we are currently recording.

The figures I have been supplied with from Injuries Prevention Unit , University Otago for the 10 year period 2006-2015 is on average 70 admissions per year. The trend is upwards in the last few year with 90admissions in 2015.

This computes to 1.45 hospital admissions / 100 000/ year in NZ curnnetly

I thought this sounded rather low so I double checked with Statistics NZ and for the 2016 year it was 88.

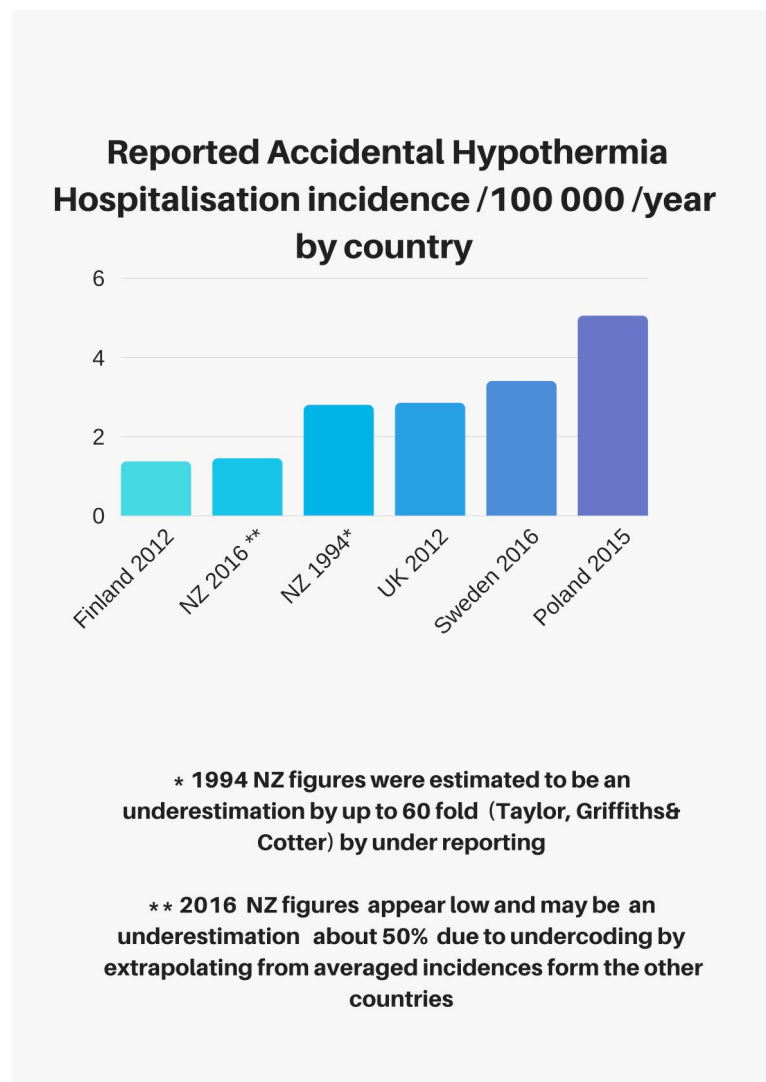
Thus our expected admissions from 1994 data would be 134

If we use the average incidence of the

Thus:

- Temperatures need to be measured
- Patients with hypothermia need to be coded as such

I believe patients are significantly under identified , it is likely that only about 50% are identified.



2) Mortality of patients admitted to hospital in percent %

Once a patient has been admitted, had their temperature taken, been coded as T68, they may live or die.

The percentage mortality varies a lot:

In Sweden in hospital accidental hypothermia death rate is 6%.³

Brändström, Johansson, Giesbrecht, Ångquist and Haney analysed cold injury hospital admission cases between 2000 and 2007. They had 244 patients admitted to hospital with hypothermia, 15 of them died, representing 6% in hospital mortality.

In Finland Pirnes and Ala-Kokko reported it to be 13%⁵

in their retrospective study 2008-2012. They had 16% of their patients becoming cold indoors and their commonest comorbidity was alcoholism .

In the UK it is 13.8%²

According to Daily Telegraph in 2010/2011 there were 1876 admissions and of those 260 died, which means the in hospital mortality is 13.8%.

In Poland the mortality rate within the Emergency Department(ie no data from the rest of the hospital wards once transferred) it is 6.3 % but overall likely to be higher⁴

In Vienna in 2001 the mortality rate was 50%⁶

Schober, Sterz, Handler et al employed a retrospective analysis of prospectively collected data in a cohort of adult cardiac arrest patients with a body core temperature less than 28 degree Celsius between 1991 and 2010. 12 out of 18 patients were intoxicated and this was the cause of them having become hypothermic in the urban environment. 50% survived, 38% with a good outcome.

If this is compared with survival from normothermic out of hospital cardiac arrest which currently ranges 5-15 % in various western countries , 38% is indeed very good.

In New Zealand between 1983 and 1986¹ excluding neonates, the overall case fatality (hospital admissions fatality) was 17% (1 of 122 of non-domestic ie 0.8%) and 51 out of 184 domestic ie 27.7%)

In Amsterdam it was found to be 28.6%⁷ in a 2010 paper by Van der Ploeg, Gosling, Walpoth and Bierens who carried out a retrospective cohort study of all patients with a body temperature less than 35 degree Celsius to the Emergency Department of VU university medical centre in Amsterdam between 1 January 2000 and August 31 2008. 84 patients were included .Twenty four patients died (28.6%) died. Prognosis was poor in older and colder patients and after indoor exposure and submersion. The authors commented that because individual teams gain little clinical experience they suggest multiple centre data collection as a first step towards an evidence based standard of care

From my NZ data accessed 2017, I have calculated hospital mortality by taking all the hospital admissions and then using the injury data base data of patients who died in hospital.

The fatal figures come from the MoH mortality collection ³¹, which collects data from multiple sources, including coroners, hospitals, births deaths and marriages, and funeral directors. The latest 10 years fatal data I have is 2004-2013 but only years 2008 -2013 have both complete coronial and injury statistics data so I am only using those **6 years** years.

Fatalities don't have diagnoses, because they are dead. These patients were identified based on external cause code = ICD10 code X31 'Exposure to excessive natural cold'. As can be seen from the non-fatal tables, X31 is the main one of many external causes for diagnosis T68, so we likely only found a subset of all hypothermia deaths.

This means this underestimates mortality but by what factor we can only guess.

The way I have calculated the percentage hospital mortality rate is this:

Data provided:

Year	Number of fatal admissions	Number of nonfatal admissions
2008	4	59
2009	5	67
2010	10	66
2011	6	77
2012	3	93
2013	5	85
Average	5.5	74.5

Number of Nonfatal admissions (ie survivors) 2008 -2013 as per IPU data :averaged out becomes 74.5 patients a year (A)

In hospital deaths as reported by the coronial data I have been provided (on average 1-2 a year only) ie 1.5 (B)

Number of Fatal admissions as by IPU data 5.5(C)

The formula I used is $(B + C) / (A+B+C)$

$$(1.5+5.5) / (74.5 + 1.5+ 5.5) = 8.5 \%$$

The calculated percentage is 8.5 % in hospital mortality per year. There is a big fluctuation between years from 13 % in 2010 to 6.25% in 2007.

All indicators point to that is is higher than that, but by what factor we can only guess.

