NSW HEALTH

Rhodes Peninsula small area cancer incidence and mortality study

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Executive summary

The former Union Carbide site, located on the Rhodes Peninsula approximately 12km west of the centre of Sydney, was used for manufacturing chemicals from 1928 until 1986. By-products of the manufacturing process, including dioxin and other chemical waste, were dumped into the wetlands and mangroves, discharged into Homebush Bay and used to reclaim land along the Rhodes foreshore, leaving a legacy of significant dioxin contamination. There are plans to clean up the peninsula for residential and commercial use. There is community concern over these plans. This study was conducted to evaluate one of the community's concerns: whether there is a difference in the historical incidence of, and mortality due to, cancer for people living around the Rhodes Peninsula compared to other people in NSW.

We selected 20 Census Collector Districts within 1.5km of the former union carbide manufacturing plant as the study area. We obtained data on all cases of cancer and deaths from cancer in NSW from 1972 to 2001. Based on a person's residential address at time of cancer diagnosis, or at time of death due to cancer, various geocoding software and processes were used to determine which Collector District the case or death should be attributed to. Population figures summarised by sex and five-year age group were obtained from the Australian Bureau of Statistics to calculate age-sex standardised incidence ratios. Indirect standardisation was used to calculate standardised incidence ratios (SIRs) and standardised mortality ratios (SMRs), to compare the study area to NSW and to the balance of the statistical local areas (SLAs) of Ryde and Concord.

During the 30 year study period, 1,106 cases of cancer and 524 deaths due to cancer were identified in the study area. This corresponds to an age-sex standardised rate of 3.2 cases per 1,000 person-years exposed and 1.6 deaths per 1,000 person-years exposed. The study area had a lower rate of cancer and deaths from cancer than the comparison areas (25 and 30 year counts). The yearly SIRs for the study area compared to NSW varied between 50.6 per cent in 1976 and 130.1 per cent in 1984, while the SMRs ranged from 43.4 per cent in 1991 to 124.4 per cent in 1984. There was no obvious trend by time during the study period. We also compared rates for some cancer types that have been associated with dioxin exposure. The case incidence and mortality due to lung and bronchus carcinomas and haematopoietic cancers did not differ significantly from the comparison areas for the study period. There was no obvious geographical trend in ratios when comparing individual Collector Districts to NSW.

We did not find a significant increase in the historical incidence of, and mortality due to, cancer for people living around the Rhodes peninsula compared to other people in NSW. This investigation found no evidence to suggest that dioxin from this site has resulted in increased cancer rates in the potentially exposed population on the Rhodes peninsula and in the surrounding area.

1 Background

The suburb of Rhodes is located on a peninsula in the Parramatta River approximately 12km west of Sydney Harbour and central business district in the state of New South Wales (NSW). The former Union Carbide site at Rhodes was used for manufacturing chemicals from 1928 until 1986, including the timber preservative creosote, xanthates, the pesticide DDT and herbicides 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxy acetic acid (2,4,5-T). Dioxin and other chemical by-products of the above manufacturing processes were dumped into the wetlands and mangroves along the Rhodes Peninsula foreshore until the 1970s, when it was discovered that these by-products were highly toxic. Until this time dioxin effluent was also discharged into Homebush Bay and dioxin contaminated solid waste was used to reclaim land along the Rhodes foreshore.

There are plans to remediate the former industrial sites on the Rhodes Peninsula to a level suitable for residential occupation. There is community concern over these plans. One concern is that potential past exposure of residents to dioxin and other pollutants released by industrial activities on the peninsula could have resulted in an increased incidence of cancer in people living around the Rhodes peninsula. This study was conducted to address this concern.

Dioxin is a generic name that refers to a group of persistent chlorinated contaminants (polychlorinated dibenzo-p-dioxins, PCDDs, and polychlorinated dibenzofurans, PCDFs). Dioxins are unintended by-products of some industrial activities, such as combustion processes, including power generation, metal works and waste incineration, and some types of chemical manufacture. Dioxins are also produced as a result of some natural processes, such as bushfires and volcanic activity. Dioxins occur in trace amounts as contaminants in air, water and soil throughout the world. Dioxins are well known for their association with a number of adverse health effects, notably cancer.

The most toxic of this group of chemicals is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). TCDD has been classified as a Class 1 human carcinogen by the International Agency for Research on Cancer (IARC).[1] TCDD is carcinogenic in experimental animals. Human exposure to TCDD, usually studied in the context of industrial accidents, has been correlated with increased risk of cancer.[1]

The purpose of this study was to examine the historical incidence of, and mortality due to, cancer in people living on or around the Rhodes Peninsula compared to other people in NSW.

Study methods 2

2.1 Selection of exposed area

Based on the presumed distribution of past dioxin contamination, the study area was defined as the immediate surrounds of the source site as well as areas directly opposite across the river. Australian Bureau of Statistics (ABS) Census Collector Districts (CD) were used to define the study area, as these are the finest level of geographical aggregation for which age and sex specific population estimates are available. These population estimates are required to calculate age-sex standardised incidence and mortality rates in the study area for comparison with the NSW equivalents.

CDs are designed for use in the quinquennial Census of Population and Housing as the smallest unit for collection, processing and output of data, comprising approximately 200 households. They also serve as the basic building block for the aggregation of statistics to larger Census geographic areas. CDs are defined for each Census and are current only at Census time.[2]

The Rhodes area is in a well-established region of Sydney and has therefore not seen many changes in the spatial population distribution over the last 30 years. The CDs were selected for inclusion in the study area if the majority of the geographic extent of the CD fell within a 1.5km radius from the Union Carbide site. Where inclusion of a CD was marginal based on the distance from the site, it was included if the outer boundaries were consistent with boundaries for CDs across Censuses from 1971 to 2001. It was desirable to include an area that had an outer boundary consistent in distance from the Union Carbide site in all directions.

