
Published in March 2005 by the
Ministry of Health
PO Box 5013, Wellington, New Zealand

ISBN 0-478-28323-7 (Internet)
HP 4028

This document is available on the Ministry of Health’s website:
http://www.moh.govt.nz
# Contents

Acknowledgements vi

Introduction 1

Data Sources 2
- Cancer mortality data 2
- Population data 2

Methodology 3
- Cancer site selection 3
- Geographic units 4
- Calculation of mortality measures 7

Map Reading Guide 11
- Layout design 11
- Classification of rates 11
- Insufficient data 11
- Statistical significance of rates 11

Cancer Maps 13
- Bladder cancer 14
- Brain cancer 17
- Breast cancer 20
- Cervical cancer 21
- Colorectal cancer 22
- Head and neck cancer 26
- Kidney cancer 30
- Leukaemia 33
- Liver cancer 37
- Lung cancer 41
- Melanoma 46
- Myeloma 49
- Non-Hodgkin's lymphoma 52
- Oesophageal cancer 56
- Ovarian cancer 60
- Pancreatic cancer 61
- Prostate cancer 65
- Stomach cancer 66
- Uterine cancer 70

Data Tables 71

References 73
List of Figures

Figure 1: District Health Boards in New Zealand 5
Figure 2: Territorial authorities in New Zealand 6
Figure 3: Rate information neighbourhood for South Waikato District showing 1st, 2nd and 3rd order CAUs 10
Figure 4: Interpreting the maps 12
Figure 5: Bladder cancer, total population 14
Figure 6: Bladder cancer, female population 15
Figure 7: Bladder cancer, male population 16
Figure 8: Brain cancer, total population 17
Figure 9: Brain cancer, female population 18
Figure 10: Brain cancer, male population 19
Figure 11: Breast cancer, female population 20
Figure 12: Cervical cancer, female population 21
Figure 13: Colorectal cancer, total population 22
Figure 14: Colorectal cancer, female population 23
Figure 15: Colorectal cancer, male population 24
Figure 16: Colorectal cancer, ethnic population 25
Figure 17: Head and neck cancer, total population 26
Figure 18: Head and neck cancer, female population 27
Figure 19: Head and neck cancer, male population 28
Figure 20: Head and neck cancer, ethnic population 29
Figure 21: Kidney cancer, total population 30
Figure 22: Kidney cancer, female population 31
Figure 23: Kidney cancer, male population 32
Figure 24: Leukaemia, total population 33
Figure 25: Leukaemia, female population 34
Figure 26: Leukaemia, male population 35
Figure 27: Leukaemia, ethnic population 36
Figure 28: Liver cancer, total population 37
Figure 29: Liver cancer, female population 38
Figure 30: Liver cancer, male population 39
Figure 31: Liver cancer, ethnic population 40
Figure 32: Lung cancer, total population 41
Figure 33: Lung cancer, female population 42
Figure 34: Lung cancer, male population 43
Figure 35: Lung cancer, Maori population 44
Figure 36: Lung cancer, non Maori population 45
Figure 37: Melanoma, total population 46
Figure 38: Melanoma, female population 47
Figure 39: Melanoma, male population 48
Figure 40: Myeloma, total population 49
Figure 41: Myeloma, female population 50
Figure 42: Myeloma, male population 51
Figure 43: Non-Hodgkin’s lymphoma, total population 52
Figure 44: Non-Hodgkin’s lymphoma, female population 53
Figure 45: Non-Hodgkin’s lymphoma, male population 54
Figure 46: Non-Hodgkin's lymphoma, ethnic population
Figure 47: Oesophageal cancer, total population
Figure 48: Oesophageal cancer, female population
Figure 49: Oesophageal cancer, male population
Figure 50: Oesophageal cancer, ethnic population
Figure 51: Ovarian cancer, female population
Figure 52: Pancreatic cancer, total population
Figure 53: Pancreatic cancer, female population
Figure 54: Pancreatic cancer, male population
Figure 55: Pancreatic cancer, ethnic population
Figure 56: Prostate cancer, male population
Figure 57: Stomach cancer, total population
Figure 58: Stomach cancer, female population
Figure 59: Stomach cancer, male population
Figure 60: Stomach cancer, ethnic population
Figure 61: Uterine cancer, female population

List of Tables
Table 1: Number of deaths for each cancer site, 1994-2000
Table 2: Page references for cancer site and population groups maps
Table 3: District Health Board population, 1996 Census
Table 4: Territorial authority population, 1996 census
Acknowledgements

This atlas is the outcome of joint work undertaken by Public Health Intelligence (Barry Borman, Ruth Pirie, Craig Wright), Ministry of Health and the School of Geography and Environmental Science, University of Auckland (Pip Forer and Ron King).