Thus:

- Recording needs to be improved
- **Without knowing the severity of hypothermia for the caseload of patients, it is Impossible to comment on the hospital mortality rate**

3) Incidence of deaths in population /100 000/ year

This includes the patients who die in hospital and the people who are not admitted to hospital because they had either died some time before they were found or they were not resuscitated despite being found soon after developing severe hypothermia.

This is multifactorial:

- pre existing medical conditions (including old age) predisposing to hypothermia,
- social isolation
- poor heating and insulation resulting in cold homes
- outdoor activities
- unintentional outdoor exposure

The coroner has furnished me with these data (but it may to be incomplete)³⁰

It is also influenced by hospital mortality rate.

We do not have accurate numbers to be able to calculate this.

Deaths in 10 years from coroners= 117 = average of 11.7 deaths/ year

Deaths in 10 years from injury data base= 50 ie an average of 5 deaths / year

(We don't believe they overlap, but they may)

The overall annual sum is rounded up to 17/ year.

Overall deaths in NZ each year in 2015 is 31608 i.e. **0.05** of the overall deaths appear to be caused by accidental hypothermia if we accept this data as correct.

The death incidence would be **0.3** / 100 000/year

The figure from reference¹ in 1994 was 0.54/ 100 000/ year. Since there was only two neonatal death in the 8 year cohort of 176 deaths in that study, this number can be used for the calculations of adult deaths.

This is unlikely to be correct since in South Australia it is 3.9 / 100 000/ year

And Sweden is 3.3/ 100 000/ year.⁸

This study used case files from Forensic Science South Australia and the Swedish National Forensic data base over a six year period 2006 to 2011. Despite the considerable demographic, geographical and climatological differences, hypothermia deaths occurred at very similar rates in the two countries. Deaths in South Australia were predominantly indoors(84%) at home addresses involving elderly females with multiple underlying illnesses and limited outside contact. Swedish hypothermic deaths generally occurred (95%) outdoors and involved middle aged and elderly males.

In Finland there are 75 deaths form hypothermia each year,in a population of 5.4 million ⁵, which is 1.38 /100 000.

In Canada a study covering the years 1998 to 2012 was done: Their calculations arrive at 0.6/ 100 000/year. There are very large regional variations within that overall figure.⁹

Thus the countries for which we have deaths/100 000 /year

New Zealand (1994) 0.54

Canada 0.6

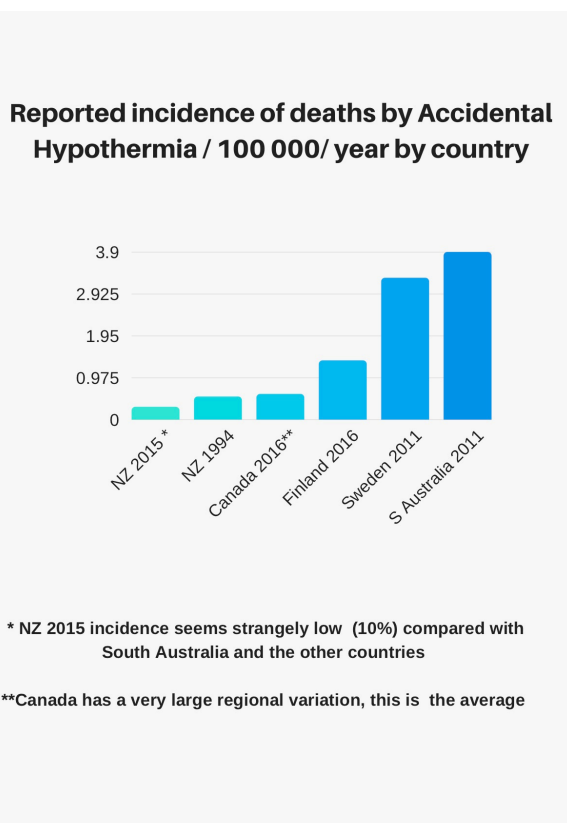
Finland 1.38

Sweden 3.3

South Australia 3.9

I have been unable to find statistics for any other countries The rate I have calculated for my data ending in 2015 **is 0.3**. I believe this is erroneously low and would expect it to be closer to the South Australian figures

This makes me believe only 10% to 20% of total Accidental Hypothermia fatalities are identified in NZ currently.



4) Number of people dying outside hospital annually

In the coroners' data of 117 deaths over a 10 year period, only 14 patients were alive when found and they later died in hospital.

Thus, 12% alive when found but then died.

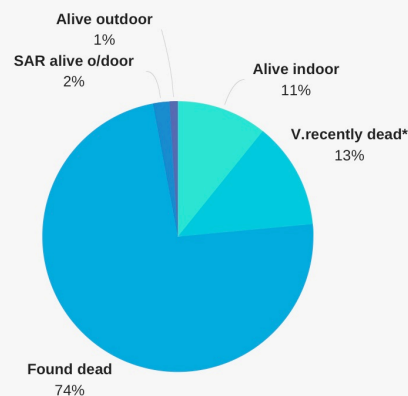
In many of the other cases the person had been dead for some considerable time before they were found.

16 decedents (13%) (were also very recently deceased or potentially amenable to resuscitation but were verified life extinct as opposed to being brought to hospital for rewarming.

This means:

- **Maybe hospital care could be better**
- **Maybe more awareness needs to be raised about not withholding active management since potential outcomes can be good**

Timing of fatalities in Accidental Hypothermia



* "very recently" estimated as less than hour to a couple of hours, presenting cardiac rhythm not available

Hypothetically, some of these 26% of patients might potentially be saved with more proactive management

5) Demographics of decedents of Accidental Hypothermia

Demographics based on coronial data 2008-2016

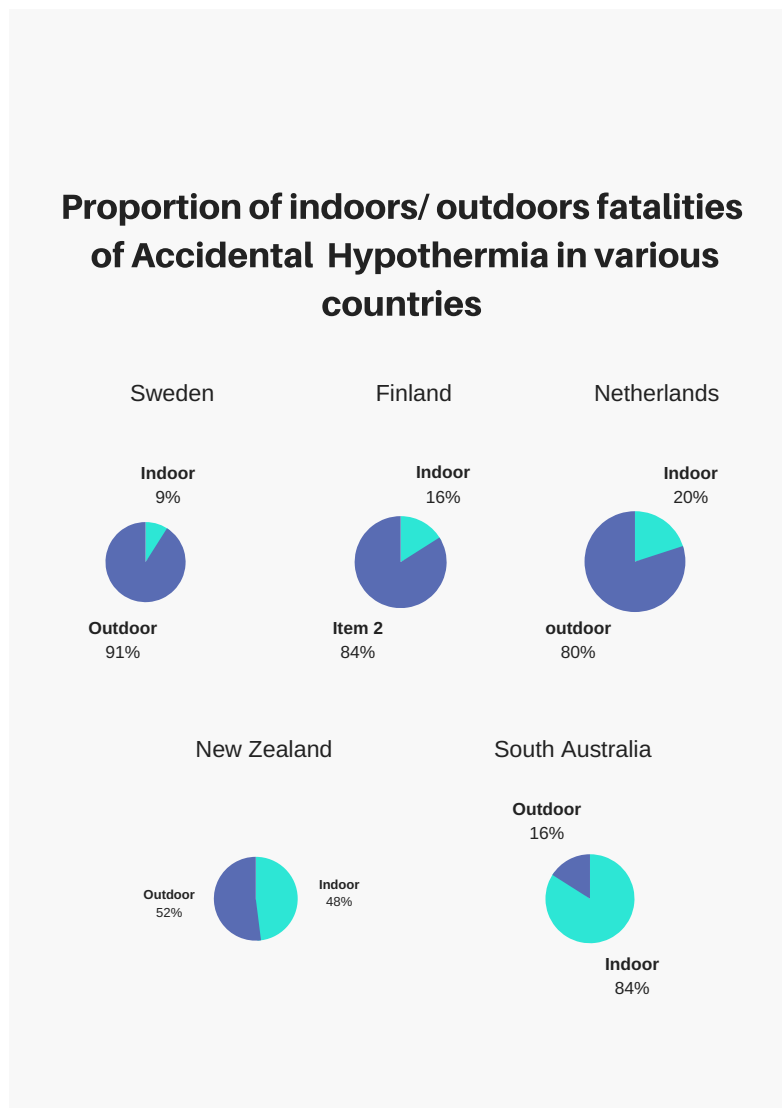
Indoors or outdoors?