Twenty CDs were chosen from the 2001 ABS Census. An aerial photograph of the study area with 2001 collector district boundaries marked out is also shown in Figure 1. The boundaries for the 1976-1996 Censuses are consistent, but there are small changes for the 1971 and 2001 Censuses, covering either end of the study period (Table 1).

2.2 Selection of cases

The Cancer Council New South Wales maintains the NSW Central Cancer Registry, a registry that has recorded all cases of malignant neoplasm diagnosed in NSW residents since the beginning of 1972. Notification of cases of, or deaths due to malignant neoplasm is a statutory requirement for public and private hospitals, departments of radiation oncology, nursing homes, pathology laboratories, outpatient departments and day procedure centres in NSW. Data collected include identifying and demographic information as well as the anatomical and histological characteristics of the disease in each case.[3]

We obtained data on all cases of cancer and deaths from cancer in NSW from 1972 to 2001. Based on a person's residential address at time of cancer diagnosis, or at time of death due to cancer, various geocoding software and processes were used to ascertain the geographic location of the residence of each case or death expressed as latitude and longitude coordinates using the GDA94 projection. These coordinates were then used to determine to which CD the case or death should be assigned.

The first method employed to determine geographic location was MapInfo's GeoLoc product, which is a commercial geocoding product that attempts to match street addresses with a spatial reference database of streets and approximate street number distributions.[4] Any addresses with postal codes of interest (2112, 2114 and 2138) that were unable to be matched by GeoLoc were then investigated individually using MapInfo's Map Marker software[5], which is a newer geocoding product of similar design from the same vendor.

Addresses that were only approximately matched by either GeoLoc or Map Marker were verified manually. Approximately matched addresses are those in which it was necessary to either ignore one or more of street number, street name, street type or suburb name, or to use phonetic encoding of street details in order to obtain a match against the spatial database. At the conclusion of this process any addresses still unmatched were then looked up in a recent file of land parcel information (a cadastral database) supplied by the NSW Department of Lands.[6] Finally, any remaining unmatched addresses were physically investigated, using a street directory and a motor vehicle, to determine whether they fell within the area of interest. Any addresses that were unable to be located were excluded.

2.3 Population data

Population counts aggregated by sex and five-year age group were required to calculate age-sex standardised incidence ratios. This was to enable comparison of the study area to two standard populations: all of the state of NSW (approximately 6 million people) and the statistical local areas (SLAs) of Ryde and Concord (only those parts of these SLAs that were not part of the study area were included). The study area is contained entirely within the SLAs of Ryde and Concord, thus the population of these two SLAs is more likely to be similar to the study area with respect to potential confounders of cancer incidence and mortality such as socio-economic status and smoking. Due to the retrospective nature of this study, there was no possibility of collecting information on such confounders on an individual basis.

Consequently, a population breakdown by sex and five-year age group was obtained for each quinquennial Census between 1971 and 2001 for all of NSW, Ryde and Concord SLAs and each of the Collector Districts in the study area. For NSW and Ryde and Concord SLAs, these population figures were Estimated Resident Populations (ERP) as at 30 June each year, provided by the ABS.

The ERP is the official ABS estimate of the Australian population. It is based on results of the Census and is compiled as at 30 June of each year. In the compilation of the ERP, three important adjustments are made to the Census count based on place of usual residence. These adjustments are to correct for under enumeration: Australian residents who are temporarily overseas on Census night and the Census being undertaken on a date other than 30 June. Inter-Censal ERPs are updated using demographic statistics (births, deaths, overseas and interstate migration) and estimates of housing growth or decline.[2]

ERPs were not available for the 20 CDs chosen from the 2001 Census, and their historical equivalents. Instead, unadjusted Census counts of usual residents were obtained as at the date of each Census between 1971 and 2001. This Census count is an enumeration of where people were located on Census night. For this reason, an adjustment was required to the figures for the CD that contains Concord Hospital.

Concord Repatriation General Hospital is located in 2001 Collector District 1410103. The NSW Central Cancer Registry, which provided the numerator data for this study, records residential address at time of cancer diagnosis, or death, and thus no cases are recorded at the hospital. The population estimate used in the denominator should exclude those people who were recorded as resident at the hospital on Census night.

To estimate the population of the hospital that was included in each Census count the average number of occupied beds for each year from 1970/71 to 2000/01 was sought from Concord Repatriation General Hospital and Central Sydney Area Health Service Annual Reports. The age-sex structure of this population was estimated using data from the NSW Inpatient Statistics Collection, which is a complete enumeration of hospital admissions in NSW.[7] The proportion of patients in each five-year age group by sex category, with a length of stay of at least one night, was calculated for each year of available data. Data for Concord Hospital is only available for 1993 onwards, the year it became integrated into the State Health System. The hospital population for earlier years was estimated using other hospital data.

These proportions were then applied to the average number of occupied beds for each Census year to estimate the age-sex distribution of resident patients at each Census night. In the absence of other data, the 1993 proportions were used for each Census between 1971 and 1991. For each Census year, the resultant estimated hospital population was then subtracted from the Census count for the Collector District equivalent to 1410103. Most collector districts in the study area had relatively stable populations over the 30 year period of the study. However, before the hospital population was adjusted for, the CD containing Concord Hospital appeared to experience a dramatic decline in population. Once the hospital population was removed this decline was much less pronounced (Figure 2).

