Government of South Australia
Department of Health

Whyalla Health Impact Study Report

DEPARTMENT OF HEALTH

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Executive summary

1. Purpose and Scope

The purpose of this study is to gain a more detailed understanding of potential health conditions associated with exposure to red dust emitted from the OneSteel plant in Whyalla, using existing data sources in the Department of Health. As such this is an ecological study, capable of further clarifying associations between Whyalla red dust and health effects, but is not able to establish causality. Evidence from the literature that underlies this report is detailed in Departmental research* 2005.

2. Methodology

The existing data sources analysed in this study were the SA Cancer Registry (1977-2004), Hospital Separations Data (1999/2000 financial year to 2004/2005), SA Health Omnibus (1993-2004), viral hepatitis notifications from CDCB (1994-2005) and Australian Bureau of Statistics Census data. Sex and age adjusted disease rates in Whyalla were compared with Pt. Augusta, Pt. Pirie, Pt. Lincoln, Mt. Gambier and Victor Harbor.

3. Results

There is significantly more lung cancer in Whyalla than the comparison towns, with a ratio of 1.51 (51% increase) and an excess of 32 lung cancers over 5 years. This increased standardised ratio of lung cancers is seen predominately in women, with a ratio of 2.0 (100% increase, double the number expected). Although women have had the increased lung cancer burden in the last five years, both men and women in Whyalla have had a higher than expected incidence of lung cancer when considering the time period from 1977 to 2004. A second analysis comparing the lung cancer rates in Whyalla with the other dusty towns, Pt Pirie and Pt Augusta found a similar but smaller significant excess of lung cancer in Whyalla. There was no association between diagnosis of cancer, (including lung cancer) and location of residence at diagnosis comparing mid to high dust affected zones. The majority of the excess lung cancer was seen in Whyalla Norrie, postcode 5608, which lies on the western half of Whyalla, away from the OneSteel plant in East Whyalla.

Diseases found to be higher (statistically significant) in Whyalla when compared with the comparison towns were:

- Chronic obstructive pulmonary disease
- Asthma
- Chronic hepatitis
- Alcoholic liver disease
- Other anaemias
- Both lung and liver cancer resulted in more hospital separations in Whyalla.

*Incomplete research conducted by the Department of Health 2005

There was an increase in the adjusted ratio of asthma in children under 15 years old and children were more likely to be admitted for respiratory infections in Whyalla than comparison towns.

In examining the factors that were considered to be confounders, Whyalla was not found to be significantly more likely to have increased exposures to smoking or alcohol than the comparison towns. Similarly, Whyalla does not have an excess of Hepatitis A, B or C compared with the comparison towns. As such, these potential confounders are unlikely to explain the overall increased disease burden in Whyalla.

Mortality data demonstrated significantly more deaths in Whyalla from COPD and alcohol related liver disease than the comparison towns. This resulted in an excess 23 deaths from COPD, and an excess of 8 deaths from Alcohol related liver disease.

4. Conclusion

There are a number of areas of uncertainty that have limited the ability to form firm conclusions in this report. There are large information gaps, such as exposure assessment and lack of definitive evidence in the literature regarding the toxicology/bioavailability of iron. In addition, the ecological design of this study is inherently weak and is not able to establish causality.

Despite these limitations, this report has generated a number of hypotheses regarding possible adverse health effects from red dust that warrant further investigation, and a number of factors support further study. Firstly, the diseases found in this study to be of higher incidence in Whyalla are all highly statistically significant. In addition, there is reasonable evidence of biologic plausibility for the diseases found in relation to iron rich dust exposure and lastly, there is indirect evidence of individuals being exposed to red dust. Given that the confounders studied do not explain the increased disease burden, further studies that address the gaps described above would be required to definitively analyse potential health effects from red dust in Whyalla.

1. Purpose and scope

The purpose of this study is to gain a more detailed understanding of potential health conditions associated with exposure to red dust emitted from the OneSteel plant in Whyalla, using existing data sources held by the Department of Health. As such this is an ecological study, capable of further clarifying associations between Whyalla red dust and health effects, but is not able to establish causality [(1)].

