MORTALITY FROM SELECTED CANCERS IN NSW AND SYDNEY, AUSTRALIA

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Abstract—This study utilizes unit list mortality data for New South Wales, Australia in differential mortality analysis, at state and local levels, and examines geographic patterns of stomach, colorectum, respiratory system, female breast cancer and total cancer mortality in Sydney. Associations between manual occupations, low socioeconomic status and male stomach and respiratory cancer mortality were found, as were higher mortality from stomach and respiratory cancer among European-born immigrants in manual occupations. However, unexpected associations were also found between high mortality from stomach and respiratory cancers and managerial occupations. There were also more acute associations between colorectum and female breast cancer and higher status areas. Further, mortality variations between specific occupational groups occurred when marital status was controlled for, and the strongest variations were between married and never married males where the social isolation risk factors were presumed to be operative. The highest mortality at the local level in Sydney occurred where more than one at risk population resided and where other influences may have been operative.

Key words—occupational mortality, marital status/social isolation, immigrant populations, geographic patterns

INTRODUCTION

This study first examines differential mortality from total cancer and selected cancers in New South Wales during 1980–86 and then spatial variations in Sydney. The aim is identification of populations at risk, by assessing socioeconomic characteristics of people dying at the state level, and in localities of higher mortality. The state of New South Wales with 5.4 million people contains a third of the population of Australia. Sixty-two percent, or 3.35 million, of the NSW population resided in Sydney at the 1986 census (Fig. 1).

Cancer has become one of the major causes of death in Australia, and the proportion of all deaths resulting from cancer increased from 16% during 1970–72 to 25% in the mid 1980s. This increase only in part reflects decreases in deaths from stroke and heart disease [1]. The cancers selected for this study were colorectum cancer, stomach cancer, respiratory cancer and female breast cancer. The cancers chosen were those in which exogenous factors are believed to be strongly influential in the development of the disease, in which the exogenous factors may vary by cancer type in relative importance; in which the geographies of mortality may vary between cancer types; and in which there may be variation by socioeconomic characteristics.

Cancer may result from the interrelationship between endogenous and exogenous factors such as socioeconomic and environmental conditions which may act on the immune system [2]. Given that cancers are comprised of many diseases whose aetiology may vary [3], there may be different geographies of cancer. Indeed in the United Kingdom, Howe [4] found that lung cancer had higher levels in the northern industrial cities, lowland Scotland and eastern London, and breast cancer in the southeast, in east London and outer western London. Meanwhile Gardner et al. [5], found higher rates of stomach cancer in urban areas of northwest England, north Wales, west Midlands, and also in southeast London. He suggested synergistic factors: smoking, social class, pollution by chemicals like polycyclic hydrocarbons, radiation, and physical materials like asbestos [6].

Cancer of the stomach has been associated with certain occupational groups—coal miners [7], oil refinery and petrochemical workers [8] rubber industry workers [9], and has been found to correlate with low socioeconomic status [10], cigarette smoking [11], alcohol intake, and radiation exposure [12]. Dietary intake may be influential, particularly dried/salted fish and pickled vegetables [13], cabbage and potatoes [14] and cooked fat, fried foods and bacon [15]. A consistent finding has been the negative correlation of stomach cancer with the intake of fresh fruits and vegetables, although green vegetables contain nitrates and complex carbohydrates which may be associated with cancer. Nitrates, as found in drinking water, green vegetables, cured meats and some cheeses, may combine with secondary aminos from food products, or tertiary aminos from certain drugs or pesticides to form nitrosamines in the presence of acidic bacterial action in the stomach [16].

Diet has also been invoked with cancer of the colon [17], with beef, string beans and total starches being implicated [18], and animal fats as biochemical agents. Bowel cancer may be promoted by metabolites of rich
foods and as such may be a cancer of affluence, with suggested relationships between high fat diets and increases in bile production and flow which may then affect the bowel [19]. Analyses of cancer and diet for 37 countries showed that colon and breast cancer have a strong correlation with each other, with animal fat, with animal protein, with egg consumption, with numbers of vehicles in the community, and with income [20]. In the U.S.A., colon cancer has higher rates in counties having higher income and educational levels and a greater proportion of the population of Irish, German or Czech descent [21], this suggesting the affluence factor in nutrition [22].

In the U.S.A., also, rates of respiratory system cancer have clustered in seacoast communities along the Atlantic and Gulf coasts [23], and a small urban excess is still evident even after controlling for smoking habits [24]. An inverse association between lung cancer and socioeconomic status has been observed in British mortality data [25], and smoking habits contribute part of the socioeconomic differential of respiratory cancer [26].

In Australia, Learmonth and Grau [27] found an urban bias in mortality from stomach cancer while Burnley [28] found with total cancer, which was higher in Sydney and Melbourne, that there were spatial correlations with social isolation and low socioeconomic status variables. So far, however, there has been limited spatial analysis of different types of cancer in Australia.