2.4 Data analysis

Indirect standardisation was used to create various age-sex standardised incidence and mortality ratios (SIRs and SMRs).[8] Ninety-five per cent confidence limits were constructed around these ratios using a Poisson distribution of errors.[9]

Age-sex standardisation is a method to account for differences in the age and sex distributions of populations being compared. The standardised incidence (or mortality) ratio is the ratio of the number of disease cases (or deaths) observed in the study area to the number that would be expected if the age-sex specific incidence rates observed in the reference (standard) population were applied to the population distribution in the study area.

Indirect standardisation was chosen in preference to direct standardisation because of the unavoidable instability in the age-sex specific rates in the study area, due to the small number of cases studied. Direct standardisation uses the age-sex specific rates of the study area.

If we use the notation as defined in *Statistical Methods in Medical Research*[8]:

For age-group by sex combination i, (i = 1,2,…36):

N_i = number in standard population

R_i = number of events (cases or deaths) in standard population

P_i = Ri / Ni = event rate in standard population

n_i = number in study population

r_i = number of events (cases or deaths) in study population

p_i = r_i / n_i = event rate in study population

Then the SIR (or SMR) is defined as:

$$\begin{aligned} SIR &= [\, (\textstyle\sum r_i) / (\sum n_i P_i)\,] * 100 \\ &= [\text{ observed events / expected events }] * 100 \end{aligned}$$

SIRs and SMRs for the following aggregations were calculated. Ratios marked with an asterisk were also compared to the balance of Ryde and Concord SLAs:

- 30 year SIRs and SMRs for the entire study area
- SIRs and SMRs for the entire study area that covered the 25 year period where collector district boundaries were consistent
- Yearly SIRs and SMRs for the entire study area
- SIRs and SMRs for 5 year periods for the entire study area, with each period centred on a quinquennial Census (Table 1 details the groupings)
- 25 year individual Collector District SIRs and SMRs
- Lung and bronchus carcinoma 30 year SIRs and SMRs for the entire study area
- Haematopoietic cancers (such as lymphoma and leukaemia) 30 year SIRS and SMRs for the entire study area.

The area that the 30 year SIRs and SMRs were based on was not completely consistent over the whole study period (Table 1). Thus SMRs and SIRs based on these boundaries included a number of cases (or deaths) that were not enumerated on the same basis as the population for all time periods. To check that these discrepancies did not bias the results, a 25 year count covering the period 1974-1998 was also calculated for comparison. This used 1996 boundaries, which were consistent for each census going back to 1976.

Dioxin is known to act primarily as a promoter of neoplasms, based on observations in cell and animal models.[1] However, end-points of carcinoma of the lung and bronchus, and haematopoietic neoplasms were chosen for closer investigation as evidence for increased risk of these cancers were found in occupational cohort studies used by the IARC in the evaluation of the carcinogenicity of 2,3,7,8-TCDD.[1] Cases of carcinoma of the lung and bronchus were identified using the International Classification of Diseases – Tenth revision (ICD-10) codes C33 to C34. Haematopoietic Cancers were identified by ICD-10 codes C81 to C96.[10]

All analysis and data manipulation was carried out using the SAS System® version 8.02 and Microsoft® Excel 2000.

3 Results

The study area surrounding the Union Carbide site at Rhodes contains 20 Census Collector Districts, representing a resident population of 11,800 people as at the 2001 Census. The population size is remarkably similar to what it was in 1971, although it fluctuated between approximately 10,800 and 11,800 during the 30 year study period. During the 30 year study period, 1,106 cases of cancer and 524 deaths due to cancer were identified in the study area. This corresponds to an age-sex standardised rate of 3.2 cases per 1,000 person-years exposed and 1.6 deaths per 1,000 person-years exposed.

3.1 30 year count for entire study area

The count of cases observed in the study area over the 30 year period equates to a standardised incidence ratio (SIR) of 87.6 per cent (95 per cent CI = 82.5-92.9) when compared to NSW (Table 2). Thus the study area has a significantly lower rate of cancer than the whole of NSW when looking at the entire study period. Similarly, the death count observed above equates to a standardised mortality ratio (SMR) of 88.7 per cent (95 per cent CI = 81.3-96.7) when compared to NSW. Thus, the study area has a significantly lower rate of death due to cancer than the whole of NSW during the entire study period.

A comparison of these observed counts was also made to the numbers expected if the rates observed in the balance of the SLAs of Ryde and Concord were experienced in the study area. This resulted in an SIR of 90.5 per cent (95 per cent CI = 85.2-96.0) and an SMR of 92.9 per cent (95 per cent CI = 85.1-101.2). Thus the case incidence in the study area is significantly lower than the rate in the surrounding local area, while the death rate is not significantly different to the comparison area.

3.2 25 year count for entire study area

The 25 year SIR for the study area compared to NSW was 91.2 per cent (95 per cent CI = 85.4-97.2), while the SMR on the same basis was 93.5 per cent (95 per cent CI = 85.2-102.3) (Table 2). The 25 year results are similar to the results obtained using the 30 year counts, suggesting that the slight variation in the definition of the study area used for the 30 year study period did not bias the results.