For many years there has been public concern over the visible red dust that comes from the ore screening and crushing operations in the OneSteel plant in Whyalla. In response to this public concern the SA Department of Health has undertaken a series of investigations to explore potential health effects from the red dust. This study continues on from work done by the Department* that highlighted potential health issues in Whyalla such as an increased incidence of lung cancer and of Chronic Obstructive Pulmonary Disease (COPD) when compared with other SA rural centres [(2)].

2. Background

2.1 Whyalla description

Whyalla has been associated with steel production since the mid 1930's. The blast furnace began operations in 1941, and the current pellet plant (previously BHP owned) was established in 1968 to pelletise iron ore. In 2000, 25.7 % of respondents in a representative sample survey reported financial reliance on the OneSteel plant, with a further 10.8% indirectly reliant financially on the plant [(3)].

In the past, Whyalla shipbuilding works was a major employer in Whyalla. The company closed in 1978 with a consequent population decline.

2.2 Land use

The iron ore used in the OneSteel plant is mined from the nearby Middleback Ranges, and transported into the plant via railway in open rail wagons.

Much of the surrounding land is dedicated to low density sheep farming, with little in the way of crop farming due to the adverse (arid) weather conditions.

2.3 Demography

Whyalla as a community experiences high socio-economic disadvantage relative to much of the population of South Australia, but has a similar demographic profile [(4)]. Figure 1 outlines the Index of Relative Socio-economic Disadvantage (IRSD) by postcode in 2001. This index is a summary indicator of disadvantage, using factors such as income, employment (unemployed, as well as unskilled versus skilled employment) and education. A lower IRSD indicates a lower socio-economic status [(5)].

* Incomplete research conducted by the Department of Health 2005

Figure1: Index of relative socio-economic disadvantage (IRSD) by postcode in Whyalla, 2001 [5]

Postcode	*IRSD*	*Population size*
5600	1027.39	6857
5608	848.76	14001
5609	1014.11	756

According to the 2001 Census, 21 866 people live in Whyalla, which has reduced steadily from 34 014 in 1976. Children less than 15 years old make up 22.9% (compared with the national 20.7%) and 11.9% are aged 65 and over (compared with 12.6% nationally). Aboriginal and Torres Strait Islanders make up 2.9% of the population, compared with 2.16% nationally.

The proportion of people born in Whyalla who live in Whyalla in 2006, considering those who are 15 years old and over is around 7 out of 10. There is however a net movement of people out of Whyalla. This decline is now small, in that over 2004-2005 there was a net loss of 50 people from Whyalla [4].

2.4 Red dust in Whyalla

The OneSteel plant is located on the eastern side of Whyalla town, adjacent to postcode 5600. From an aerial photo, it can be seen that the red dust covers only a small part of Whyalla town, most of which is concentrated in the few streets adjacent to the plant. An aerial photo demonstrating the red dust in Whyalla in 2002 is in Appendix 1.

3. Work undertaken to date

3.1 Hazard identification

3.1.1 Toxicology

The study by Graham Ohmsen, finalised in October 2004, examined the composition of the red dust in Whyalla [6, 7]. His summarised findings are outlined below:

Winds from the direction of OneSteel bring dusts that are:

- at higher dust concentration
- dominated by iron rich materials (up to 76% of deposited dust)
  - the iron is up to 66% haematite and 18% goethite
- dust is up to 7% quartz, up to 25% kaolin (clay), up to 20% calcite and up to 2% talc
- from recently crushed iron ore
- particulate matter with up to 15% below 5 micrometres in diameter and up to 60% particles below 10 micrometres diameter.

Winds from directions other than OneSteel (background) are:

- of lower dust concentration
- dominated by quartz (up to 22%), kaolin (up to 67%), sea salt (up to 100%) and mica (up to 29%)
- low in iron.

3.1.2 Epidemiology

Preliminary analysis of Whyalla hospital separations data and SA Cancer Registry data indicated higher prevalence than expected of various health conditions when compared with the comparison towns. With the diseases outlined below, the ratio shown in brackets refers to the ratio of observed cases in Whyalla from 1999-2004 to the expected cases over the same period, if Whyalla had the same disease prevalence as the comparison towns for each age and sex profile. For example, a lung cancer ratio of 1.5 means there is 50% more lung cancer measured than expected, or 1.5 times more lung cancer than expected. The diseases that were statistically significant in the Department of Health's research were:

SA Cancer Registry data 1999-2004

- Lung cancer (1.51, 51% more lung cancer than expected)

Whyalla hospital separations data 1999-2004

- Chronic obstructive pulmonary disease (1.77, 77% more than expected)
- Chronic hepatitis (4.3, 330% more than expected)
- Alcoholic liver disease (1.7, 70% more than expected)
- Other anaemias (1.4, 40% more than expected).