61 out of 117 fatalities (i.e. 52 %) became cold outdoors .

This means that the other 48 % became cold enough to die in their own homes.

The gender breakdown of all the fatalities are this:

34 out of 117 i.e. 29% were female i.e. males were predominant with 71% of fatalities.



Different countries overseas have different proportions of indoors and outdoors fatalities.

Countries with colder climates generally speaking have more well insulated and heated houses so even elderly and frail people do not freeze to death in their homes.

However, countries with somewhat warmer climates tend to have less well heated or insulated houses, and thus elderly frail people die in their homes.

As can be seen in New Zealand , not all those who die indoors are “old”.

Age distribution of indoor cohort

In the **indoor group** things look like this: 56 in total

No one in the under 18-age group

Ages 18-49: 3 males (5%)

47 m maybe possible CVA

49 m seizures

49m diabetic ketoacidosis

Ages 50-64: total of 11 i.e. 20% (4 out of 11 were female)

Age	Gender	Main cause
55	f	encephalopathy,drug abuse
64	m	squamous cell ca lung,hypothermia
59	m	Upper Gi bleed
62	f	fell,fractured ribs,hypothermia
57	m	hypothermia, acute oesophageal necrosis syndrome, alcohol dependency
61	m	diabetic ketoacidosis
61	m	possible stroke, then hypothermia
53	m	medical history
63	f	mental health history
52	f	seizure,incapacitated onfloor,hypothermia
52	f	unascertained,hypothermia contributing

Age's 65-74:total of 13, i.e. 23% again 5 out of 13 were female

Age	Gender	Main cause	Contributory casue
67	m	hypothermia	chronic alcohol use , IHD, emphysema
72	f	Hypothermia	fall,undeterminable

67	m	hypothermia	multiple comorbidities, reclusive
73	m	Hypothermia	on floor 1 day,died of multiorgan failure due to hypotheria
71	m	Hypothermia	lived in a cold garage
69	f	hypothermia	cardiac arrest,taken to Lower Hutt Hosp, then to Wellington hops
73	m		Had had a stroke.hypothemic dehydrated pressure sore
65	m	cardiac event incapacitated him, alcoholic,died of cold	
68	m		coronary&hypothermia
66	f		
66	m		alcoholism
71	f		
68	f	discharged from hospital to a locked house,fell,injured,froze,Had undiagnosed cancer	

Ages 75-84 total of 23 i.e. 41% of all indoor fatalities .12 out of 23 (48%) were female

Age Group	Gender	Main cause
75-84	m	emphysema,DM,caridomyopathy
75-84	m	CVA
75-84	f	hypothermia ,stuck in bath
75-84	m	Taranaki base hospital by heli,died 2 days later
75-84	f	Fell,# NOF,immoblie
75-84	m	fell,talking,detrioarted,died CH hosp next day
75-84	f	emphysema,hypothermia
75-84	f	cardiorespiratory arrest due to hypothermia
75-84	m	alcoholic ketoacidosis & hypothermia
75-84	f	cold in bath,maybe coronary
75-84	f	became trapped in a broken deck chair
75-84	m	cardiac arrest in ambulance, CPR 30 minutesthen stopped
75-84	m	immobilised by stroke, hypothermia
75-84	m	
75-84	m	reclusive, alcoholic GI bleed
75-84	f	cva causing immobilisation
75-84	f	
75-84	f	#NOF,rhabdo,hypothermia
75-84	m	alcohol , suicidal

Age Group	Gender	Main cause
75-84	m	complex fall causing immobility and hypothermia
75-84	f	neglect,underweight,hypothermia
75-84	m	fractured wrist,stuck in bath
75-84	f	hypothermia,bronchopneumonia,underlyiglung cancer

Ages 85 and over: 6 out of 6 were female and represent 10% of all the indoor fatalities.

Age Group	Gender	Main cause
85+	f	possibly TIA but just laying on floor gettig cold
85+	f	hypothermia,gash to leg getting firewood
85+	f	fall, uable to get up,10degreeC indoors, 38 kg
85+	f	early Alzhemers, cold room
85+	f	fall with minor injuries
85+	f	probably CVA then hypothermia

I believe that many people will find it surprising that 25% of people who die of hypothermia indoors in New Zealand are under the age of 65 and that another 23% are between 65 and 74, not particularly “old” by today’s standard.

As is shown in the tables above, it can be seen that there is comorbidities in the decedents but not always.

Accidental hypothermia is traditionally thought of a cause of death for the elderly, which sadly it is since 52% are in the over 75 age group.

Age distribution of the outdoors cohort

Analyzing the **outdoor** fatalities only 8 out of 61 i.e. 13% were female

Under 18 (excluding neonates) there were 2 out of 61 i.e. 3%

Ages 18-49:23 out of 61 i.e. 37%

Ages 50-64:also 23 out of 61 i.e. 37%

Ages 65-74; 6 out of 61 i.e. 10%

Ages 75-84: 3 out of 60 i.e. 5%

Ages 85 and over: 3 out of 60 i.e. 5%

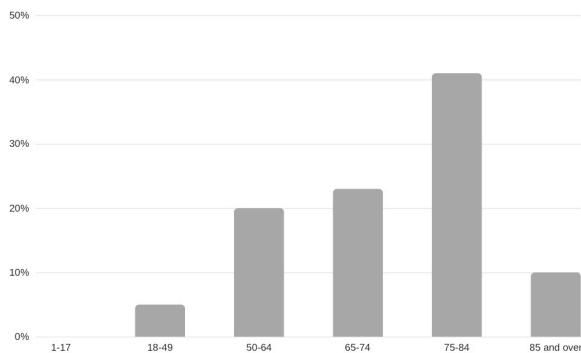
There were 5 females in the 18-49 group and 3 females in the 50-64.

Thus, 77% of people who die of hypothermia outdoors are 64 years old or younger.

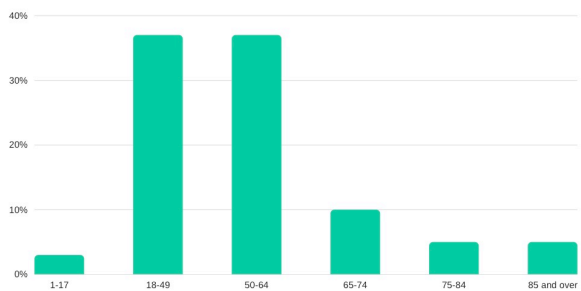
20% are 65 or over (it does not add to 100% due to Swedsh rounding) ,10% are 75 years old or older.