3.3 Counts for various time periods

The annual SIRs for the study area compared to NSW varied between 50.6 per cent in 1976 and 130.1 per cent in 1984, while the SMRs were between 43.4 per cent in 1991 to 124.4 per cent in 1984 (Table 3). There was no obvious trend in ratios with apparently random, symmetrical fluctuation around the overall 30 year averages of 87.6 per cent and 88.7 per cent, for SIR and SMR respectively. The count of cases and deaths that determined these ratios varied between 20 and 50 cases or 10 and 30 deaths per year.

Similarly, when groups of years were aggregated around Census years for year-block analysis (Table 4) there was no obvious pattern in the SIRs and SMRs for the study area compared to NSW. The SIR ranged from 77.0 per cent in the period 1974-1978 to 98.5 per cent in the period 1984-1988, while the SMR varied between 76.1 per cent in the period 1989-1993 to 107.8 per cent in the period 1984-1988. SIRs for 1974-1978 and 1989-1993 and SMRs for 1989-1993 were statistically significantly lower than the comparison area.

3.4 Neoplasm of the lung and bronchus

Over the 30 year study period there were 143 cases and 121 deaths due to carcinoma of the lung and bronchus identified in the Rhodes study area. This equates to an SIR of 105.5 per cent (95 per cent CI = 88.9-124.2) and SMR of 107.1 per cent (95 per cent CI = 88.9-128.0) (Table 5), compared to NSW and an SIR of 115.7 per cent (95 per cent CI = 97.5-136.3) and SMR of 116.2 per cent (95 per cent CI = 96.4-138.8) compared to the balance of the SLAs of Ryde and Concord. The case incidence and mortality due to carcinoma of the lung and bronchus is not significantly different to the comparison areas for the study period.

3.5 Haematopoietic neoplasm

Over the 30 year study period there were 85 cases and 46 deaths due to haematopoietic neoplasm identified in the Rhodes study area. This equates to an SIR of 80.5 per cent (95 per cent CI = 64.3-99.6) and SMR of 80.8 per cent (95 per cent CI = 59.2-107.8), compared to NSW and an SIR of 75.0 per cent (95 per cent CI = 59.9-92.7) and SMR of 78.3 per cent (95 per cent CI = 57.3-104.4), compared to the balance of the SLAs of Ryde and Concord (Table 5). Therefore the case incidence of haematopoietic neoplasms in the Rhodes study area is significantly lower than the comparison areas over the study period. However, there is no significant difference in mortality due to this haematopoietic neoplasm.

3.6 25 year count for individual census collector districts

The SIRs for the individual CDs compared to NSW varied between 48.5 per cent and 184.1 per cent, while the SMR ranged from 21.7 per cent to 137.4 per cent (Table 6). There was no obvious trend in ratios with symmetrical fluctuation around the total study area 25 year average SIR of 91.2 per cent and SMR of 93.5 per cent. There was no apparent relationship between SIR and SMR and distance of the collector district from the potential source of dioxin contamination. The count of cases and deaths that determined these ratios varied between 1 and 100 cases or 2 and 50 deaths per collector district.

4 Discussion

We examined age-sex standardised incidence and mortality ratios due to cancer in the 20 Collector Districts within 1.5km from the former Union Carbide site (the study area). We used incidence and mortality for all of NSW and for the balance of the Ryde and Concord Statistical Local Areas, which enclose the study area, as the comparison. We calculated standardised incidence and mortality ratios for all cancer as well as carcinoma of the lung and bronchus and haematopoietic neoplasm. Annual 25 year and 30 year comparison periods were used. We found that the incidence and mortality ratios for all types of cancer for all comparison periods of study in the study area did not differ significantly from expectation, based on cancer incidence and mortality rates in all of NSW and in the areas immediately surrounding the study area.

There are a number of strengths to this study. We were able to obtain information on all cases of and deaths from cancer in the study and control areas during the study period. Information on cancer cases for this study was obtained from the NSW Central Cancer Registry. The Cancer Registry is supported by compulsory notification of all cancers in NSW. We selected those collector districts whose population fell within 1.5km of the former Union Carbide site. The study area included 20 Collector Districts with a population of approximately 11,500 people. Since there was data available for a number of years we were able to examine cancer incidence and mortality in individual Collector Districts, demonstrating that even the residential areas closest to the site did not have increased cancer rates.

The study did present several challenges, however. As with any small area study, one of the biggest difficulties was the formation of study boundaries, which are consistent over a sufficiently long period to accumulate a reasonable number of cases or deaths. This was a challenge for a number of reasons. Firstly, the exposed community was not easily defined, because the potential exposure route was unclear. Historically there was no known exposure via air. Potential exposure routes may have been contact with Homebush Bay, eating fish caught in the bay, soil transferred from the site or occupational exposure from working at the facility. It is also possible that no exposure to dioxins occurred in residents surrounding the Union Carbide plant.

Secondly, the choice of possible boundaries was limited to those for which denominator (population) counts were available, as these were needed to calculate expected counts of cases and deaths due to cancer. The smallest units for which population data are available are the ABS Census Collector Districts. Unfortunately, these boundaries were still too coarse to enable definition of a study area with a circumference that was a uniform distance from the putative exposure source. Also, the ABS may change the boundaries of Collector Districts at each Census in response to significant changes in population. Fortunately, for 25 of the 30 years of this study the boundaries remained consistent allowing direct comparisons across time periods.