The hypotheses to be tested were:

(a) that total cancer mortality varied by socioeconomic status, with higher mortality expected among low socioeconomic status workers;
(b) that mortality from respiratory and stomach cancer mortality would be higher among low socioeconomic status workers, and in areas characterized by these workers;
(c) that mortality from colorectal cancer would be higher among higher status persons, the imputed inference being that lifestyle influences the development of the disease [19];
(d) that breast cancer would vary by socioeconomic status, possibly reflecting fewer children and related biological factors that may influence the development of the disease [20]. This involves analysis by marital status and by usual residence of the deceased;
(e) that cancer mortality would be higher among never married and divorced persons [21].
marital status data are surrogates for the 'social isolation' construct, viz. some persons living alone may be more at risk for a complex of dietary, life style, self respect and selectivity reasons. Of course many never married and divorced persons have supportive social networks; (f) that cancer mortality might vary between areas because of factors associated with higher densities or crowding [30].

It was also considered that occupational (socio-economic) differences in mortality might vary in relation to marital status (or social isolation), and that occupational differences might also vary by birthplace. Specifically, that persons of lower socioeconomic status, and who were never married would be more at risk, and that ethnicity and lower socioeconomic status together could result in some categories of people being more at risk from dying of cancer, this reflecting in part societal inequalities.

DATA

The data comprises death certificate information on the unit list mortality tapes produced by the Australian Bureau of Statistics. Deaths by ICD Ninth Revision primary cause of death by age and sex are available for NSW and statistical local areas, by marital status, and birthplace, and by occupational status for males under age 65. The female occupational status data are incomplete. Prior to 1985, data were not provided by occupation with women at all, and data in 1985 and 1986 were only partially recorded. Attempts are being made by the Australian Bureau of statistics and the State Registrar Generals, to record occupations more fully for women, on death certificates.

As the mortality statistics are de jure statistics, the Australian Bureau of Statistics (ABS) estimated resident population statistics for the 43 Sydney SLAs for the 1981 and 1986 censuses were used for the derivation of expected numbers of deaths. Interpolated populations were derived for the mid point in time, of the data set, 30 June 1983. The estimated resident populations have been adjusted by the ABS for census underenumeration and for usual residence. The occupational status, birthplace group and marital status proportions from the census counts in 1981 and 1986 were averaged, and fitted to the interpolated populations, by age and sex. Occupational information is not included on death certificates for males and females, for ages over 65.

METHODOLOGY

At the State level, marital status by occupation, and birthplace by occupation analyses were conducted for 10-year age groups from 15-64 and utilized standardized mortality ratios. Expected deaths were calculated for each age-occupational marital status and birthplace category by application of the state age-sex specific death rate for each type of cancer, to the census derived age-occupational-marital category, or age-occupational-birthplace category. Actual deaths were disaggregated for these categories by cross tabulation.

The key age division was between ages 15-64 and 65+. The basic reason for this division was that occupational data were only available for persons up to age 64. Second, as some cancers take 30 or more years to develop after exposure to particular carcinogens, such mortality might be more evident at later ages. Third, preliminary tabulations by age for geographic areas indicated differences in mortality trends for the two age groups in some areas. However, analysis by marital status is taken to age 74. Age group 15 was taken as the divide at younger ages. With total cancer, there were over 400 deaths in the 15-24 age range, and over 1100 between ages 25-34, and so the lower limit was taken.

Testing for statistical significance used the Poisson probability distribution which allows statistically significant high and low mortality to be determined. However, this renders the findings vulnerable to the multiple testing problem, given that with more comparisons, it is more likely that some will be 'significant' by chance, i.e. the 'finding' of an effect where no true effect exists (type 1 error). Hence two levels of significance are utilised, 0.05 and 0.02. The 0.02 level was chosen so that the stringency of a safeguard against type 1 errors would not be so severe that true effects would not be found, given the inversely related probability of making type 1 and type 2 errors [31].

At the SLA level, the expected number of deaths was obtained by application of the state age specific annualized death rates to the corresponding interpolated age group and multiplying by 7 as there are 7 years in the period of analysis. Thus within the 15-64 age range, age specific state rates for the five 10 year age groups were applied to the corresponding census derived populations. The difference between observed and expected deaths in each age group were summed before statistical significance for the whole 15-64 age range was determined. There was a similar procedure for the 65-69, 70-74 and 75+ age groups within the 65+ category. The rate mapped by SLA were derived in the following way for the 15-64 age range. The actual deaths in the age range were divided by the expected deaths and multiplied by the crude death rate in the age range for New South Wales. The rates are thus indirectly standardized rates for this age range. The same procedure was followed for the 65+ range.