These disparate age distributions in the outdoors and the indoors cohorts aswell as the frequent existence of comorbidities in the indoor group have traditionally made them be considered as difficult to rescue with a good outcome.

However, it has less to do with chronollogical age and more with physiological age as borne out by Anders Carlsson and colleagues in their case report of sucessful resuscitaion of a 95 year old genetleman²⁹



Age distribution (%) of indoor decedents

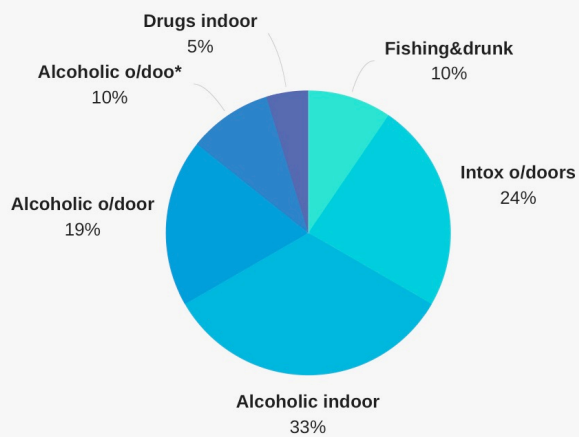


Age distribution (%) of outdoor decedents

Co factors: alcohol etc

The majority of data originating overseas regarding fatal accidental hypothermia finds that it is linked with alcohol or substance abuse and homelessness.

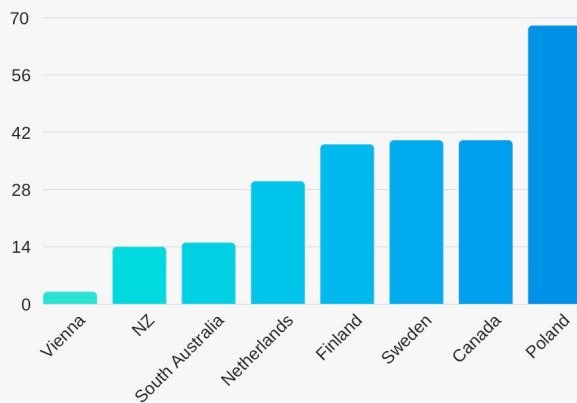
Alcohol & recreational drugs in decedents of Accidental Hypothermia in NZ



* These decedents had alcoholism but had no blood alcohol levels when froze to death

An overall incidence of 14% of alcohol intoxication or alcoholism as co-factor in fatal Accidental Hypothermia is very low compared to overseas

Alcohol as co-factor in decedents of Accidental Hypothermia in various countries (%)



This is not borne out in this data set. Since it is coronial information it is likely to have been recorded, even if it might not have been recorded in hospital medical records.

In the entire cohort of 117 fatalities only 16 patients had acute or chronic alcohol as a contributory factor. (13.6%) and only one (0.8%) was noted to be a substance abuser.

Similarly, mental illness was only present in 11 out of 117. (9.4%)

Only 4 decedents were of no fixed abode. (3.4%)

Dementia was only present in 4 out of 117 cases. (3.4%)

Trauma, which incapacitated the patient, either indoors or outdoors, was recorded in 20 out of 117. (17%) This is the biggest group and thus relevant for the Major Trauma Clinical Network to be aware of, as we will see in part 2.

Outdoor activities at time of death

Outdoor recreation (other than fishing) accounted for 16 out of 117 (13.6%) and or **26%** of outdoor fatalities

Tramping 9 = **15%** of outdoor

Climbing 2 = **3%**

Hunting 3= **5%**

Skiing 1= **1.5%**

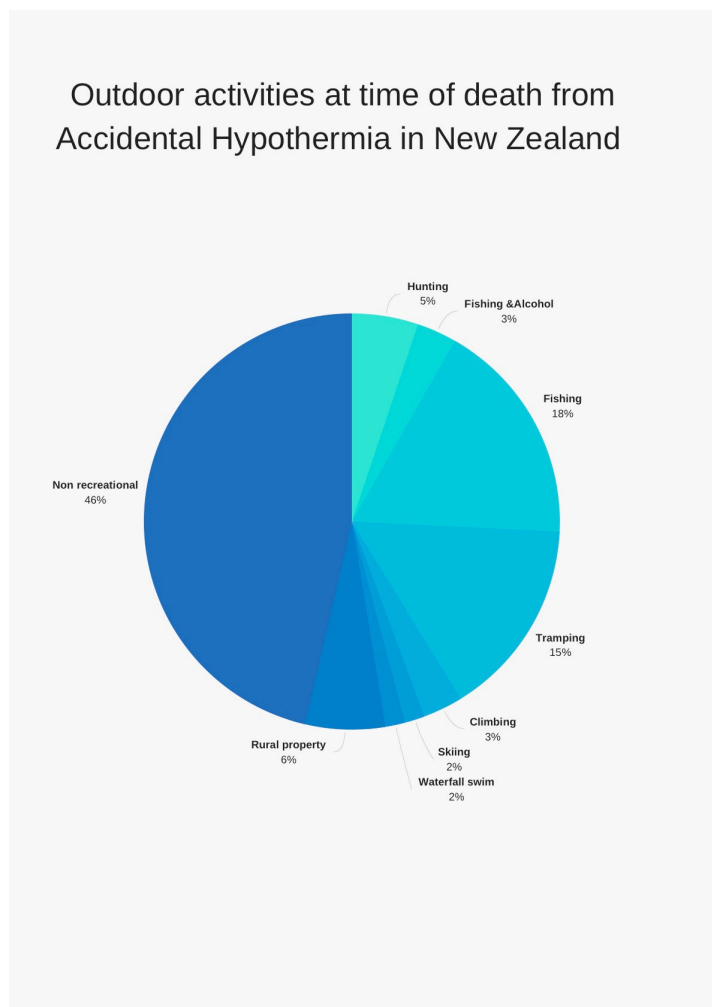
Swimming in waterfall 1=**1.5%**

Alcohol intoxication 2 =**3%**

Rural property or outdoors at home 4= **6%**

fishing was the activity for 12 out of 117. (10%) or **20%** of outdoor fatalities

Thus the other outdoor fatalities (**45%**) were not recreating but were on beaches, in forests or in reserves, outdoor workers or people travelling.



Geographical distribution by coronial district:

Auckland Indoors 14

Outdoors 10

Rotorua none indoors

Outdoors 9

Wellington 3 indoors

2 outdoors

Hastings none indoors

2 outdoors

Whangarei 2 indoors

3 outdoors

Hamilton 1 indoors

4 outdoors

Palmerston North 8 indoors

8 outdoors

South Island:

Christchurch 20 indoors

12 outdoors

(pre 2011 earthquake there were 4 indoor deaths in 3 years 2008,2009 and 2010.If extrapolated for 2011, 2012, 2013, 2014, 2015 and 2016 one would have expected another 8 deaths but in fact there were 16, ie an additional 8 in 6 years which means 1.3 deaths per year increase since the 2011 earthquake)

However, when one scrutinizes the home addresses, it becomes apparent that 6 out of these 17 deaths took part in areas of the Christchurch coronial district not affected by the earthquakes,(Ashburton and Timaru and other locations)

Thus, there were indeed only 3 additional ones above what were expected in areas of potential earthquake damaged housing.