The geocoding process used to determine if a case belonged to the exposed study area may present some difficulties. Although the address information for each case was quite 'clean' and well formatted, only 81 per cent (4592 out of 5644) of the cases falling into the postcodes containing the study area could be matched exactly using an automatic process. On further investigation, approximately 7 per cent of cases originally attributed to the study area, but not matched exactly, were re-allocated to another Collector District. However, overall the total number of cases falling into the study area changed by only 2 (out of 1106). The number of cases where the address was unable to be found, and therefore the case excluded from the study area, was a very small proportion of the total number of cases recorded in these postcodes (21 cases out of 5644, or 0.4 per cent).

An additional challenge in this study was assigning population estimates to areas for the purpose of calculating expected numbers of cases and deaths. The methods used to assign population estimates varied between the study and control areas. Since yearly population estimates (in the form of Estimated Resident Populations (ERPs)) were not available at the Census Collector District level, Census year enumerated population counts were used and extrapolated to inter-Censal years (Table 7). ERPs (from the Australian

Bureau of Statistics) were used for NSW and the SLAs of Ryde and Concord and more closely reflect actual population. The use of enumerated usual resident populations in the study area instead of ERPs may result in small errors in the SIRs and SMRs. However, the magnitude of these errors is unlikely to be large enough to affect the results of the study. Additionally, population figures for the Collector Districts, which included Concord Hospital, overestimate the residential population due to counting of hospital inpatients on Census night. The population figures were adjusted by subtracting the estimated number of people at Concord Hospital on Census night, thus providing a better estimate residential population in this Collector District.

Another limitation of this study is our inability to adjust for potential confounders in the relationship between cancer incidence and mortality and place of residence. Potential confounders include smoking rates and socio-demographic variables. The comparison of the study area to the balance of the SLAs of Ryde and Concord may compensate in part for this deficiency, as this area, which is contiguous with the study area, is likely to have demographic characteristics which are very similar to the study area.

One of the major weaknesses in small area studies is that the numbers of events being examined are often very small and therefore variation in these numbers can more often be attributed to chance than any exposure effect. Due to these small numbers the confidence intervals around the ratios are wide and consequently there are only three significant results, with the SIR for 1974 and 1976, and the SMR for 1991 being significantly lower than 100 per cent. When testing the significance of this many ratios (60 in total) at the 95 per cent confidence level, three significant results are expected purely as a result of chance. Given the negative result no attempt was made to adjust for the effect of multiple comparisons. Based on this and the fact that there is no obvious trend in the yearly SIRs and SMRs we conclude that there is no time effect on the incidence of and mortality due to cancer in the Rhodes area compared to NSW.

It is possible that many workers at the Union Carbide plant resided in the study area. Had occupational exposure to dioxin on the site been high, workers may have experienced greater rates of cancer than the general population and may have raised the observed risk of cancer in our study. The cancer registry does not collect occupational data, thus it was not possible to adjust for such potential confounding.

There are a number of additional issues to be considered when interpreting studies of cancer incidence around a point source of carcinogenic exposure. Cancer risk is likely to be significantly greater for those working at the plant than those residing near to the plant, because potential exposure to carcinogens is likely to be much greater in workers. Accordingly, in residents the same cancers would be expected as those observed in workers, but at lower incidence. Thus, many studies of cancers in residents are negative and may be underrepresented in the literature. In some cases where an increased risk of cancer has been demonstrated in residents, a causal association has not been assumed, as the cancers observed are different to those seen in occupational studies[10], or there is an absence of measured exposure to the contaminant of concern.[11]

Human exposure to TCDD, studied in the context of industrial accidents and occupational exposure, is associated with increased risk of cancer (all sites), and in some groups, increased risk of lung cancer, soft tissue sarcoma and non-Hodgkin lymphoma have been observed.[1,12] TCDD, therefore, is considered to be an overall promoter of cancer. Cancer excesses have not been observed in TCDD-exposed cohorts with lower exposures.[12] Increased risk of cancer reasonably attributed to site contamination by TCDD (as distinct from exposure to TCDD consequent upon an industrial disaster or in workers) has never been demonstrated.[1] In the present study we found no evidence that dioxin from this site has resulted in increased cancer rates in the potentially exposed population on the Rhodes peninsula and in the surrounding area. The findings of this study are consistent with the understanding that the risk of cancer attributable to residing near a site contaminated by TCDD is low.

In summary, we did not find a significant increase in the historical incidence of, and mortality due to, cancer for people living around the Rhodes peninsula compared to other people in NSW.

