**Discussion**

The maps presented in this report show some geographic variation in New South Wales for incidence, and to a lesser extent, mortality for common cancers.

This is a comprehensive atlas of cancer incidence for NSW and is the first publication to systematically present cancer mortality maps in NSW. We have kept interpretation to a minimum, dealing only with those cancer sites for which a statistically significant geographic variation was identified.

**All cancers**

There was no statistically significant geographic variation in the incidence of all cancers for either sex. However, statistically significant variation was observed for mortality from all cancers for both males and females. For males, high mortality rates extended north from Sydney along the coast to Newcastle and south along the coast to Shoalhaven. Higher mortality rates were observed for males in the inner western suburbs of Sydney and lower rates in Sydney’s northern suburbs and in the Sutherland Shire. An area in the northeast corner of the State adjacent to the Queensland coastal border had generally lower than average mortality for both sexes.

Differences in mortality are often caused by similar circumstances as those that determine incidence rates. When considering all cancers combined, mortality rates can be highly influenced by those cancers with higher case fatality ratios. The availability and uptake of effective screening, early detection and treatment in different areas can also affect mortality. Significant variation in site-specific mortality rates occurred only in lung, rectal and stomach cancers. The overall mortality pattern, particularly for males, most closely resembled the mortality pattern observed in lung cancer. Lung cancer is the most common cause of cancer mortality and has a high case fatality ratio. Smoking, alcohol consumption, diet, and Hepatitis B and C infection are risk factors known to be associated with cancers with poorer prognoses, which may affect the patterns of mortality observed. This underlines the continued importance of prevention of lung cancer through tobacco control.

Socioeconomic status, associated with differing smoking habits, appears to be related to overall cancer mortality, with higher mortality in areas of lower socioeconomic status. The quality of the healthcare system and its use by cancer patients and clinicians may also have a role in influencing this pattern.

The lower mortality rates in both sexes in the north of the State may be influenced by under enumeration caused by patients seeking treatment in Queensland and dying outside of NSW. While the NSW Central Cancer Registry obtains notifications from Queensland institutions the deaths may not always be attributed to NSW as the place of residence.

**Specific cancers**

**Liver cancer**

The incidence of liver cancer for both sexes was higher in inner Sydney and the eastern and western suburbs of Sydney. Lower incidence rates were observed throughout the rest of the State.

There is wide international variation in liver cancer incidence, with relatively lower rates in Australia and other Western countries, but it is one of the most common cancers in eastern Asian and African countries. Liver cancer is more common in Asian-born migrants to NSW (from
Vietnam, Hong Kong, Korea and China) with incidence rates being more than five times those of the Australian born population\(^\text{11}\). Hepatitis B Virus (HBV) and Hepatitis C Virus (HCV) are the major causes of liver cancer. Aflatoxins, alcohol consumption, cirrhosis and smoking also increase the risk of developing liver cancer\(^\text{12}\).

The reasons for the higher rates in the western and eastern suburbs of Sydney may be different. The higher incidence rates in the western suburbs of Sydney, especially in the Liverpool-Fairfield area, are probably due to the higher proportion of migrants from Vietnam and other eastern Asian countries where the prevalence of Hepatitis B infection is much higher than for Australia as a whole. In the eastern suburbs of Sydney, the higher rates might be due to a combination of higher alcoholic liver disease and the higher prevalence of notified Hepatitis C infection\(^\text{13}\).

The NSW Chief Health Officer’s Report established that Hepatitis B notifications are highest in Sydney South West (125.2 per 100,000) and Sydney West (65.5 per 100,000) area health services and Hepatitis C notifications in Sydney South West (121.3 per 100,000) and the North Coast (136.4 per 100,000) area health services\(^\text{14}\). The high notification rates for Hepatitis B and C infection in Sydney South West coincided with the higher SIR for liver cancer indicating that these infections were likely to be a contributing factor.

While alcohol is a known risk factor for liver cancer, the reported patterns of alcohol consumption across the State do not reflect the pattern of liver cancer incidence. Both the NSW Health Survey and the Australian Longitudinal Study on Women’s Health respectively have shown that males and females in rural and remote areas of NSW consume alcohol at higher levels than in urban areas\(^\text{15,16}\).

### Lung cancer

Lung cancer incidence for males, and mortality from lung cancer for both sexes, showed a significant geographical variation across NSW. With a poor prognosis, as indicated by a five-year relative survival of 13.2\(^\text{17}\), mortality patterns were very similar to incidence patterns across the State. Male incidence rates were highest in the inner western and western Sydney regions and in the north central plain of NSW. For females, the higher mortality rates extended from the eastern suburbs of Sydney to the western suburbs and also south from Sydney along the coast to Eurobodalla. Incidence and mortality rates for males were lowest in the northern suburbs of Sydney.

Tobacco consumption is a proven risk factor for lung cancer. English et al\(^\text{18}\) estimated that in Australia 77\% of all lung cancers in women and 84\% in men were caused by smoking. Passive smoking, certain occupational exposures, domestic and environmental pollution also increase the risk of lung cancer. The National Health Survey conducted by the Australian Bureau of Statistics, in 2004-2005 found that in Australia 20\% of major city residents, 23\% of inner regional residents and 26\% of outer regional residents are current daily smokers\(^\text{19}\). Although a larger percentage of rural residents were current daily smokers compared to urban residents, it is likely that the lower rate of lung cancer in the Sydney area may be driven by historical smoking patterns. Studies have shown a negative correlation between socioeconomic status and both the occurrence and duration of smoking\(^\text{20,21}\).