The atlas was reviewed by Paul White (Public Health Intelligence, Ministry of Health) and Jamie Pearce (Department of Geography, University of Canterbury).

Disclaimer

Opinions expressed in this report are those of the authors alone, and do not necessarily reflect the views of the Ministry of Health or the peer reviewers. The Ministry of Health accepts no liability for decisions or actions based on the contents of this report.
Introduction

The first cancer mortality atlas for New Zealand was published more than 20 years ago by the Department of Health (Borman 1982). Cancer deaths over a five-year period (1974 to 1978) were used to calculate standardised mortality ratios for hospital boards and at the finer scale of urban areas and counties in effect at that time. Data were mapped for the male and female population groups showing the statistical significance of the mortality rates compared to the total New Zealand population. Age and sex specific annual mortality rates for a 25-year time period (1949 to 1973) were calculated and graphed. Rates were also calculated for two different decades (1949 to 1958 and 1969 to 1978) and statistical methods were applied to test whether mortality was significantly different between the two time periods.

More recently, Public Health Intelligence published statistical models of cancer incidence and mortality for all adult cancer, all childhood cancer, and 26 selected types of cancer separately in Cancer in New Zealand: Trends and Projections (Ministry of Health 2002). The models were fitted to historical trend data from the 1950s (incidence) or 1970s (mortality) to the late 1990s, and then projected out to the early 2010s.

The Atlas of Cancer Mortality in New Zealand 1994–2000, shows the recent spatial patterns of cancer mortality in New Zealand. The patterns show areas with a high or low cancer mortality, but they do not imply the causation of any cancer. No attempt has been made to investigate or suggest possible factors underlying or causing these patterns. However, the maps can be used as a stimulus for further research by suggesting possible aetiological hypotheses.

Seven years of data, based on the ‘usual place of residence’, have been used to calculate cancer mortality rates for the total population (all ages, both sexes and all ethnic groups), for each sex (males and females) and for two ethnic groups (Māori and non Māori). A spatial smoothing technique and statistical tests are applied to provide robust cancer mortality estimates for the administrative areas of District Health Boards (DHBs) and Territorial Authorities (TAs).
Data Sources

Cancer mortality data
Cancer mortality data for the period 1994 through to 2000 are used for this atlas. Mortality data are collected as part of National Minimum Dataset (NMDS) by the New Zealand Health Information Service (NZHIS).

The causes of death were coded to the Australian Version of the World Health Organisation (WHO) International Classification of Diseases, 9th Revision (2nd ed), Clinical Modification (ICD-9-CMA-II).

The specified underlying cause of death is based on information from a range of sources including death certificates from doctors or coroners, post-mortem reports from private pathologists and hospitals, and death registration forms which are usually completed by funeral directors.

Information was extracted by ICD-9 code, and included year of death, age at death (grouped into five-year age bands), gender, ethnicity (Māori and non Māori), DHB, Territorial Authority (TA) and domicile code.

The domicile code, which is equivalent to a census area unit (CAU), is assigned to each record based on the usual residence of the person at the time of death.

Population data
Population data for DHBs and TAs from the Statistics New Zealand 1996 Census of Population and Dwellings are used to calculate the mortality rates for each cancer site.
Methodology

Cancer site selection

The selection of cancer sites for the atlas was based on having sufficient numbers of deaths over the seven-year time period in which to calculate robust sub-national mortality rates for the geographic areas of DHBs and TAs (Table 1).