5 References

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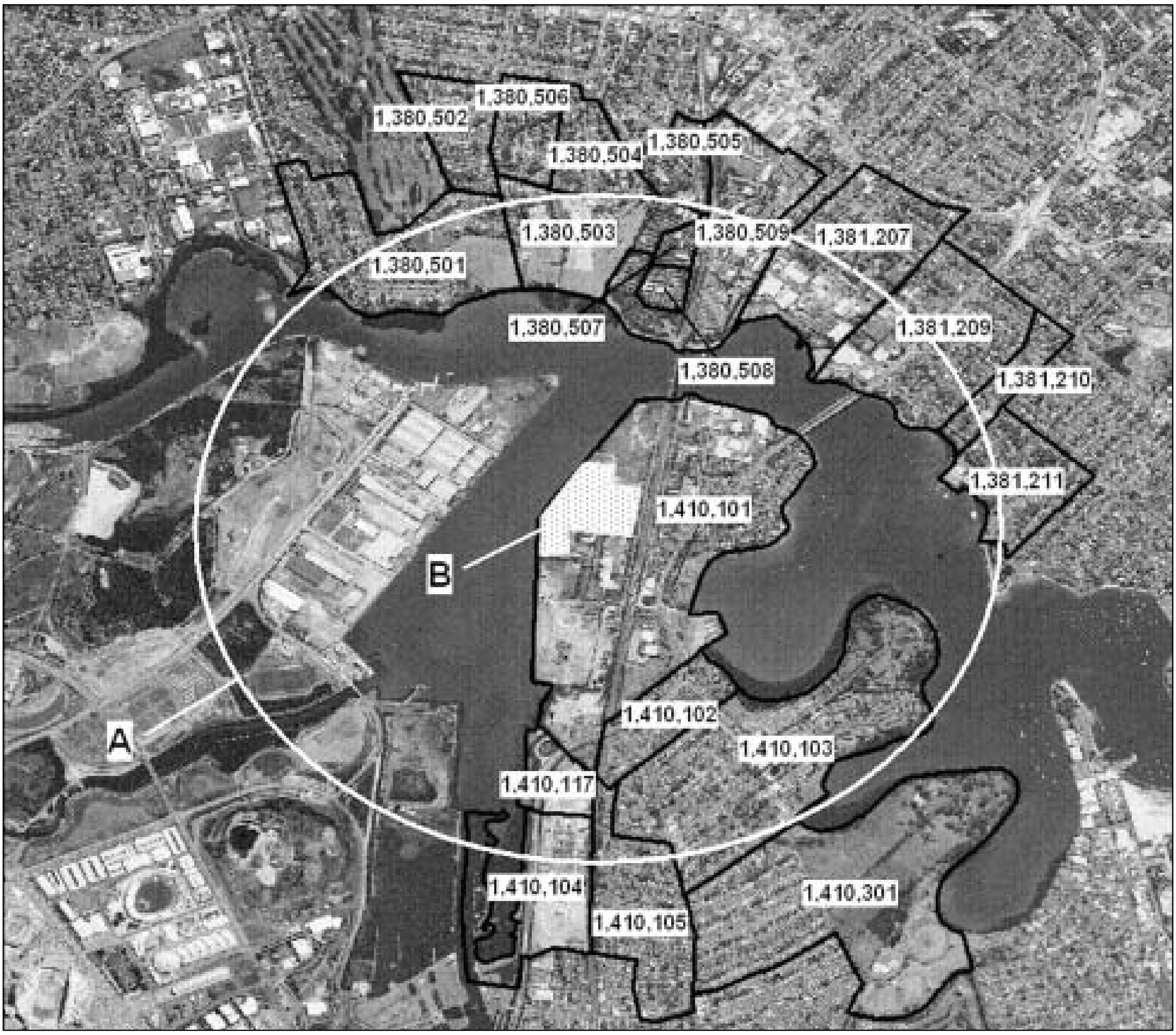
Tables and figures

Figure 1: Aerial photograph of the study area indicating the Census Collector District boundaries (marked) and the site of the former Union Carbide plant.



Legend:

A: Approximate 1.5km distance from the former Union Carbide plant.

B: The site of the former Union Carbide plant.

Study Area: Includes all Collector Districts marked on the aerial photograph. Ryde Statistical Local Area: Is located to the north of the study area.

Concord Statistical Local Area: Is located to the south of the study area.

The area to the west of the former Union Carbide plant is former industrial land. No residential occupation occurred here until approximately the year 2000.

Table 1: Mapping of Census Collector District from 1971 to 2001 for the study area.

The collector areas of interest for each census are:

	2001	1996/1991	1986	1981	1976	1971
Meadowbank	1,380,501	1,380,501	1,421,401	1,271,001	1,330,109	1,330,109
	1,380,502	1,380,502	1,421,402	1,271,002	1,330,108	1,330,108
	1,380,503	1,380,503	1,421,403	1,271,009	1,330,301	1,330,301
	1,380,506	1,380,506	1,421,406	1,271,005	1,330,310	1,330,310
	1,380,509	1,380,509	1,421,409	1,271,008	1,330,314	
		1,380,510	1,421,410	1,271,103	1,330,304	1,330,304
	1,380,504	1,380,504	1,421,404	1,271,003	1,330,302	1,330,302
	1,380,505	1,380,505	1,421,405	1,271,004	1,330,308	1,330,308
	1,380,507	1,380,507	1,421,407	1,271,006	1,330,313	1,330,309
	1,380,508	1,380,508	1,421,408	1,271,007	1,330,309	
Putney	1,381,207	1,381,207	1,421,507	1,271,108	1,330,506	1,330,506
	1,381,209	1,381,209	1,421,509	1,271,109	1,330,507	1,330,507
	1,381,210	1,381,210	1,421,510	1,271,110	1,330,504	1,330,504
	1,381,211	1,381,211	1,421,511	1,271,111	1,330,503	1,330,503
Rhodes	1,410,101	1,410,101	1,480,101	1,320,101	1,330,601	1,330,601
	1,410,102	1,410,102	1,480,102	1,320,102	1,330,602	1,330,602
	1,410,103	1,410,103	1,480,103	1,320,103	1,330,603	1,330,603
	1,410,301	1,410,301	1,480,104	1,320,104	1,330,604	1,330,604
	1,410,105	1,410,105	1,480,105	1,320,105	1,330,605	1,330,605
	1,410,104	1,410,104	1,480,110	1,320,110	1,330,610	1,330,610
	1,410,117					

Indicates an exact match of CD boundaries between census years

Indicates one CD is the amalgamation of 2 separate CDs in an adjoining census year.