It is of note that one decedant lived in an unheated garage and another one the indoor temperature was 10 degrees C.

Fuel poverty and poor standards of housing stock contribute to these fatalities.

Dunedin 4 indoors

10 outdoors

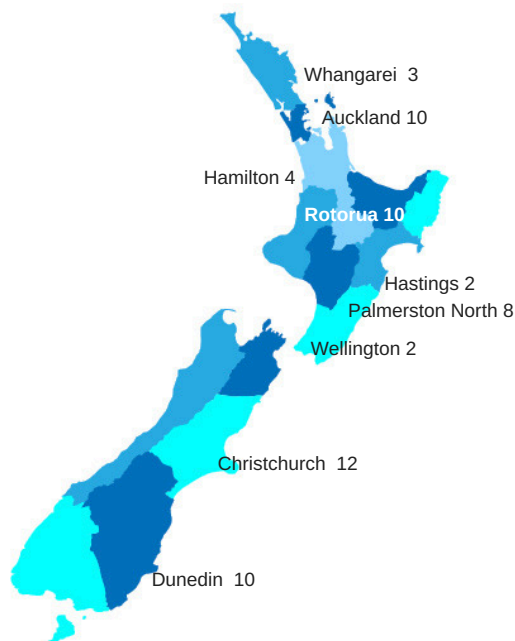
(There are 2 fatalities which I cannot locate geographically)

It should be noted that since 29 October 2012 the Coronial districts have been working as “clusters”. This was prompted by the earthquake events in Christchurch. It means that the various coronial districts help each other out on a calnedar basis and thus a case may not be investigated by the nearest office.

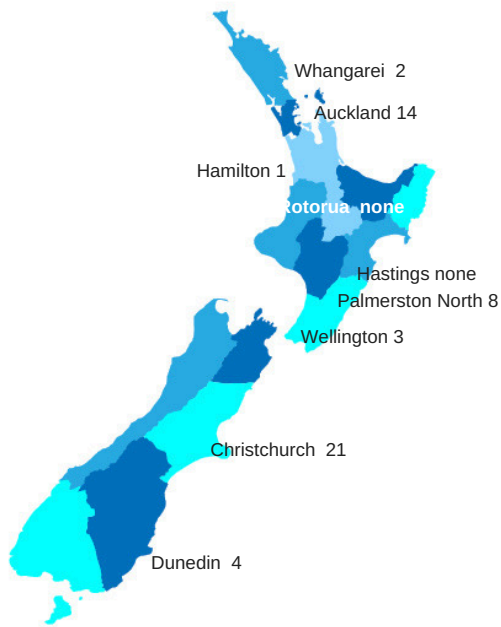
I have scrutinized the geographical locations of the fatalities and for those in the South Island I have established that there are no cases where this cluster system has misrepresented the locality of the death.

I am less familiar with North Island geography but I have not found any obvious cluster system impact, thus I feel it is of value to represent the data in map form.

**Geographical distribution by Coronial districts:
Accidental Hypothermia Outdoor fatalities
2008-2016**



**Geographical distribution by Coronial districts:
Accidental Hypothermia Indoor fatalities
2008-2016**



3 cases have no geographical locator

Seasonality

It is normal to expect that accidental hypothermia fatalities should occur during winter months.

Work done on “ excess winter mortality” by kiwi researchers ¹² define winter months as being June, July, August and September.

For the **indoors** fatalities they are indeed more prevalent in the **winter** months:

June 6

July 16

August 9

September 7 =38

Whereas **indoors non winter** incidence is

October 1

November 1

December 0

January 3

February 1

March 4

April 2

May 5 = 17

The **outdoor** fatalities are quite different:

Winter

June 6

July 14

August 4

September 5 = 29

Nonwinter

October 10

November 3

December 3

January 4

February 2

March 3

April 1

May 6 = 32

This demonstrates that winter and nonwinter outdoor accidental hypothermia fatalities are very similar if done by season rather than strictly by months since obviously, non winter months are 8 months and winter months are only 4 .

Timing of fatalities

In total 14 of the patients were alive when found and all later died (because this is the coronial information I am using).To me, this could raise questions regarding the care they are given by the ambulance and hospital teams.

(Refer back to in hospital mortality rate and the problems raised by incomplete data collection)

One patient was verified life extinct in ambulance by paramedic without any rewarming efforts

(61 year old male)

Furhter analysis of the outdoor fatalities:

Search and Rescue were involved in 33 out of 61 outdoor hypothermia fatalities. (54%)

As we saw above, 14 patients were alive when found but all later died (this is the analysis of coronial data, thus there are no survivors) . Only 3 of these were outdoor deaths, and SAR was only involved with 2 patients who were alive when found and later died in hospital. Thus the other 12 who did not have SAR involvement were indoor decedants and had ambulance service involvement. Some of these had significant comorbiditeis, some did not but I have no details available of the severity of hypothermia on admission.

(young boy in trapped by ankle in Motatapu gorge, went to Dunedin for heart lung bypass)

(the young female on Mt Taranaki in 2013 when there were 2 deaths. Mouth to mouth was used in attempt to rewarm, no CPR. Recent multimedia feature in Stuff)

The third one was a lady who had been in a ditch for 5 hours and was conscious when found but died in hospital.

SAR found 6 fatalities soon (ranging from one hour to 12 hours and no significant trauma) after having succumbed to hypothermia.

Some of those might possibly have been theoretically amenable to rewarming.

This is highly relevant for the person who verifies life extinct in the field.

It is interesting to note that the formal verification of death directives issued by Ministry of Health does not mention the special case of hypothermia at all ¹³.

A person with hypothermia should not be verified life extinct until they have been rewarmed to a body temperature over 35°C unless there are injures incompatible with life or chest is frozen solid in such a way that it is impossible to perform CPR.

At a hypothermic temperature it may not be possible to feel a pulse due to it being slow and of low volume and breathing may be very slow and shallow.

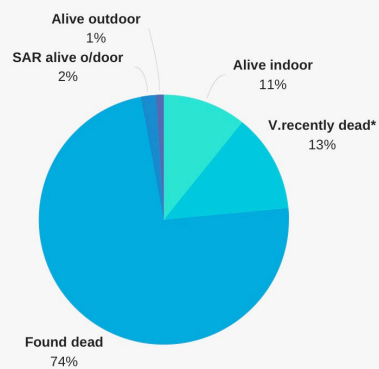
An ECG monitor (i.e. not an AED since they do not have monitor screens) must be available. Bradycardia and ventricular fibrillation in a hypothermic person can easily be mistaken for absent vital signs.

Asystole if combined with snow/ice/water immersion may indicate that the person died of asphyxia and then became a cold dead body.

However, if there is no airway obstruction they may well have become very cold, so such an extent that they appear dead but may be amenable to resuscitation.

This goal can be reached if awareness is raised for the potentially very good outcome from resuscitation of apparently dead people who have (non hypoxic) accidental hypothermia as we will see in part 2.

Timing of fatalities in Accidental Hypothermia



* "very recently" estimated as less than hour to a couple of hours, presenting cardiac rhythm not available

Hypothetically, some of these 26% of patients might potentially be saved with more proactive management

So how many lives can we save?

From section 1) we can say that extrapolated hospital admissions should be around 134 (excluding neonates) per year instead of the current average of 70 / year which means that currently only about 50% of admissions are identified.