3.2 Exposure Assessment

Exposure assessment involves analysis of hazard locations, identification and analysis of exposed populations as well as identification and analysis of potential exposure pathways [(1)]. There is limited information regarding exposure to red dust in Whyalla.

There is no local information regarding potential important routes of exposure, including the importance of the gastrointestinal (hand mouth) route over the respiratory route. On the basis of work done elsewhere, an assumption was made for this study that the respiratory route is likely to be the most important route of exposure [(8)]. This gap in knowledge limits the effectiveness of any exposure assessment.

Some work has been undertaken to analyse hazard locations by the EPA, as well as the study by the Department of Health. The Environment Protection Authority (EPA) has been monitoring concentration of dusts at various sites in Whyalla, including Hummock Hill, Walls Street and Civic Park [(9)]. Figure 2 details the monitoring methods for each of the sites:

Figure 2: EPA monitoring

Site	*Date of commencement*	*Sampling frequency*	*Purpose*
Hummock Hill	1990	One day in 3 (since 2002)	Study of Concentration of dust near plant
Walls Street	2003	Continuous	Industrial compliance site
Civic Park	2001	One day in 3 (since 2002)	Background site

The maximum recommended standard of particulate matter (PM_{10}) exposure is 50µg/m^3 averaged over a 1 day period, with a maximum of 5 exceedences per year [(10)]. The evidence for this standard has been derived predominately from urban ecological epidemiological studies, where a larger proportion of the PM_{10} is finer ($PM_{2.5}$) than in rural environments ($PM_{2.5-10}$). As such there is some debate as to whether this standard is appropriate for rural environments such as in Whyalla, with most of the evidence of negative health effects used for the standard being due to the $PM_{2.5}$ fraction [11]. There is, however, an increasing body of evidence that the coarse fraction of PM_{10} also has significant negative health effects and so the Australian particulate matter standard has been used in this report [8, 12]. The Walls Street site found that of 357 24-hour averages obtained, 24 exceeded 50µg/m^3 in the 2004-2005 financial year. In comparison, monitoring at Civic Park had no measurements exceeding 50µg/m^3. At Hummock Hill, of the 112 samples taken, 23 exceeded 50µg/m^3 [9]. Given that over the 2004-2005 financial year levels of environmental dust in some sites exceeded the maximum recommended standard, exposure to dust in levels higher than recommended for human health occurred.

The study by the Department of Health in May-June 2005 investigated the amount and composition of airborne and surface dust infiltration at various indoor locations in Whyalla (falling within the densely dust covered zone). Sampling sites were 3 houses and 2 classrooms in the Whyalla Town Primary School. All the locations had high levels of dust, with iron making up between 3 and 15% of the dust samples [13].

Detailed analysis of exposed populations was not possible within the scope of this study. Direct measurement of exposure is ideal in exposure analysis, but was not possible as it involves measurement of either personal monitoring and/or biological markers. It is likely that measuring individual exposures using current personal monitoring technology is not possible, as it is cumbersome, relatively expensive, and has never been applied to a large proportion of a population to accurately measure individual exposures. A possible future option for measuring individual exposures is the use of adapted cohort study designs know as “panel “studies. Panel studies, for example, compare daily symptoms of people with asthma with daily environmental PM monitoring results. Large sample sizes are possible and so adequate data can be gathered and analysed to describe the risk of symptoms per environmental exposure level.

Biological markers can potentially accurately indicate individual biologically significant exposure to toxins, however this is frequently limited by the sensitivity of the tests to analyse low exposure levels [1]. There are a number of biological markers that could potentially measure exposure to red dust, including serum iron assessments, chest X-rays and/or pulmonary function tests (PFT). PFT are insensitive to damaged lung tissue, as at least 15-20% of lung tissue needs to be involved in destructive changes before complaints of shortness of breath or impaired function on PFT can be demonstrated [2]. This relatively insensitive test is however more sensitive than radiology, as although chest X-rays are able to pick up the presence of iron in the lungs, a ventilatory defect can occur without X-ray changes [2]. Blood tests can be used to measure the iron in the blood, and not necessarily accurately reflect iron effects in the lungs. As such, although this information would have added to the exposure assessment, it could not provide definitive exposure results when considering red dust.