Indicates the outer boundaries of the amalgamation of these CDs are consistent between census years but internally the boundaries changed.

Indicates a small part of another CD not included in the area of interest for that census year is needed to completely match the selection from the adjoining census year.

Figure 2: Populations of Concord Repatriation General Hospital and 2001 Census Collector District 1410103 by time.

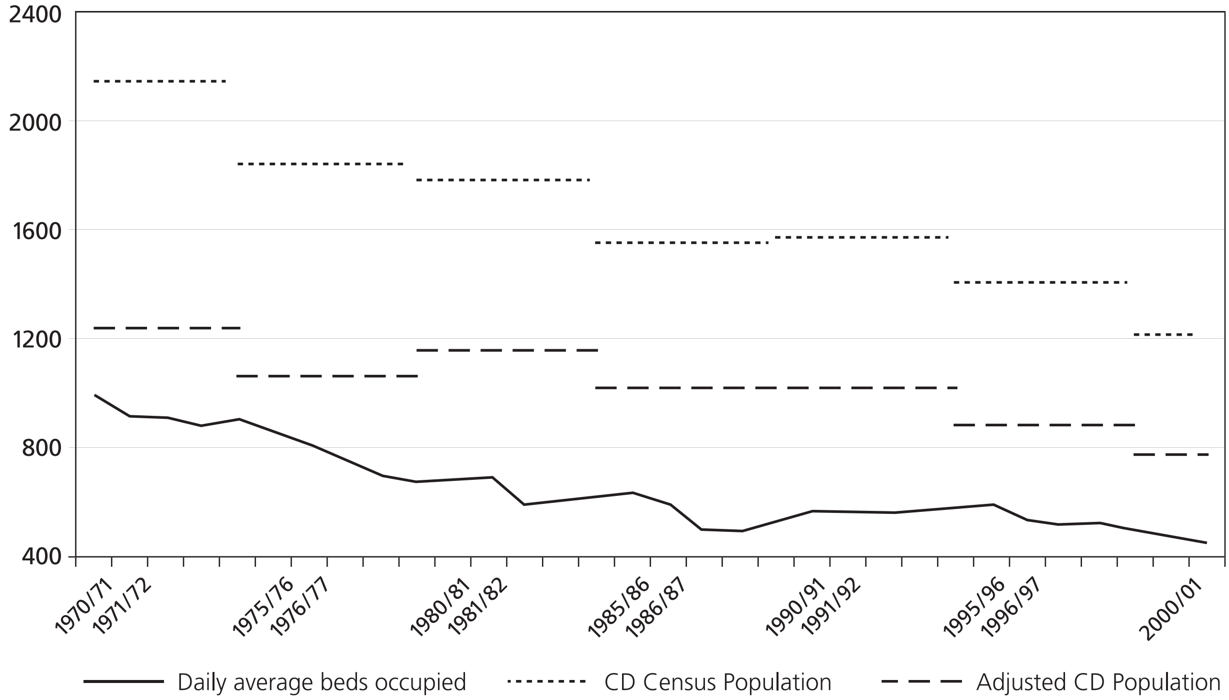


Table 2: Standardised Incidence Ratios and Standardised Mortality Ratios for Rhodes study area compared with NSW and compared with Ryde and Concord Statistical Local Areas for all cancers (30 year and 25 year counts).

Timeframe	Comparison Area	Case SIR (Indirectly standardised)	95% Confidence Interval	Death SMR (Indirectly standardised)	95% Confidence Interval
30 years	NSW	87.57#	82.48, 92.89	88.72#	81.28, 96.65
30 years	Concord and Ryde SLAs	90.50#	85.24, 95.99	92.87	85.09, 101.17
25 years	NSW	91.15#	85.43, 97.15	93.48	85.22, 102.33

SLA = Statistical Local Area
NSW = New South Wales
SIR = Standardised Incidence Ratio # Statistically significantly lower than the comparison area
SMR = Standardised Mortality Ratio * Statistically significantly higher than the comparison area

Table 3: Standardised Incidence Ratios and Standardised Mortality Ratios for Rhodes study area compared with NSW for all cancers for each year of the study period.

Year	Case SIR (Indirectly standardised)	95% Confidence Interval	Death SMR (Indirectly standardised)	95% Confidence Interval
1972	91.08	61.00, 130.80	105.74	48.35, 200.74
1973	98.70	67.06, 140.10	106.71	59.73, 176.01
1974	65.34#	40.95, 98.93	98.72	57.51, 158.05
1975	85.14	57.02, 122.28	111.37	68.03, 172.00
1976	50.62#	30.00, 80.01	69.20	36.84, 118.33
1977	107.26	75.9, 147.22	99.50	59.91, 155.39
1978	76.55	50.45, 111.38	72.85	39.83, 122.24
1979	101.50	71.09, 140.53	95.76	56.75, 151.34
1980	87.89	60.12, 124.07	66.66	35.49, 113.99
1981	94.66	65.93, 131.65	74.98	41.96, 123.66
1982	88.18	60.70, 123.84	98.19	59.98, 151.65
1983	86.09	59.26, 120.90	95.97	58.62, 148.22
1984	130.12	97.18, 170.63	124.38	81.97, 180.97
1985	89.68	62.81, 124.16	107.55	68.18, 161.37
1986	100.16	71.88, 135.88	99.93	61.86, 152.76
1987	84.45	58.82, 117.44	98.33	60.87, 150.31
1988	89.02	62.68, 122.70	108.47	68.76, 162.76
1989	103.51	74.91, 139.42	91.77	56.05, 141.73
1990	75.60	51.71, 106.72	70.78	39.61, 116.74
1991	84.45	59.46, 116.40	43.37#	19.83, 82.33
1992	92.95	66.99, 125.64	86.45	51.23, 136.62
1993	71.67	49.63, 100.15	87.41	51.81, 138.15
1994	87.44	63.02, 118.19	97.26	59.41, 150.22
1995	96.18	70.42, 128.29	70.36	38.47, 118.05
1996	93.44	67.62, 125.86	75.72	42.38, 124.88
1997	89.97	64.84, 121.61	114.93	72.03, 174.01
1998	84.12	59.82, 115.00	78.73	44.07, 129.86
1999	95.97	71.00, 126.87	71.81	40.19, 118.44
2000	89.38	65.44, 119.23	77.24	44.15, 125.43
2001	90.95	66.83, 120.95	89.96	54.16, 140.48