The 1994 NZ reference hinted maybe only one sixtieth of admissions suffering from hypothermia were actually identified which would be 1.6% so in that case we have improved over the last two decades.

If mortality is between 6.5% in centers of excellence to 13 % in UK (our calculations suggested 8% and those are inaccurate) not specifying the severity of hypothermia on admission.

OHCA caused by hypothermia can have an approximately 30% survival which is really good compared to normothermic OHCA which is currently 15% In NZ (St Johns).

Looking at the reverse, this equates to a 70% mortality so the 6.5-13% mortality is an average for mild and severe cases.

If we had twice the number of hospital admissions (134 instead of 80) we would have twice the in hospital fatalities ie about 10 a year.

So instead of having 80 admissions , 5 of those die and 75 survive, we would have 134, 10 deaths and 124 survivors.

This would mean 49 (roughly 50 more survivors a year).

There are about 80 preventable drownings each year in NZ¹⁰

This is a conservative estimate. If we go along with the Polish research which found that the actual incidence of hypothermia was about four times higher than the currently official figures state then this number might be higher.

The countries where public educational and health care educational campaigns have been invested in find that it isn't the actual incidence which increases but the coding and recognition.

Water Safety NZ are working relentlessly to improve these statistics, their public awareness and education campaigns are award winning. They have realized the importance of accurate statistics and now include those of nonfatal drownings, ie hospitalisations. Much of their work could be almost directly translated to hypothermia prevention work.

NZ annual road toll has been approximately 320 deaths per year the last few years.¹¹

Thus based on my data analysis, it is reasonable to suggest that the number of preventable hypothermia deaths annually could be roughly the same number as preventable of drownings.

(or a about 2 months worth of road toll)

When one calculates number of incidence of deaths in population (section 3) annually the current NZ figures I have obtained suggests **0.3**) the 1994 research paper suggested 0.54 per 100 000/ year.

If we use the 1994 figure there should be **24** deaths annually.*(ok to use that number since only 2 neonatal deaths in 176 in that study)*

If we use the Australian figures of 3.9 / 100 000/year we reach a figure of **175** deaths per year.

If we average out 24 and 175 we get **100 deaths per year. We are currently identifying 11 a year, i.e. roughly 10%**

(The current NZ coronial data is 117 deaths in **10 years; ie roughly 13** a year for both in hospital and out of hospital deaths combined)

I am not suggesting all of these deaths can be prevented but I think I have clearly demonstrated that the current NZ data do not stack up with international experience.

If we don't identify them, how can we offer them appropriate management?

If some of these additionally identified out of hospital patients can be identified, they will feature in the increased hospital admissions. If more people are admitted, more people can potentially be saved.

ABSTRACT 2

Accidental Hypothermia in New Zealand: What can we do to save lives?

Every link in the chain of survival needs to be strong, agile and based on current best evidence.

This can be achieved by the development of a NZ National Accidental Hypothermia Strategy and implementation of the following:

- Updating St Johns' and Wellington Free Ambulance clinical practice guidelines and review of NZ Resuscitation Council guidelines in order to align with international best practice with regards to defibrillation and use of cardiac arrest drugs.
- Education of first responders and health care professionals of all levels
- Availability of suitable equipment:
 1. for recording temperatures
 2. for preventing further heat loss and active rewarming
 3. mechanical CPR devices
- Improved recording and data input of temperatures: site of measurement (oral, oesophageal etc) to be stated. This will optimize clinical case management, enable research and encourage quality improvements
- Major Trauma minimum data set to include pre hospital body temperatures
- A destination policy with designated rewarming centers
- Revision of referral criteria for ECMO (extra corporeal membrane oxygenation) in Auckland in line with international practice
- National coordination of response
- International Hypothermia registry participation for New Zealand

I am advising on the development of the NZ National Accidental Hypothermia Strategy guidelines for LandSAR, (Search and Rescue) NZ Police and Civil Defence. This is on schedule to be complete in May 2018.

My other, free-standing, abstract submission is an analysis of NZ Coronial information and Ministry of Health data and identifies the current baseline of harm.

Part 2: What can we do to save lives?

What needs to be done for New Zealand to achieve internationally accepted standards of management of Accidental Hypothermia?

The international experience is that unless specifically addressed, it is only too easy to manage accidental hypothermia in a suboptimal fashion.

There is no need to reinvent the wheel, precedents have been set by Canada, Scandinavian countries and Poland. Significantly improved patient outcomes are already being achieved there.

The seminal work done by Dr. Doug Brown et al in Canada in 2012 stressed the importance of strong links in the chain of survival and how to achieve those.¹⁴

The Polish team have in effect written a “receptie book” or manual in a series of published articles, starting with the article I referenced in part 1 about the incidence and under reporting of accidental hypothermia.

Public awareness and education by health care professionals

The article “Severe Accidental Hypothermia Center “¹⁵ explains the practical setting up of a programme: the need for a high profile public awareness campaign, the educational programmes for a wide range of health care professionals and emergency personell. In Poland this has been done via a free online e learning resource which had been completed by 25 000 staff by 2016.

A similar public education initiative was taken in Sweden, starting after a report by the Socialstyrelsen (Department of Health and Welfare) in 2003 and updated in 2009

“Undervisningsprogrammet grundar sig på Socialstyrelsens rapport Hypotermi, kylskador och drunkningstillbud i kallt vatten (artikelnr 2003-123-6), till vilken vi hänvisar för fördjupad kunskapsinhämtning.” This is published in Swedish, which I can read.

The estimated incidence from a similar area rose from 1.1 / 100 000 to 3.4 /100 000 between the years 1995 and 2014.^{3, 36} It was felt that this was due to increased recognition by health care professionals and the general public.

Coordinated response

The structure for a coordinated response also needs to be set up.

The current population of Poland is 38.5 million and the area of the country is 312 683 square km compared to NZ area is 268 021 i.e. Poland is 20% bigger but has 8.6 times bigger population.

In Poland health spending in 2013 per capita spend share of GDP is 6.4 %

In New Zealand health spending in 2013 per capita share of GDP is 9.5 % ie relatively speaking ¹⁶, more money is spent on health in NZ than in Poland.

Scotland also has fairly recently coordinated their emergency services and hospital response and has already started to reap good outcome, as shown in this 2016 letter to the editor of Resuscitation Journal. ³⁷

In New Zealand it should be fairly easy to coordinate: There may be 20 different District Health Boards, but in south Island 5 district health boards have grouped together to form the "South Island Alliance" and in North Island there are 3 alliances: Northern Regional Alliance (Upper North Island), Health Share (mid North Island), Central TAS (Lower North Island)

The Major trauma National Clinical Network (Northern Region, Midland Trauma, Central region and South Island) would be a perfect agency to implement this initiative.

As reported by Major Trauma National Clinical Network in their 2016-2017 annual report published in March 2018, which can be found here :

http://docs.wixstatic.com/ugd/bbebfb_7ca20c869cfa46f2a396c2d3cdfa339d.pdf

in February 2017 the Single Air Desk was implemented to coordinate primary air ambulance operations, and ACC and the MoH have commenced sector engagement on a co-design project for the future air ambulance system. This may mean longer response times for air ambulances compared to the current rescue helicopters. The Rotorua and Taupo helicopters may be rationalised away, potentially causing hypothermic patients to become more profoundly hypothermic due to increased response and transport times.