Table 1: Number of deaths for each cancer site, 1994-2000

<table>
<thead>
<tr>
<th>Cancer site description</th>
<th>ICD9 code(s)</th>
<th>Deaths</th>
<th>% (as a proportion of all cancers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder</td>
<td>188</td>
<td>1,160</td>
<td>2</td>
</tr>
<tr>
<td>Brain</td>
<td>191</td>
<td>1,403</td>
<td>3</td>
</tr>
<tr>
<td>Breast (female only)</td>
<td>174</td>
<td>4,406</td>
<td>8</td>
</tr>
<tr>
<td>Cervix</td>
<td>180</td>
<td>542</td>
<td>1</td>
</tr>
<tr>
<td>Colorectal</td>
<td>153–154</td>
<td>7,877</td>
<td>15</td>
</tr>
<tr>
<td>Head and neck</td>
<td>140–149,161</td>
<td>1,884</td>
<td>4</td>
</tr>
<tr>
<td>Kidney</td>
<td>189</td>
<td>1,073</td>
<td>2</td>
</tr>
<tr>
<td>Leukaemia</td>
<td>204–208</td>
<td>1,770</td>
<td>3</td>
</tr>
<tr>
<td>Liver</td>
<td>155</td>
<td>824</td>
<td>2</td>
</tr>
<tr>
<td>Lung</td>
<td>162</td>
<td>9,857</td>
<td>19</td>
</tr>
<tr>
<td>Melanoma</td>
<td>172</td>
<td>1,517</td>
<td>3</td>
</tr>
<tr>
<td>Myeloma</td>
<td>203</td>
<td>938</td>
<td>2</td>
</tr>
<tr>
<td>Non-Hodgkin's lymphomas</td>
<td>200, 202</td>
<td>3,934</td>
<td>7</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>150</td>
<td>1,352</td>
<td>3</td>
</tr>
<tr>
<td>Ovary</td>
<td>183</td>
<td>1,222</td>
<td>2</td>
</tr>
<tr>
<td>Pancreas</td>
<td>157</td>
<td>2,093</td>
<td>4</td>
</tr>
<tr>
<td>Prostate</td>
<td>185</td>
<td>3,768</td>
<td>7</td>
</tr>
<tr>
<td>Stomach</td>
<td>151</td>
<td>2,026</td>
<td>4</td>
</tr>
<tr>
<td>Uterus</td>
<td>179, 182</td>
<td>1,016</td>
<td>2</td>
</tr>
<tr>
<td>All cancer deaths</td>
<td>140–239</td>
<td>53,175</td>
<td>–</td>
</tr>
</tbody>
</table>

The cancer sites selected for analysis in the atlas are similar to those used in the publication Cancer in New Zealand: Trends and Projections (Ministry of Health 2002). A separate analysis of cancers of children and adults could not be carried out, as the number of deaths for children at the DHB level was insufficient to calculate stable rate estimates.
**Geographic units**

The primary geographic areas used in this atlas are the 21 DHBs in New Zealand (Figure 1) ranging in population size from 411,837 for the Canterbury DHB to 32,566 for the West Coast DHB (average DHB population of 177,966). To provide a more detailed level of analysis, the 74 TAs in New Zealand (Figure 2) with populations from 345,280 in Auckland City to 732 in the Chatham Islands District Council (average population of 50504) are also used for analysis.
Figure 1: District Health Boards in New Zealand

District Health Board
1 Northland
2 Waitemata
3 Auckland
4 Counties Manukau
5 Waikato
6 Bay of Plenty
7 Lakes
8 Tairawhiti
9 Taranaki
10 Whanganui
11 MidCentral
12 Hawke's Bay
13 Wairarapa
14 Hutt
15 Capital and Coast
16 Nelson Marlborough
17 West Coast
18 Canterbury
19 South Canterbury
20 Otago
21 Southland

Population (1996 Census)
- <100,000
- 100,000-250,000
- >250,000

The Chatham Islands are part of the Hawke's Bay DHB
Figure 2: Territorial authorities in New Zealand
Calculation of mortality measures

Two different measures have been calculated allowing comparisons to be made between different regions and between a regional and the national cancer mortality rate. A directly standardised rate (DSR), taking into account the underlying population structure (age and gender), and a comparative mortality ratio (CMR)\(^1\) have been calculated.

The DSR has been calculated for each region and the total New Zealand population using the World Health Organization (WHO) world population (WHO 2000) as the standard population. In order to provide stable rates, the regional rates have been calculated from spatially smoothed data (see spatial smoothing section below).

The CMR has been calculated using the equation:

\[
\text{CMR} = \frac{\sum_i w_i \frac{d_i}{n_i}}{\sum_i w_i \frac{D_i}{N_i}}
\]

The equation in this form (where a standard population is used instead of the national population) is essentially one directly standardised rate (the local) over another (the national). In this equation \(w_i\) is the standard population weight (WHO 2000), \(d_i\) represents deaths and \(n_i\) is the population for age group \(i\) in the study area, and \(D_i\) and \(N_i\) the corresponding national values.

The CMR has been used in preference to the standardised mortality ratio (SMR) that has been more commonly used historically. An SMR can only be used to compare the mortality for each geographic area to the standard population (i.e. the total New Zealand mortality rate). In contrast the CMR can be used to compare different geographic areas to each other as well as to the standard population. In addition the directly standardised rate can be shown on the same legend as the CMR (Pickle et al 1996).