Spatial correlation analysis was used by SLAs for a range of variables not included on death certificates, notably density, crowding and industrial variables. The dependent variables were mortality rates per 100,000 people aged 15-64 and per 10,000 aged 65+. Maps show rates per 100,000 population in Sydney.
Table 1. Male mortality from selected forms of cancer in New South Wales by occupational status for persons aged under 65. Standardized mortality ratios

<table>
<thead>
<tr>
<th>Cancers</th>
<th>Professional</th>
<th>Managerial</th>
<th>Farmers</th>
<th>Clerical sales</th>
<th>Transport workers</th>
<th>Trades related</th>
<th>Service and</th>
<th>Not stated</th>
<th>Total deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach cancer</td>
<td>0.78*</td>
<td>1.29**</td>
<td>1.06</td>
<td>1.02</td>
<td>1.11*</td>
<td>1.09*</td>
<td>1.03</td>
<td>1.01</td>
<td>610</td>
</tr>
<tr>
<td>Colo-rectum cancer</td>
<td>0.96</td>
<td>1.41**</td>
<td>0.98</td>
<td>1.07</td>
<td>1.12*</td>
<td>0.92†</td>
<td>1.06</td>
<td>1.03</td>
<td>1443</td>
</tr>
<tr>
<td>Respiratory system cancer</td>
<td>0.95†</td>
<td>1.11*</td>
<td>1.03</td>
<td>0.98</td>
<td>1.05</td>
<td>1.19**</td>
<td>1.07*</td>
<td>0.96</td>
<td>3743</td>
</tr>
<tr>
<td>Total cancer</td>
<td>0.93†</td>
<td>1.04</td>
<td>1.05</td>
<td>1.03</td>
<td>0.94†</td>
<td>1.05</td>
<td>1.02</td>
<td>1.11**</td>
<td>11568</td>
</tr>
</tbody>
</table>

Source: Unit list mortality files (ABS).
Note: 45% of the tests were statistically significant. **Significantly high at 0.02 level; *significantly high at 0.05 level; †significantly low at 0.05 level.

Table 2. Male mortality from cancer in New South Wales by marital and occupational status for persons aged under 65. Standardized mortality ratios

<table>
<thead>
<tr>
<th>Marital status</th>
<th>Professional</th>
<th>Managerial</th>
<th>Clerical sales</th>
<th>Transport workers</th>
<th>Trades related</th>
<th>Service and</th>
<th>Not stated</th>
<th>Total deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never married</td>
<td>1.02</td>
<td>0.79†</td>
<td>1.04</td>
<td>1.08*</td>
<td>0.89†</td>
<td>1.12**</td>
<td>1.11*</td>
<td>1.27**</td>
</tr>
<tr>
<td>Married</td>
<td>0.99</td>
<td>1.28**</td>
<td>1.09*</td>
<td>1.01</td>
<td>0.93†</td>
<td>1.01</td>
<td>1.04</td>
<td>0.93†</td>
</tr>
<tr>
<td>Divorced</td>
<td>0.48</td>
<td>1.00</td>
<td>0.88‡</td>
<td>0.96</td>
<td>1.27*</td>
<td>1.01</td>
<td>1.25*</td>
<td>1.74**</td>
</tr>
<tr>
<td>Widowed</td>
<td>0.47</td>
<td>0.69*</td>
<td>0.67*</td>
<td>0.97</td>
<td>1.05</td>
<td>1.26**</td>
<td>0.72</td>
<td>1.29*</td>
</tr>
<tr>
<td>Not known</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Totals (ratios)</td>
<td>0.97</td>
<td>1.04</td>
<td>1.05</td>
<td>1.03</td>
<td>0.94†</td>
<td>1.05</td>
<td>1.04</td>
<td>1.11**</td>
</tr>
</tbody>
</table>

Source: Unit list mortality files, NSW.
Note: **Statistically significant high at 0.02 level; †statistically significant high at 0.05 level; †statistically significant low at 0.05 level.
Note: (I) 50% of the tests were statistically significant.

SLAs for the 15–64 age group. There are heavy outlines around SLAs having mortality with significance levels at the 0.02 level. The occupational information is grouped into the ABS major groups which gives some indication of socio-economic status and industry. Area specific industrial variables taken from the censuses of manufacturing are used to provide indicators of industrial land uses and possible health risks, viz. heavy chemical and related manufacturing industry. A crowding variable was introduced, following the work by Myers and Manton which suggested the possibility of environmental factors associated with crowding which may induce stress [30].

MORTALITY TRENDS AT THE STATE LEVEL

Table 1 shows age-adjusted mortality from total cancer, and stomach, colo-rectum and respiratory system cancer for males under age 65 by occupational status. Variation by occupational major groups in the case of total cancer were not significant. This contrasts with Dasvarma's [32] earlier findings for total cancer in Australia in which workers in transport and in trades and labourer occupations had standardized mortality ratios of 1.83 and 1.21 respectively while farmers and professional workers had below average ratios. The table shows however, that there were significant variations between occupational status groups in the case of stomach, colo-rectum and respiratory system cancer. While inequalities between occupational status groups in cancer may have declined, with structural economic change, the relative sizes of the ABS occupational categories changed, and some categories became more heterogeneous. Internal migration of different groups at risk between NSW and the rest of Australia, and vice versa may complicate comparisons between the studies.