Relevance for trauma

It is well recognised that accidental hypothermia significantly adversely affects bloods' capability of clotting and thus increases blood loss in trauma. This increases morbidity and mortality.

There are different ranges of temperatures for the various stages of hypothermia (mild, moderate, severe and profound). For a patient who has traumatic injuries, a milder hypothermia (higher temperatures) have worse effect Thus, my proposed

initiative should be very welcome by the Major Trauma Clinical Network since it will have a great impact on the outcomes of their trauma patients.

Midland Trauma recognise in their guidelines that hypothermia prevent successful surgical outcomes.^{16b}

Data collection

Temperatures from referring hospital and definitive hospital are part of the National Trauma Minimum Dataset¹⁷, however, there is nothing to about documenting if it is oral, axillary rectal or oesophageal probe. Thus, this is not the most helpful way to collect temperature. There is also no mention of temperature on scene of trauma taken by emergency services.

This makes it impossible to assess how well emergency services do in keeping the patients warm or warming them up.

South Island data collection and input into national major trauma registry commenced 1 July 2016^{17b} The South Island is now contributing information to the national minimum dataset under a national agreement. Not all DHBs are submitting a complete set of data yet.

The South Island is now receiving a proportional share of the ACC incentive funding for entering data (Quarter 3 report 2016-2017)

Ambulance clinical guidelines

There are only two ambulance services in New Zealand , St Johns and Wellington free. They use the same clinical guidelines. These, and the NZ Resuscitation council guidelines, need to be updated in order to align with current best evidence from Europe as per the ICAR algorithm.¹⁸

The St John and Wellington Free practice guidelines only consider a patient with hypothermia to possibly be successfully resuscitated if they have been immersed by snow or water rather than having become cold just by exposure to the cold air or wet. This is erroneous and needs to be corrected.

The maximum number of defibrillator shocks recommended in the hypothermic patient (3) and the use of cardiac arrest drugs (none to be administered below body temp of 30 degree C) should be updated in the practice guidelines .

LandSAR NZ have already adopted this ICAR hypothermia algorithm for their use in the field, but do not currently have all the optimal equipment or training to use it.

The Polish Severe Hypothermia Centre team have in October 2017 published the results of a survey sent to international mountain rescue teams in order to find out about equipment, training and coordination of rewarming facilities and destination policies.¹⁹

The article has very clear directives as to what is optimal arrangements in these matters.

The electronic link to the “supplementary data” accesses the questionnaire. It is well worth clicking through to that, because it so clearly sets out the equipment and training requirements

Equipment: Thermometers, heating devices, fluid warmers, ECG monitor

Equipment shortcomings are often cited as explanation for suboptimal care.

Thermometers to record a patient's core temperature can be of help to determine the best management in the pre hospital environment. Rectal thermometers are not practical because the person's rectal regions need to be exposed and also if the probe is inserted into feces it does not register an accurate temperature. If the patient is intubated then oesophageal probes should be used.

If the patient is not intubated, then thermistor ear probes are the most accurate tool but sadly they are not easily available. (Made by Gilbert Metraux Electronique, Crissier, Switzerland)

The zero heat flux temperature sensor is very accurate for measuring core temperature, but currently no portable version is available (3M spot on now called Bair Hugger temperature sensor system).

Draeger have also produced what they call a "dual sensor" and is named "Tcore". It is compatible with Draeger monitors, some of which are totally portable and battery operated, and does not need additional batteries.

The Braun Thermoscan Pro 6000 is an infrared tympanic thermometer. These have until now not been considered accurate due to interference of ambient ear canal temperature. This version, which has only been available for about a year, has overcome this by having a separate thermistor sensor for the ear canal and then an algorithm is used to obtain an accurate core temp. The cost is currently \$NZ 366.

It accurately (± 0.3 °C) measures core body temp down to 20 °C.

Patients need to be able to be rewarmed, or be prevented to become cooled further in appropriate ways, depending on their level of hypothermia.

The equipment needed for this depends on the location i.e. where the patient is rescued and treated i.e. on the mountainside, in an ambulance or rescue helicopter.

Realistic expectations need to be made e.g., chemical heat packs may increase body temp by no more than 1°C but can at least prevent further cooling.

Reflective blankets should not be used since if a person is cold they do not produce any heat and thus there is none to be reflected.

It is a common mistake to underestimate the latent thermal heat energy of a hypothermic human body. An old wilderness survival technique used to be to put a warm person in the same sleeping bag as a hypothermic patient in order to rewarm them. If one does the energy calculations, it becomes apparent that there would need to be 300 additional people in the sleeping bag in order to generate sufficient heat to rewarm a hypothermic patient.

Warm blankets etc may give the rescuer a false sense of security that they are actively rewarming the patient when this is not actually possible with the equipment available in the prehospital location.

Vapour impermeable barriers need to be available, there are now body sized plastic bags made for this purpose. Bubble wrap has been used with good success in Scandinavia and Switzerland.³²

An ECG monitor needs to be available in order to tell what rhythm the patient is in. An AED will only advise whether it is a shockable or unshockable rhythm. However, in hypothermia one needs to know if the patient is brady cardiac (pulse may not be palpable) or in a-systole or in VF which should only be shocked no more than 3 times.

A-systole can be a trigger to terminate resuscitation efforts depending on other variables within the ICAR algorithm.

In the future POCUS (point of care ultra sound) is likely to be deployed a lot more widely in the pre hospital environment and it can be used to ascertain if there is cardiac activity.

If IV fluids are to be given to a patient who is or may become hypothermic, the fluids need to be warmed. However, it should be realised that an excessively large volume (14 litres) would be needed to raise the body temperature from 35 degree C to 37 degree C.

Equipment: mechanical CPR devices

Performing CPR during transport can be dangerous for the person performing it and the effectiveness may thus be subtherapeutic. Mechanical CPR devices have not shown better outcomes than manual CPR in hospital based studies but for transport the considerations mentioned above means they are definitely preferred for transport. When writing this (March 2018) there are only two mechanical CPR machines in NZ used for transport: Lucas 3 deployed since late 2017 by Auckland HEMS and a Corpulse being deployed by Westpac helicopter Christchurch since early 2018 on a trial basis. There are another 4 Corpulse devices currently being trialled in New Zealand but to my knowledge there are no mechanical CPR devices deployed in NZ land ambulances.

Once the patient has been found, and it has been considered that although they may look dead they are actually just cold which looks the same as being dead but may very well be reversible, active management is started. That means that priorities such as controlling external bleeding, airway, breathing and circulation is attended to and then their initial temperature will be measured, arrangements made to attempt to warm them (or not allow them to get progressively colder) and then a destination for their further care needs to be decided on.

Destination policy and ECMO

In New Zealand the Spinal cord injury destination policy was introduced in July 2015. This was a collaboration between St Johns ambulance, Wellington Free Ambulance, the ministry of health and ACC. I suggest the accidental hypothermia destination policy should be launched in the same way.