The interpretation of CMRs is analogous to that of an SMR (ie, any value over 100 indicates a less favourable outcome).

With small numbers and large variations in populations between geographic areas it is important to distinguish between those areas that show a statistically significant difference in mortality rate and those for which incidence is more likely due to random variations in the data. Three methods have been used to address this issue. Confidence intervals have been calculated, a minimum number of deaths and person years of population data has been set for calculating mortality rates and a spatial smoothing technique has been used.

Each of these methods is explained in more detail in the following sections.

Confidence intervals

Confidence intervals for the directly standardised rates have been calculated using a binomial approximation model. This model is recommended when health events are rare and not normally distributed as is the case with cancer mortality (Devesa et al 1999).

\(^1\) Also known as comparative mortality figures (CMF) and standardised rate ratios (SRR).
**Small numbers**

A small number of cancer deaths in a particular area can make the estimation of rates difficult. Two circumstances introduce small number problems even using geographically large administrative regions in New Zealand. The first is that the population is unevenly distributed. At the DHB level there is a tenfold difference between the largest and smallest DHB and this increases to a hundredfold difference at the TA level. A second factor is the desire to extend any analysis to the Māori population who number approximately 530,000 people in New Zealand. The DHB populations range from 63,000 living in the Waikato DHB area to 3000 living in the West Coast DHB.

The calculation of rates and confidence intervals using small numbers of health events and small populations may produce significant rates, even though the rate is considered unstable. Rates are considered unstable when small variations in mortality disproportionately affect rate estimates. A relative standard error (the standard error as a proportion of the rate) of 25% was selected to determine the minimum criteria of 16 deaths and a minimum population of 50,000 person years over the time period 1994 to 2000 that was used to calculate mortality rates. Where geographical areas did not meet these minimum requirements the areas have been shaded grey on the map and labelled as “insufficient data”.

Population maps are not provided where the national level mortality numbers are insufficient to provide a relatively complete or useful geographic representation of mortality for a particular cancer site (though these data is available in tabular form in the spreadsheet associated with this atlas).

**Spatial smoothing**

Spatial smoothing techniques attempt to reduce the level of random variation in the data by adding information from elsewhere. Information can be added by increasing the time period or the extent of the area used to calculate the rate. The resulting map or graph shows a clearer picture of the spatial or temporal distribution of the data as the random effects have been removed.

A combination of a seven-year time period and a geographic smoothing technique has been used to provide a robust estimate of the cancer mortality incidence.

The principle of spatial smoothing is simple. Adjacent information is added to an area in order to increase data stability. Spatial smoothing will adjust a rate towards either the national or regional value. While spatial smoothing has traditionally been applied globally, equally affecting all rates, the technique developed for this atlas is an adapted form of using a filter size of constant or nearly constant population size (Talbot 2000). With this technique rates are only smoothed when the population and event numbers do not meet the minimum criteria (16 deaths and 50,000 person years). Regions with population numbers that meet the minimum criteria will not be affected by smoothing.
The smoothing is applied at both DHB and TA levels in an identical manner. For each TA and DHB area a ‘rate information neighbourhood’ (Figure 3) is constructed using contiguous, adjacent CAUs of first, second and third orders. The neighbourhood data is weighted according to distance, with first order data set at 1.00, second order at 0.66, and third order at 0.33 to maintain maximum geographic specificity. The weighted CAU data is added to the DHB or TA area data until the specified minimum deaths and population criteria, set at 16 and 50,000 respectively for this atlas, are met. This summed data is used to calculate the directly standardised rates. In addition, the hierarchy ensures optimal concordance between TA and DHB rates by using the same CAU information where the boundaries coincide.

This smoothing confers a number of advantages to the atlas over unsmoothed rates. First, rates can be calculated for areas that would otherwise be censured due to small number issues. Secondly, rates calculated in less populated regions are more stable as they are less affected by random variation in the data. Finally, this greater stability better enables national or regional comparisons between more densely populated urban areas and sparsely populated regions.

Depending on the technique employed the use of smoothing may result in the loss of some local spatial information and a reduction in the geographic specificity. Data tables are provided as an Excel spreadsheet to allow more detailed examination of the number of deaths and the calculated mortality rates for each geographic area.
Figure 3: Rate information neighbourhood for South Waikato District showing 1st, 2nd and 3rd order CAUs