Port Hedland study, 2006

The Western Australian Department of Health recently commissioned a study in relation to the potential health affects from respirable dust in Port Hedland. The BHP Billiton Iron Ore processing and loading facility is immediately adjacent to Port Hedland at Nelson Point. Much alike to Eastern Whyalla, Port Hedland is impacted by dust, principally fugitive iron ore from the BHP iron ore facility, with the town experiencing frequent exceedences of the NEPM PM_{10} standard.

Further to the debate on the appropriateness of the PM_{10} NEPM standard being applied to non-urban areas, an extensive literature review was undertaken. The authors recommended that the NEPM standards for exposure to PM_{10} should be revised for non-urban areas to an annual average of 100µg/m^3 per day, with a daily average limit of <200µg/m^3 (14). This finding was based on the presumption that dusts in rural areas are likely to be less toxic than those in urban areas. This assumption was made in the absence of evidence directly relating to dust exposure and potential health effects in rural areas. As such this finding is opinion based, rather than evidenced based.

An exploratory geographic analysis at the census collection district level of respiratory admissions to hospital from 1993-2004 was also undertaken (15, Appendix 2). The study analysed respiratory, cardiovascular and gastrointestinal admissions in aggregate, with the cardiovascular and gastrointestinal admissions included to aid in the study of confounders. The study found a higher rate of respiratory admissions for all of Port Hedland compared with the rest of WA (1.29, 29% more than expected). There was an increased rate of all three of respiratory, cardiovascular and gastrointestinal admissions, however there was a relatively higher rate of admissions for respiratory illness in the collection districts in the Western part of the township, closer to the BHP plant. The western part of town had rates of respiratory admissions ranging from 1.33 to 6.59. This could not be accounted for by demographic factors including race, or by socio-economic status, although the study did not examine smoking and other risk behaviours.

The study design was ecological and so although the results are indicative of increased respiratory illness in Pt Hedland, there are a number of limitations to the findings. It is not clear if the authors for the issue of counting individuals who were admitted more than once in the study period, nor did they examine admissions for Port Hedland usual residents out of Port Hedland. It is also unclear which parts of the town are affected by dust, and if this corresponds to the collection district areas that had evidence of higher rates of respiratory admissions.

4. Methods for this study

4.1 Comparison towns for the analysis

The comparison towns for the analysis are Pt Pirie, Pt Augusta, Pt Lincoln, Victor Harbor and Mt Gambier. Comparison towns should be alike to Whyalla in a number of parameters to try and control to some degree the effect of living in Whyalla on health that is separate from the OneSteel plant. Figure 3 below outlines key parameters for comparison:

Figure 3: Comparison towns in the Phase 1 Whyalla study

Town	*Size (2001)*	*Index of relative socio-economic disadvantage*∗	*Accessibility/Remoteness Index of Australia* ∗∗
Whyalla	21 866	911	Accessible (2.9)
Pt Pirie	3 646	921	Accessible (2.6)
Pt Augusta	13 516	943	Accessible (2.7)
Pt Lincoln	27 306	-	Remote (6.1)
Mt Gambier	23 503	957	Accessible (2.2)
Victor Harbor	11 108	1011	Highly accessible (1.2)

∗ Lower the number, the higher the social disadvantage [16]

∗∗ Accessibility/Remoteness Index of Australia [17]

4.2 Rationale for the diseases chosen for investigation

There were a number of factors that were taken into account when selecting the diseases to be examined. The evidence from the literature supporting the disease selection is outlined in detail in Departmental research 2005 [2].

4.2.1 Diseases associated with the effects of iron on the body

There are a number of diseases in which the body adversely handles iron leading to iron overload. These diseases include:

- Hereditary Haemochromatosis
- Anaemias such as Thalassaemia, Sideroblastic anaemia and chronic haemolytic anaemias
- Chronic liver disease such as Hepatitis C, Alcoholic cirrhosis, Porphyria cutanea tarda and post portacaval shunting.