Patients who are profoundly cold would need to be taken to hospitals which can rewarm them in an appropriate manner. This has traditionally been done by various means such as peritoneal lavage or thoracic lavage etc. Heart lung bypass machines can be used but this is a surgically invasive procedure and overseas ECOM (extra corporeal membrane oxygenation) is the favoured method because it is less invasive and has better outcomes. This means that if a patient is transported to a district hospital, even before they arrive there the national hypothermia liaison officer will be notified that there is likely to be an ECMO case and preparations can start in order to save time. All this time the patient will be undergoing CPR, ideally by a mechanical device (which in Poland gets delivered from where the nearest device is kept to where it is needed) in order to have consistently high quality compressions. As can be seen in the literature, CPR for over 6 hours before ECMO is started is no barrier to a positive patient outcome. The awareness for this needs to be raised and CPR needs to be continued. This is in stark contrast in normo thermic cardiac arrest situations, and this is where the EMS and Health care professional education programs are of utmost importance.^{20,21,22,23,24,25,26,27,28,29,}

New Zealand has one ECMO center, in Auckland. They provide an outreach service where they collect patients from district hospitals all over the country. They pride themselves on their response time (unless adverse weather conditions) and the maximum time from being contacted to putting a patient on the ECMO machine is 6 hours. They then retrieve the patient, attached to the machine to Auckland.

I have been in email contact with the head of the department discussing the case load of severe accidental hypothermia up to now (April 2017) but the answer I received is that it is not an indication they recognize. This is contrary to the rest of the developed world health care provisions and this situation causes me considerable concern.

It is however, contradictory, that a clinical decision which is recommended in the Canterbury Health Pathways is for an intervention which is actually currently not possible to be accessed for patients in New Zealand.

All the considerations above for equipment and destination policies also need to take into account that there may be a mass casualty incident of hypothermic patients and how resources can be best planned to cope with a sudden influx of many patients.

HOPE score for prediction of outcome

There is now a Hypothermia outcome prediction after ECLS for hypothermic cardiac arrest: the HOPE score. This has been published in the March 2018 edition of Resuscitation journal³³ and the score mechanism is freely available online at www.hypothermiascore.org

These severe hypothermia cases may indeed be very rare but since the patient has a very good chance of survival with a very good neurological outcome.

In the HOPE score study the survival rate of hypothermic cardiac arrest is 37% with 84% of survivors neurological performance state 1 and 2.

In a previous single centre study from the Severe Hypothermia Centre in Krakow in 2013-2015 a 70% survival rate with excellent neurological outcome was achieved.³⁴

Even patients with primary hypoxia can have an unexpectedly good rate of survival with good neurological outcome (10.5%) according to a 2016 Norwegian paper³⁵

This compares more than favourably with the current survival rate of normothermic OHCA in NZ which is 15% to discharge home.

I feel strongly that patients in New Zealand should be afforded this possibility.

I believe this can only be achieved with a nationwide Accidental Hypothermia Guideline as discussed above.

International Hypothermia registry

I also believe that New Zealand should start reporting accidental hypothermia cases to the international hypothermia registry in order to further international knowledge. hypothermia-registry.org

Similarly, the Auckland ECMO center should join the Asia Pacific ELSO registry, in order that the patient outcomes of this unit are available in a transparent and professional manner.

Potential lives saved

As demonstrated in Part1 there may be about 100 lives per year positively impacted by improved accidental hypothermia care.

By reducing proportion of fatal outcomes there will be cost savings for Ministry of Health and ACC.

Patients who have had hypothermic cardiac arrest and been put on ECMO , if they do have a successful outcome then there is the potential that they could become organ donors. There is currently a shortage of organs for donation of in New Zealand according to the New Zealand official donor agency website Donor.co.nz. There were 72 alive and 73 deceased donors in 2017 and there are currently 550 patients on the donor waiting list, many of whom will die whilst waiting for organs.

Appendix 1:

The survivors

2006 to 2016 the total number of recorded, coded admissions with live discharge was 706.

Averaged out it is 70.6 admissions per year.

There may be a bit of an upward trend. 2015 had 90 admissions and from Ministry of Health they already had 88 recoded as of August 2017 (personal correspondence)

384 survivors (54 %) are over the age of 65

over age 85 : 163 patients

80-84: 86 patients

75-79:45

70-74:52

65-69:38

28 (3.9 %) are under the age of 15

13 patients under age of 4,

6 patients age 5-9 and

9 patients ages 10-14

The age group 15-19 has 36 patients (i.e. 5%) so whether one wants to treat them as paediatric or adult patients, that is the currently identified proportion.

Thus the remainder 412 patients (i.e. 58%) are ages 15 to 64.

If we treat the teenagers as children then 53% between 19 and 65

Again, that is unusual by international standards.

The commonest global experience is that it is the extremes of age i.e. the very old and the very young who suffer most. This data is may or may not be capturing any neonates even though the age range starts at 0 years.

The data does not tell us whether the patients admitted to hospital became cold indoors or outdoors.

Length of admission varies from 0 days to 132 days:

233 patients were admitted for 0 days stay (33%)

139 patients were admitted for 1 day (19.6%)

146 patients were admitted for 2-7 days (20%)

79 patients were admitted for 8-14 days (11%)

64 patients were admitted for 15 to 28 days (9%)

38 patients were admitted from 29 to 60 days (5%)

7 patients were admitted for 61 to 132 days (0.9 %)

Thus it can be seen that 50% of patients were admitted for one day or less.

Another 20% were admitted for up to and including 7 days.

No real conclusions can be drawn from this information since we do not have body temperatures on admission, method of rewarming or co morbidities, whether they be medical or trauma and nothing about whether the hypothermia was acquired indoors or outdoors.

This is the data which needs to be captured and be accessible for analysis.

This is only going to be possible if District Health Boards and emergency services are prepared to collect and share the data for research and clinical care improvement purposes.

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28: Swedish-Norwegian co-operation in the treatment of three hypothermia victims: a case report

Anders Wetting Carlsen, Nils K. Skjaervold, Nils Johan Berg, Øystein KarlsenEli Gunnarson and Alexander Wahba

*Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*2017**25**:73

<https://doi.org/10.1186/s13049-017-0418-5> (Open access)

29:A 95 year-old suffering circulatory arrest after accidental hypothermia: a case report Anders Wetting Carlsen, Anders M. Winnerkvist and Guri Greiff

BMC geriatrics October 2017

<https://doi.org/10.1186/s12877-017-0646-6> (open access)

30:Spreadsheets of data from Coroners Information Service can be supplied (I would need to de-identify personal data a little more prior to sharing)

31:Spreadsheet from Injury Statistics database can also be forwarded on request.

32) The prehospital management of hypothermia — An up-to-date overview, F Haverkamp, G Giesbrecht , E Tan

<https://doi.org/10.1016/j.injury.2017.11.001>

33) Hypothermia outcome prediction after extra corporeal life support for hypothermic cardiac arrest patients:The HOPE score

M Pasquier, O Hugli, P Pall, T Darocha,M Blancher,P Husby, T Sifvast PN arrone,V Rousson

<https://doi.org/10.1016/j.resuscitation.2018.02.026>

34) “The chain of survival in hypothermic circulatory arrest: encouraging preliminary results when using early identification, risk stratification and extracorporeal rewarming”

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35) Outcome after rewarming from accidental by use of extracorporeal circulation

Annals of Thoracic Surgery: Ö S Svendsen, K Grong, K Andersen, P Husby

<http://dx.doi.org/10.1016/j.athoracsur.2016.06.093>

36) Fatal Hypothermia: An analysis from a subarctic region

International Journal of Circumpolar health

H Brändström, A Eriksson, G Giesbrecht

<https://doi.org/10.3402/ijch.v71i0.18502>

37)

[http://www.resuscitationjournal.com/article/S0300-9572\(16\)30076-4/pdf](http://www.resuscitationjournal.com/article/S0300-9572(16)30076-4/pdf)