While a diet high in vegetables and fruit has been proven to offer marginal protection against the development of lung cancer\(^\text{22}\), the National Nutrition Survey in 1993, reported little difference in the daily intake of fruit and vegetables between metropolitan, rural and remote areas of Australia\(^\text{23}\).
Melanoma of the skin

The previously observed patterns in the incidence of melanoma in NSW\textsuperscript{24} continued in NSW in 1998 to 2002. Higher incidence rates for both sexes were evident along the coast, particularly the North Coast. For females, higher incidence rates extended inland off the northern coastline and in the Sydney harbour-side and northern suburbs. For both sexes, rates were lower in the western suburbs and for males in the inner west of Sydney.

Exposure to ultraviolet (UV) radiation from sunlight is the main risk factor for melanoma and is estimated to cause in excess of 96\% of melanoma cases in Australians\textsuperscript{25}. Intermittent or recreational exposure to sunlight, and exposures in childhood, appear to be more important risk factors compared with occupational exposure and adult levels of exposure\textsuperscript{26}. Migrants to Australia and people with pigmented skin are at lower risk of melanoma than pale skinned Australians\textsuperscript{11}.

Areas with higher incidence appear to correspond with coastal areas in which people of current or past higher sun-related recreational activity are likely to live. Lower rates, particularly for males, were found in areas where higher proportions of migrants live.

Oesophageal cancer

Oesophageal cancer incidence in males showed strong urban-rural differences. Higher incidence rates for males were found in non-metropolitan areas, with southern NSW consistently having the highest rates. The inner Sydney LGAs, comprising the Sydney Statistical Division, had the lowest incidence rates.

Tobacco and alcohol use are known to increase the risk of oesophageal cancer, as well as having Barrett’s Oesophagus, heartburn, being overweight or having a diet low in fruit and vegetables\textsuperscript{12}.

The geographical patterns of oesophageal cancer for males show similarities with other tobacco-related cancers, particularly lung and head and neck cancers, indicating the likely role of tobacco, possibly in combination with alcohol in contributing to the observed variations in NSW. Both the NSW Adult Health Survey and the Australian Longitudinal Study on Women’s Health have shown that people living in rural and remote areas of NSW consume alcohol at higher levels than in urban areas\textsuperscript{15,16}.

Prostate cancer

Incidence rates for prostate cancer varied greatly across NSW. Rates were significantly higher in the central west and south of NSW. Lower incidence rates were seen in the north-eastern area of NSW.

Australia has a high incidence rate of prostate cancer and it ranks as the most common type of cancer in Australians after non-melanoma skin cancer. Little is known about the causes of most prostate cancers. The most credible hypotheses about causation identify hormonal patterns, family history and diet as risk factors\textsuperscript{12}.

Screening using the Prostate Specific Antigen (PSA) test can result in the detection of otherwise insignificant abnormalities and is likely to play a role in the high rates of prostate cancer in NSW and to contribute to geographic variation. However, studies have shown that across Australia, PSA testing was less common in regional/rural areas than in capital cities\textsuperscript{27}, which tends to
counter the geographical patterns observed in this report, and individual factors may play a role for example, access to urologists.

Australian-born residents of NSW have the highest risk of diagnosis of prostate cancer compared to most of the major countries from which migrants have arrived. It is possible that PSA testing rates differed across different migrant groups in different areas, particularly in Sydney where most of the migrant populations live.

**Rectal cancer**

While there was no spatial pattern in the incidence of rectal cancer for either sex there was evidence of geographical variation in mortality for males. Rates were slightly (but not statistically significantly) higher in the Riverina.

Smoking, diet, being overweight, having a family history of bowel cancer and having a history of polyps are all thought to be important causes of rectal cancer. Early detection programs, although not widespread during the study period for this report, may account for some of the geographical variation.

**Stomach cancer**

The incidence and mortality for stomach cancer for both sexes showed spatial variation across NSW. Incidence and mortality rates were generally higher in the greater Sydney region than in the rest of NSW, particularly in the west and southwest Sydney areas. Lower mortality rates for females were observed in the north-eastern corner of NSW and the north shore and eastern suburbs of Sydney.

*Helicobacter pylori* is a known cause of stomach cancer. Long-term infection with this bacterium can lead to chronic inflammation and damage to the lining of the stomach, and possible pre-cancerous changes. Studies have shown an association between increased prevalence of *Helicobacter pylori* bacteria and lower socioeconomic status. Risk of stomach cancer is reduced by higher intake of fruit and vegetables and lower consumption of salted, smoked or pickled foods.

Stomach cancer is generally more common in NSW residents from southern European and Asian countries than in Australian-born residents.

The observed higher incidence reflects areas with larger proportions of migrant populations from places where *Helicobacter pylori* exposure is common and dietary intake of smoked, salty or pickled foods is high.

As the mortality pattern largely reflected the incidence patterns for both sexes it would appear that most of the differences in mortality are due to differences in incidence patterns. They may also be influenced by regional differences in the patterns of care.

**Thyroid cancer**

Thyroid cancer incidence for females showed a strong geographical relationship, with higher rates in Sydney and lower rates in almost all other non-Sydney areas. Rates in the Hunter and New England areas were significantly lower.
The only known risk factor for thyroid cancer is ionising radiation. However, several more recent studies have implicated benign thyroid nodules and goitre, hormonal and reproductive factors, diet (particularly iodine deficiency or excess) and genetic factors.

The precise reason why there are such great differences for females between Sydney and non-Sydney areas in the incidence, is not currently clear. Internationally, where this type of variation exists in thyroid cancer, it appears that wide diversity in diagnostic, treatment and reporting practices are partly responsible.