Table 2 indicates however, for total cancer, that when occupational status data are disaggregated by marital status, variations by occupational status emerge. Indeed never married clerical, trades, process workers and labourers, and service workers experienced significantly high mortality. An unexpected finding was that married men in managerial occupations experienced high mortality significant at the 0.01 level, and that mortality among married farmers was also high.

Overall, mortality among never married men was relatively high (Table 3). In the age range 55–64, there were 753 cancer deaths to never married men in the period, compared to an expected number of 612. Mortality was significantly high among widowed men aged 55–74, but not among such males at other ages.
With females there were no statistically significant variations by marital status with total cancer mortality, although among never married and divorced women aged 55–64, and 65–74, differences approached significance at the 10% level.

Table 4 shows age adjusted standardized mortality ratios by occupational and major birthplace categories for males dying of respiratory system cancer in NSW. Mortality was significantly high among Australian-born men in transport, and trades, process and labourer occupations, and approaching significance among Australian-born farmers and managers. Mortality ratios were high with European-born men in trades, process and labouring work. Among females in the 55–64 age group, mortality was significantly high at the 0.05 level among European-born women, but not at other ages.

Table 5 depicts standardized mortality ratios for males in selected occupational groups by birthplace for stomach cancer and colorectal cancer. Differences emerged between birthplace and occupational groups. Highly significant levels of mortality occurred with stomach cancer among European-born males in trades, process and labouring work, and Australian-born men in managerial work. Stomach cancer mortality was significantly low among professional men born in Europe and Australia.

In contrast to stomach cancer, colorectum cancer was lower among trades process workers and labourers born in Europe and Australia. Mortality was higher among Australian-born men in managerial occupations but not European-born men in these occupations. Colorectum cancer was significantly high among Australian and European-born men in transport occupations.

Table 6 shows standardised mortality ratios of males by marital status for the three types of cancer. The variation by marital status was greatest with respiratory cancer although persons not currently married had higher mortality, with all three groups. Variations by marital status among females were mostly not significant. In the case of breast cancer,
Table 7. Mortality rates of females from breast cancer by age and marital status. Standardized mortality ratios.

<table>
<thead>
<tr>
<th>Age</th>
<th>Never married</th>
<th>Married</th>
<th>Separated or divorced</th>
<th>Widowed</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-34</td>
<td>0.52</td>
<td>1.00</td>
<td>0.38</td>
<td>—</td>
<td>61</td>
</tr>
<tr>
<td>35-44</td>
<td>0.51†</td>
<td>1.01</td>
<td>0.17†</td>
<td>—</td>
<td>325</td>
</tr>
<tr>
<td>45-54</td>
<td>1.72**</td>
<td>1.00</td>
<td>0.70†</td>
<td>1.00</td>
<td>659</td>
</tr>
<tr>
<td>55-64</td>
<td>1.47**</td>
<td>1.00</td>
<td>0.70†</td>
<td>1.21**</td>
<td>1165</td>
</tr>
<tr>
<td>65-74</td>
<td>1.38**</td>
<td>0.88</td>
<td>0.58</td>
<td>1.11*</td>
<td>1200</td>
</tr>
</tbody>
</table>


Note (1) **Significant at 0.02 level; *significant at 0.05 level; †significantly low at 0.05 level.
(2) 40% of tests were statistically significant.

Table 8. Standardized mortality ratios in metropolitan and non-metropolitan New South Wales from colorectal; stomach, respiratory, breast, and total cancer 1980-86.

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-64</td>
<td>65+</td>
</tr>
<tr>
<td>Colo-rectum cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>0.99</td>
<td>1.03</td>
</tr>
<tr>
<td>Balance of NSW</td>
<td>1.01</td>
<td>0.95</td>
</tr>
<tr>
<td>Stomach cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>1.19**</td>
<td>1.08*</td>
</tr>
<tr>
<td>Balance</td>
<td>0.74†</td>
<td>0.87†</td>
</tr>
<tr>
<td>Respiratory cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>1.08*</td>
<td>1.05</td>
</tr>
<tr>
<td>Balance</td>
<td>0.88†</td>
<td>0.92</td>
</tr>
<tr>
<td>Breast cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Balance</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>1.06</td>
<td>1.09*</td>
</tr>
<tr>
<td>Balance</td>
<td>0.91*</td>
<td>0.88*</td>
</tr>
</tbody>
</table>

Source: (1) Unit list mortality files. (2) Estimated resident population 1981 and 1986 census.
*Significantly high at the 0.05 level; **significantly high at the 0.02 level; †significantly low at the 0.05 level.

METROPOLITAN–NON-METROPOLITAN VARIATIONS IN CANCER MORTALITY IN NEW SOUTH WALES

Table 8 shows standardized mortality ratios from the various types of cancer, and total cancer in metropolitan and non-metropolitan NSW, 1980–86. Total cancer was significantly high in Sydney for males aged 65+ and for females aged 15–64 and 65+.