SLA = Statistical Local Area
NSW = New South Wales
SIR = Standardised Incidence Ratio # Statistically significantly lower than the comparison area
SMR = Standardised Mortality Ratio * Statistically significantly higher than the comparison area

Table 4: Standardised Incidence Ratios and Standardised Mortality Ratios for Rhodes study area compared with NSW for all cancers when groups of years were aggregated around Census years for year-block analysis.

Timeframe	Case SIR (Indirectly standardised)	95% Confidence Interval	Death SMR (Indirectly standardised)	95% Confidence Interval
1974-1978	76.97#	64.49, 91.16	89.86	71.57, 111.39
1979-1983	91.47	78.2, 106.35	86.32	69.05, 106.61
1984-1988	98.45	85.31, 113.04	107.82	89.02, 129.43
1989-1993	85.19#	73.45, 98.27	76.12#	60.36, 94.73
1994-1998	90.30	78.55, 103.31	87.44	69.94, 107.99

SLA = Statistical Local Area

NSW = New South Wales

SIR = Standardised Incidence Ratio # Statistically significantly lower than the comparison area (p<0.05)

SMR = Standardised Mortality Ratio * Statistically significantly higher than the comparison area

Table 5: Standardised Incidence Ratios and Standardised Mortality Ratios for Rhodes study area compared with NSW and compared with Ryde and Concord Statistical Local Areas for lung and bronchus carcinoma and haematopoietic cancers (30 year counts).

Cancer type	Comparison Area	Case SIR (Indirectly standardised)	95% Confidence Interval	Death SMR (Indirectly standardised)	95% Confidence Interval
Lung and Bronchus Carcinomas	NSW	105.46	88.89, 124.24	107.09	88.86, 127.96
Haematopoietic	NSW	80.55#	64.34, 99.60	80.82	59.17, 107.80
Lung and Bronchus Carcinomas	Concord and Ryde SLAs	115.70	97.51, 136.29	116.19	96.41, 138.84
Haematopoietic	Concord and Ryde SLAs	74.98#	59.89, 92.71	78.29	57.32, 104.43

SLA = Statistical Local Area

NSW = New South Wales

SIR = Standardised Incidence Ratio # Statistically significantly lower than the comparison area

SMR = Standardised Mortality Ratio * Statistically significantly higher than the comparison area

Table 6: Standardised Incidence Ratios and Standardised Mortality Ratios for each Census Collector District (1996) in the Rhodes study area compared with NSW for all cancers (25 year counts).

Geographical region	Case SIR (Indirectly standardised)	95% Confidence Interval	Death SMR (Indirectly standardised)	95% Confidence Interval
1380509	184.13*	128.25, 256.08	128.21	61.48, 235.79
1410102	148.95*	108.65, 199.31	113.83	66.31, 182.25
1410101	113.59	90.34, 141.00	118.95	85.36, 161.37
1380502	105.83	80.16, 137.12	109.06	72.47, 157.62
1381209	102.78	81.86, 127.41	137.38*	102.29, 180.63
1381211	101.31	72.37, 137.95	83.47	46.72, 137.67
1380506	100.91	63.24, 152.78	116.69	58.25, 208.79
1380503	96.30	67.81, 132.74	111.24	67.95, 171.81
1380505	94.34	63.18, 135.49	107.66	58.86, 180.64
1410103	91.34	73.98, 111.54	81.88	58.76, 111.08
1410105	89.59	68.84, 114.62	98.99	68.56, 138.34
1410104	84.53	56.17, 122.18	93.41	52.28, 154.06
1380504	82.97	63.47, 106.58	93.07	66.18, 127.23
1410301	81.08	63.55, 101.95	82.63	58.18, 113.89
1381207	80.09	61.12, 103.10	79.53	54.04, 112.89
1380501	76.32#	57.81, 98.89	66.76#	42.77, 99.33
1380510	71.80#	51.3, 97.78	79.89	52.19, 117.06
1381210	56.25	28.08, 100.64	88.32	38.13, 174.02
1380508	49.02#	26.8, 82.25	52.33	19.2, 113.89
1380507	48.46#	25.04, 84.64	21.66#	2.62, 78.23

SLA = Statistical Local Area

NSW = New South Wales

SIR = Standardised Incidence Ratio # Statistically significantly lower than the comparison area

SMR = Standardised Mortality Ratio * Statistically significantly higher than the comparison area

Table 7: Groupings of years for year-block analysis.

Census year	Years of available data grouped around Census year
1971	1972-1973
1976	1974-1978
1981	1979-1983
1986	1984-1988
1991	1989-1993
1996	1994-1998
2001	1999-2001