As these diseases make an individual more susceptible to iron overload, it could be proposed that such individuals would have an increased susceptibility to illness in the setting of high iron exposure and thus would be more likely to have complications from their disease. This may be seen by increased admission rates to hospital.

In addition, iron overload itself can lead to widespread organ fibrosis, in particular:

- Chronic liver disease
- Hepato-cellular carcinoma
- Range of chronic and acute respiratory diseases.

Alcohol has an impact on various aspects of the above disease profile in relation to iron overload disorders. Alcohol and iron work synergistically to damage the liver in both primary and secondary Haemochromatosis (iron overload). For example, those with Hereditary Haemochromatosis are more likely to develop cirrhosis when drinking more than 60g of alcohol per day than those who do not. In addition, alcohol consumption itself may lead to altered iron homeostasis which may exacerbate the severity of liver disease and an increased risk of cirrhosis. Alcohol is therefore an important consideration in the study of iron effects on health.

4.2.1 Diseases resulting from exposure to dust

Health outcome studies have shown that particulate matter has a negative health effect on respiratory and cardiovascular disease that can be the result of any biologically or chemically active component of dust, as well as any irritative effect of the dust. In addition, there are “nuisance dust” effects that reduce visibility and increase irritation of eyes, ears, nasal passages and other mucous membranes [(18)]. Although this nuisance effect may be happening in Whyalla due to the red dust, it is not within the scope of this study to examine this, with hospital admissions and available data sets not likely to have any information relating to these issues. There is considerable evidence that people exposed to high levels of particulate matter are at greater risk of developing COPD.

The disease areas that are being investigated in this study in relation to dust effects (and also possibly to the composition of the dust itself) are:

- Chronic obstructive pulmonary disease (bronchitis and emphysema)
- Pneumoconiosis (nodular fibrotic changes)
- Asthma
- Respiratory infections, including pneumonia and infections in children.

4.2.2 Cancer

There is limited information about an association between people who work in iron and steel foundries and lung cancer. Although they are associated, there are problems with confounding (e.g. concurrent exposure to silica and smoking), and delineating any potential synergistic effect between smoking and environmental dust exposure has been difficult. Given this association with lung cancer, but understanding there is uncertainty, lung cancer was included in the study.

4.3 Methods for this analysis

An exploration of the potential health effects of red dust in Whyalla looks at the sources already examined in more depth (SA Cancer Registry and hospital separations data) as well as using different data sets that exist in the Department of Health. The diseases examined are limited to the above outlined disease areas.

4.3.1 Further analysis of preliminary results from hospital separations data and the South Australian Cancer Registry.

From the hospital separations data, 1999/2000 to 2004/2005 financial year:

- Determine the number of individuals with suspected health conditions (looking at Whyalla hospital separations only)
- Examine all SA public hospital data for separations from people living in Whyalla post codes and comparison towns
- Describe the basic demographic features of cases
- Review respiratory infections in children.

From Cancer Registry data, 1977 to 2004*

- Further map suspected associated cases, in particular in relation to the One Steel plant (comparing collection districts closer to the plant with those further away)
- Further describe the cancers in question (e.g. histopathology)
- Describe the basic demographic features of cases– age, gender and (occupation if available)
- Increase the length of time of analysis.

4.3.2 Collection and analysis of more detailed information about potential confounding factors:

From Health Omnibus study (randomised sample from SA with annual data collection, surveys 4400 households with approximately 3000 respondents)

- Determine the age and sex adjusted smoking rates in Whyalla compared with towns of comparison (data from 1993 to 2004)
- Determine the age and sex adjusted rate of alcohol abuse as above (data from 1993-1998)
- Determine the age and sex adjusted rate of asthma diagnosis.

From Australian Bureau of Statistics data (publications)

- Size of the population, demographic factors – gender, age.

From CDCB

- Notifications of viral hepatitis from Whyalla and comparison towns (1995/1996 to 2005).

4.3.3 Mapping process

In order to analyse data in relation to proximity to OneSteel, Whyalla town was divided into three zones; a densely red dust affected zone, a moderately dust affected zone and a minimally/no dust affected zone. This was done with the use of an aerial photograph of Whyalla taken in 2002, visually determining the different zones according to the amount of red dust seen from the aerial view, within statistical collection district areas. Both the densely covered and moderately covered zones fall within postcode 5600 (Whyalla). A map demarcating the areas is in Appendix 3.