Nevertheless there were variations between types of cancer. With colorectal and breast cancer, differences were mostly insignificant, although colorectal cancer was lower in metropolitan Sydney among females aged 15–64. Respiratory cancer mortality was higher in Sydney than in the remainder of NSW in aggregate, and more so among women aged 65+.

which was significantly higher in Sydney with both age and gender categories but especially with males and females aged 15–64.

SPATIAL TRENDS WITHIN METROPOLITAN SYDNEY

Total cancer

Figures 2–3 show age 15–64 male and female mortality from total cancer in Sydney. Male mortality rates were almost three times greater in the highest mortality area than in the lowest. With females, the contiguous inner city SLAs figured prominently, and in the outer northern SLAs. Among males aged over 65, mortality was again significantly high in 5 contiguous inner SLAs, in outer western Blacktown and Fairfield, and in higher status Mosman. Care must be used in interpreting these
figures for many elderly dying of cancer are a select group who have not died from other diseases. The highest male mortality was in Sydney SLA where in comparison to 525 expected deaths to the 15+ age groups over the 7 years, there were 750 actual deaths, an excess of 225, and there were 124 more deaths to females than expected deaths. Female mortality was also significantly high at the 0.01 level in higher status Mosman, and Woollahra.

Colo-rectum cancer

Figures 4 and 5 indicate that in contrast to total cancer, age 15–64 colo-rectum mortality was lower in the inner SLAs with both males and females, and was high among males in the lower north shore SLAs, and above average among females in the upper north shore SLAs, all middle class areas. Female mortality was significantly high in the contiguous middle class southern SLAs of Hurstville, Kogarah and Rockdale. Mortality to persons aged over 65 was significantly high in Sydney SLA (males and females) and in the middle class northern SLAs of Hunters Hill and Mosman, in middle class Woollahra, (females), Randwick and Rockdale (both sexes), and Sutherland (males). Mortality was significantly low in several outer SLAs of lower socioeconomic status.
**Stomach cancer**

Male and female age 15–64 mortality from stomach cancer was spatially divergent with significantly high female mortality in inner city SLAs of Leichhardt, Sydney, Woollahra and Canterbury and in contiguous western SLAs centred on industrial Auburn, and Fairfield and male mortality was high in inner city lower income Marrickville, Botany, and Drummoyne (Figs 6 and 7). Among persons over age 65, male mortality was highest in lower income inner SLAs, in industrial Fairfield and Holroyd in the west, and in Gosford in the north. Female mortality was higher in five inner lower income SLAs, and in three lower income western SLAs.

**Respiratory cancer**

The male pattern of age 15–64 male deaths (Figs 8 and 9) showed some association with lower status areas, although with females, both lower and higher status areas had higher mortality. In the case of the 65+ populations, the lower status inner Leichhardt, Sydney and Marrickville SLAs experienced high mortality significant at the 0.01 level as did lower income Auburn and Blacktown to the west.

**Breast cancer (females)**

With the age group 15–64, six of the seven SLAs with mortality significantly high at the 0.02 level were areas of higher socioeconomic status. Mortality was
average or less, in most inner city SLAs and was significantly low in virtually all outer SLAs (Fig. 10). At ages over 65, mortality was significantly high at the 0.02 level in Baulkham Hills, north shore SLAs of Hunters Hill, Willoughby and Mosman, and in Woollahra, all of higher socioeconomic status, and significantly low in the outer north, in Blacktown, Bankstown and Wollondilly in the west, and in Marrickville, and Concord in the inner city, mostly lower status areas.

**Correlation analysis**

Pearson's correlation analysis was undertaken, using independent variables mostly not obtainable from death certificate information (Table 9). A significant correlation was that between male stomach cancer rates and persons born in southern Europe (0.41). This, along with the differential mortality analysis suggests that the findings of McMichael et al. [33] may have been supported, viz. that southern Europeans have higher mortality from stomach cancer in Australia. A significant negative correlation was that between breast cancer (women) and the percentage of labourers/tradespersons in the workforce (-0.29). This, along with positive correlations of 0.35 with managers/professionals and 0.32 with proportions with degrees suggests some association between middle class status and breast cancer risk.
The risks of wrong inferences associated with the ecological correlation approach must be noted, however. Confounding may also be involved with southern European migrant settlement and the low socioeconomic status variable.

The crowding and density associations with cancer observed by Myers and Manton [31] in Germany were found mostly with respiratory cancer in Sydney: crowding, density, lone person households and chemical establishments (females 65+); crowding (males 15–64); and crowding and density (males 65+). The result concerning crowding may be confounded by the social isolation variable (lone person household), in that many lone persons live in smaller dwelling units in areas with higher residential densities.

There can be many years between exposure to carcinogens and the development of the disease. Accordingly, variables were derived from earlier population and manufacturing censuses. However the only significant increase was with chemical manufacturing per km$^2$ ratios and age 15–64 male respiratory cancer mortality—from 0.39 using 1980s variables to 0.47 using 1971 variables.

Stepwise multiple regression was undertaken using the 1980s manufacturing and population census variables. The strongest statistical explanation was with...
Mortality from selected cancers 205

Table 9. Pearson's correlations between selected industrial and socioeconomic variables and mortality from major types of cancer

<table>
<thead>
<tr>
<th></th>
<th>Crowding % dwelling with less than 3 rooms</th>
<th>% Born southern Europe</th>
<th>Chemical establishments per km²</th>
<th>Tradesmen process workers</th>
<th>Lone person households</th>
<th>Population density</th>
<th>Percentage managerial/ professional</th>
<th>Percentage with degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorectum cancer</td>
<td>M 15-64: -0.18</td>
<td>0.09</td>
<td>-0.02</td>
<td>-0.25*</td>
<td>0.10</td>
<td>0.10</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>F 15-64: -0.06</td>
<td>-0.14</td>
<td>0.12</td>
<td>-0.25</td>
<td>0.09</td>
<td>0.05</td>
<td>0.15</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>M 65+: -0.21</td>
<td>-0.14</td>
<td>0.10</td>
<td>-0.11</td>
<td>0.54*</td>
<td>0.28*</td>
<td>0.12</td>
<td>0.29*</td>
</tr>
<tr>
<td></td>
<td>F 65+: 0.27</td>
<td>0.15</td>
<td>0.07</td>
<td>0.26*</td>
<td>0.49**</td>
<td>-0.01</td>
<td>0.33*</td>
<td>0.50**</td>
</tr>
<tr>
<td>Stomach cancer</td>
<td>M 15-64: 0.21</td>
<td>0.41**</td>
<td>0.34*</td>
<td>0.15</td>
<td>0.17</td>
<td>0.15</td>
<td>0.11</td>
<td>-0.21</td>
</tr>
<tr>
<td></td>
<td>F 15-64: 0.21</td>
<td>0.15</td>
<td>0.36*</td>
<td>0.25*</td>
<td>0.10</td>
<td>0.14</td>
<td>-0.14</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>M 65+: 0.04</td>
<td>0.12</td>
<td>0.10</td>
<td>-0.02</td>
<td>0.24*</td>
<td>0.17</td>
<td>-0.24*</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>F 65+: 0.24*</td>
<td>0.02</td>
<td>0.03</td>
<td>0.21</td>
<td>0.07</td>
<td>-0.06</td>
<td>-0.27*</td>
<td>-0.12</td>
</tr>
<tr>
<td>Respiratory cancer</td>
<td>M 15-64: 0.41**</td>
<td>0.38**</td>
<td>0.19</td>
<td>0.40*</td>
<td>0.10</td>
<td>0.11</td>
<td>-0.19</td>
<td>-0.25*</td>
</tr>
<tr>
<td></td>
<td>F 15-64: 0.28*</td>
<td>0.22</td>
<td>0.03</td>
<td>-0.07</td>
<td>0.08</td>
<td>-0.11</td>
<td>0.34*</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>M 65+: 0.35*</td>
<td>0.31*</td>
<td>0.37*</td>
<td>0.41*</td>
<td>0.13</td>
<td>0.36*</td>
<td>-0.22*</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>F 65+: 0.46**</td>
<td>0.19</td>
<td>0.49**</td>
<td>-0.23*</td>
<td>0.55**</td>
<td>0.52**</td>
<td>-0.18</td>
<td>0.41**</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>F 15-64: -0.15</td>
<td>0.24</td>
<td>-0.12</td>
<td>-0.23*</td>
<td>0.28*</td>
<td>0.07</td>
<td>0.35*</td>
<td>0.32*</td>
</tr>
<tr>
<td></td>
<td>F 65+: 0.18</td>
<td>-0.19</td>
<td>-0.29</td>
<td>-0.26*</td>
<td>0.23*</td>
<td>0.06</td>
<td>0.44**</td>
<td>0.29*</td>
</tr>
<tr>
<td>Total cancer</td>
<td>M 15-64: -0.19*</td>
<td>0.26*</td>
<td>0.24*</td>
<td>0.35*</td>
<td>0.11</td>
<td>0.15</td>
<td>-0.21</td>
<td>-0.14</td>
</tr>
<tr>
<td></td>
<td>F 15-64: 0.09</td>
<td>0.29</td>
<td>0.19</td>
<td>0.29*</td>
<td>0.02</td>
<td>0.11</td>
<td>-0.16</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td>M 65+: 0.41**</td>
<td>0.37**</td>
<td>0.46**</td>
<td>0.51**</td>
<td>0.12</td>
<td>0.41**</td>
<td>-0.24*</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>F 65+: 0.27</td>
<td>0.27</td>
<td>0.15</td>
<td>0.40**</td>
<td>0.55*</td>
<td>0.52**</td>
<td>-0.21</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Source (1) Manufacturing census, 1981-82.
(2) Census, 1981, full format tables; Census, 1986 21 page format tables.
(3) Unit list mortality files.
*Correlation significant at 0.05 level.
**Correlation significant at 0.01 level.

Table 10. Stepwise multiple regression: respiratory cancer mortality of women over 65

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multiple R</th>
<th>R²</th>
<th>Significance of R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Percentage of lone person households</td>
<td>0.523</td>
<td>0.274</td>
<td>0.276</td>
</tr>
<tr>
<td>2. Chemical industries/km²</td>
<td>0.637</td>
<td>0.406</td>
<td>0.132</td>
</tr>
<tr>
<td>3. Fabricating industries/km²</td>
<td>0.699</td>
<td>0.488</td>
<td>0.082</td>
</tr>
</tbody>
</table>

Source: (1) Unit list mortality files.
(2) Manufacturing census, 1981.

Characteristics of persons dying from cancer in particular areas

Mortality from respiratory system cancer was particularly high in Sydney SLA (Table 11) where there were 159 more male deaths over the 7 year period, than expected, and 33 more female deaths. Male mortality was significantly high with all marital categories but relatively higher with never married persons, as the standardized mortality ratios indicate (Table 12). Deaths from respiratory cancer were significantly high with both the Australian and overseas born. In Sydney SLA, 134 men aged under 65 died from cancer of the respiratory system in the

Table 11. Actual and expected deaths from cancer of the respiratory system in selected Sydney SLAs

<table>
<thead>
<tr>
<th>SLA</th>
<th>Actual</th>
<th>Expected</th>
<th>Difference</th>
<th>Standardized mortality ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney</td>
<td>369**</td>
<td>210</td>
<td>+159</td>
<td>1.76</td>
</tr>
<tr>
<td>Marrickville</td>
<td>192**</td>
<td>158</td>
<td>+34</td>
<td>1.22</td>
</tr>
<tr>
<td>Blacktown</td>
<td>776*</td>
<td>188</td>
<td>+38</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Note: **Significantly high at the 0.02 level; *significantly high mortality at the 0.05 level.

Source: Unit list mortality files.

Table 12. Actual and expected deaths from cancer of the respiratory system by marital status in Sydney SLA, Males

<table>
<thead>
<tr>
<th>Marital Status</th>
<th>Actual</th>
<th>Expected</th>
<th>Difference</th>
<th>Standardized mortality ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>247**</td>
<td>152</td>
<td>+95</td>
<td>1.63</td>
</tr>
<tr>
<td>Never married</td>
<td>67**</td>
<td>27</td>
<td>+40</td>
<td>2.48</td>
</tr>
<tr>
<td>Widowed/divorced</td>
<td>45**</td>
<td>31</td>
<td>+14</td>
<td>1.41</td>
</tr>
<tr>
<td>Other/NS</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Totals</td>
<td>369</td>
<td>210</td>
<td>159</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Note: **Significantly high mortality at the 0.01 level; *significantly high mortality at the 0.05 level.
Table 13. Actual and expected male deaths from stomach cancer by birthplace, and by marital status in selected SLAs

<table>
<thead>
<tr>
<th></th>
<th>Sydney</th>
<th>Fairfield</th>
<th>Marrickville</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other overseas</td>
<td>Europe</td>
<td>Australia</td>
</tr>
<tr>
<td>Expected number</td>
<td>22</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>Actual number</td>
<td>29**</td>
<td>22**</td>
<td>42**</td>
</tr>
<tr>
<td>Difference</td>
<td>+7</td>
<td>+7</td>
<td>+8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other overseas</td>
<td>Europe</td>
<td>Australia</td>
</tr>
<tr>
<td>Expected number</td>
<td>6</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>Actual number</td>
<td>9</td>
<td>25**</td>
<td>28</td>
</tr>
<tr>
<td>Difference</td>
<td>+3</td>
<td>+7</td>
<td>+4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other overseas</td>
<td>Europe</td>
<td>Australia</td>
</tr>
<tr>
<td>Expected number</td>
<td>4</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>Actual number</td>
<td>7</td>
<td>20**</td>
<td>28**</td>
</tr>
<tr>
<td>Difference</td>
<td>+3</td>
<td>+7</td>
<td>+8</td>
</tr>
</tbody>
</table>

Source: Unit list mortality files.
Note: *Statistically significant difference at 0.05 level; **statistically significant difference at 0.02 level.

Table 14. Actual and expected female deaths from stomach cancer by birthplace in selected SLAs

<table>
<thead>
<tr>
<th></th>
<th>Fairfield</th>
<th>Leichhardt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other overseas</td>
<td>Europe</td>
</tr>
<tr>
<td>Expected number</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Actual number</td>
<td>6</td>
<td>21**</td>
</tr>
<tr>
<td>Difference</td>
<td>+2</td>
<td>+11</td>
</tr>
</tbody>
</table>

Source: Unit list mortality files.
Note: *Significant at the 0.05 level; **Significant at the 0.02 level.

DISCUSSION AND CONCLUSION

At the state level, mortality variations by marital status for males were significant, confirming the marital status variation found in earlier research by Young [34] with total mortality in Australia. Variations by marital status were less significant with females, except with breast cancer. The key findings were first that marital status-occupational status relationships, and occupational status-ethnic status relationships affected cancer mortality variation amongst males, and second, that male Australian-born managerial workers had higher mortality, an observation not conforming with the conventional findings of low socioeconomic status associations with stomach and respiratory cancer [36]. However, it was cancer of the colon-rectum that was highest among managerial men born in Australia. Cancer of the stomach was higher among men born in Europe in manual work [37], but lower with European-born in other occupations [38].

Male cancer of the respiratory system varied by occupational status with mortality among tradesmen, process workers and labourers significantly high among overseas and Australian-born persons, the highest mortality being with European-born men in these occupations. Respiratory system cancer was also elevated among Australian-born managerial and related workers, although not as markedly as with persons dying from stomach or colo-rectum cancer.

Mortality from total cancer was higher in metropolitan Sydney than in the remainder of NSW in aggregate, and respiratory and stomach cancer mortality also. On the other hand there were limited metropolitan-non metropolitan differences in the case of colo-rectum and breast cancer. The lower mortality from total cancer, and stomach and respiratory cancers in non metropolitan NSW may reflect the greater concentration of populations at risk in the metropolitan area, including smokers, and also the greater prevalence of industrial environments there.
It is possible however that social isolation (never married persons living alone) is as important as occupational status in influencing cancer mortality. It is suggested that the following are associated with social isolation: smoking, which affects respiratory cancer in particular; poor self image which may mean neglect of symptoms; and lack of regular medical checks and inappropriate diet [18]. It is arguable that people are less likely to take care of themselves. More research is required on how social isolation and poor self regard relate to the onset of cancer, for it is probable that there has been more research on the self concept after cancer has developed [40].

It is also possible, that there are specific relationships between ethnicity, class and cancer mortality in that lack of awareness of symptoms, or dietary and lifestyle factors linked to language difficulties and lesser education could interact with exposure to carcinogens in industrial work environments and genetic factors together increase the risk of developing cancer. Loneliness, stress and psychological depression possibly have a measurable effect on the immune system, making victims more susceptible to disease [39]. However, the development of cancer may occur because stressed people are less likely to take care of themselves. More research is required on how social isolation and poor self regard relate to the onset of cancer, for it is probable that there has been more research on the self concept after cancer has developed [40].

Significant geographic variation in cancer took place across Sydney, and specific populations having higher mortality at the state level contributed strongly to higher mortality in several areas. Nevertheless occupational specific influences may also be operative, there, as suggested by moderate correlations between manufacturing land-use variables and male mortality from stomach and respiratory system cancer.

It is probable that there has been drift of multiple populations at risk to some locations. In Sydney and adjacent SLAs where respiratory cancer mortality in particular was high, there is a concentration of never married males in cheap rental accommodation, and it is likely that negative dietary and lifestyle factors including smoking and alcohol abuse were common. The rationale here is that psycho-social assets (e.g. a close relationship with a spouse or partner) may give considerable protection from the adverse affects on health, of stress inherent in modern lifestyles, and thus lower risk [42]. The social support factor may be reflected in overall lower mortality among married men from cancer in NSW in the 1980–86 period. In this sense, the social support-social isolation hypothesis can be seen at a lifestyle factor as well as a social condition factor. The challenge is to reach the populations at risk earlier, through preventative approaches via hospital and community health centre outreach programs and advice in the workplace.

A further lifestyle hypothesis arises from the difference in mortality for various cancer categories between professional workers (lower mortality) and managerial workers (higher mortality). In theory, they are both middle class groups. The hypothesis is that sedentary and affluent lifestyles, including excess smoking, alcohol consumption and bad diets may have been more common among managerial workers than among professionals on a long term basis. That this was more a lifestyle than a social isolation trend is suggested by the fact that mortality was higher with married men in managerial work and Australian-born men in such work.

In sum, "society cannot be satisfied until the prospects of existence, life expectancy and quality of life are comparable in all parts of the country and for people in every walk of life" [43]. Indeed, there was higher mortality from stomach and respiratory cancer among lower status men, and among never married men. However, married women, and/or women often living in higher status areas experienced higher mortality from breast cancer, and colo-rectum cancer rates were higher in higher status areas and managerial occupations, although not exclusively so. Some cancers, notably those of the colon, and breast may be in part cancers of affluence [44]. Sedentary lifestyle, alcohol, and the imbibing of fat and meat [45], have been associated with colon cancer and this may have been higher among affluent higher status persons in the past.

Acknowledgement—This research was initiated by a grant from the New South Wales Cancer Council.

REFERENCES