4.3.3 Ethics and confidentiality issues

The report does not identify individuals, and will remain confidential for Cabinet consideration. All data was analysed in a de-identified form. All data sources with identifying information (e.g. SA Cancer Registry, CDCB) were de-identified before being provided for analysis. Hospital unique identifiers have been used but have not been linked with the names of the individuals they belong to.

* some analyses covered period 1999-2004 and are marked as such

5. Health outcome data results

5.1 Further analysis of the SA Cancer Registry data

There is significantly more lung cancer in Whyalla than the 5 comparison towns, with a ratio of 1.51 (51% more than expected, p<0.001). This translates to an adjusted excess of 32 lung cancers over the five year period from 1999 to 2004 in Whyalla compared with the 5 comparison towns. A second analysis was done comparing the lung cancer rates in Whyalla with the other dusty towns, Pt Pirie and Pt Augusta to explore if the excess was possibly due to crustal dust alone. A similar but smaller significant (p=0.02) excess of lung cancer in Whyalla was found, with a ratio of 1.28 (28% more than expected) more lung cancer, leading to 20 excess cases of lung cancer over 1999-2004.

Women were more likely to have lung cancer in Whyalla than the 5 comparison towns, making up 47% of diagnoses compared with 33.9% over the five years from 1999-2004 (p=0.02). Although the ratio of lung cancer in Whyalla is 1.5 aggregating men and women, women had a standardised morbidity ratio of 2.0 (100% more than expected), and men of 1.1. The excess lung cancer seen in the 5 years analysed from 1999-2004 in Whyalla is therefore essentially only seen in women.

Figure 4 outlines the change in lung cancer diagnosis by year of diagnosis over time in Whyalla. There has been a steadily increasing crude rate of lung cancer diagnoses over time (significant p<0.001), which was not significant when adjusted for age and sex (p=0.369). Looking at men and women separately, found that men had a significant decreasing trend in the age adjusted rate of lung cancer over time (p=0.021). Conversely, women were found to have had a significant increasing trend in the age adjusted rate of lung cancer, with an increase of 1.38 cases per 100 000 population per year (p=0.02). This relationship is demonstrated in figure 5.

Figure 4: Lung cancer diagnoses over time in Whyalla (number of lung cancers observed and age and sex adjusted rates/100 000 population)

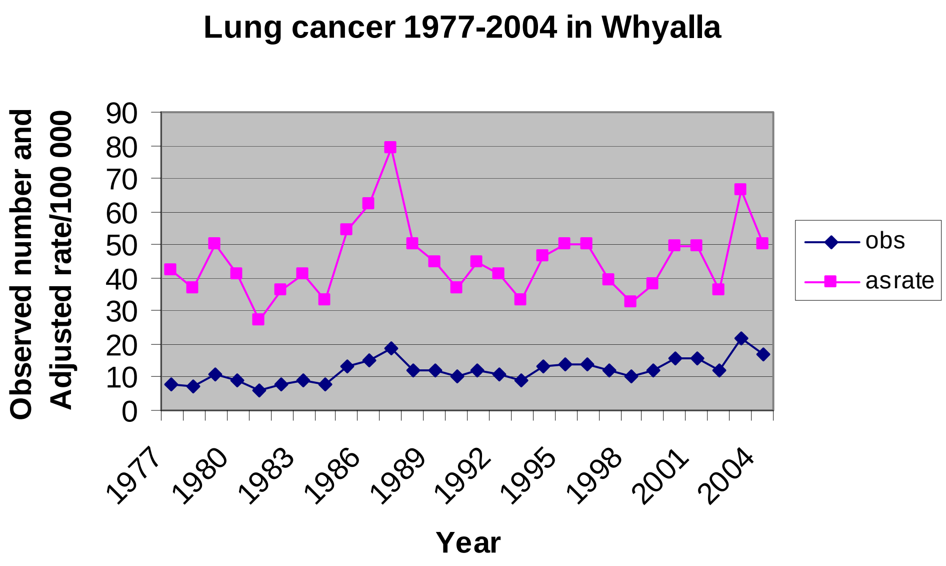


Figure 5: Age adjusted rate of lung cancer/100 000 from 1977-2004 in Whyalla by gender

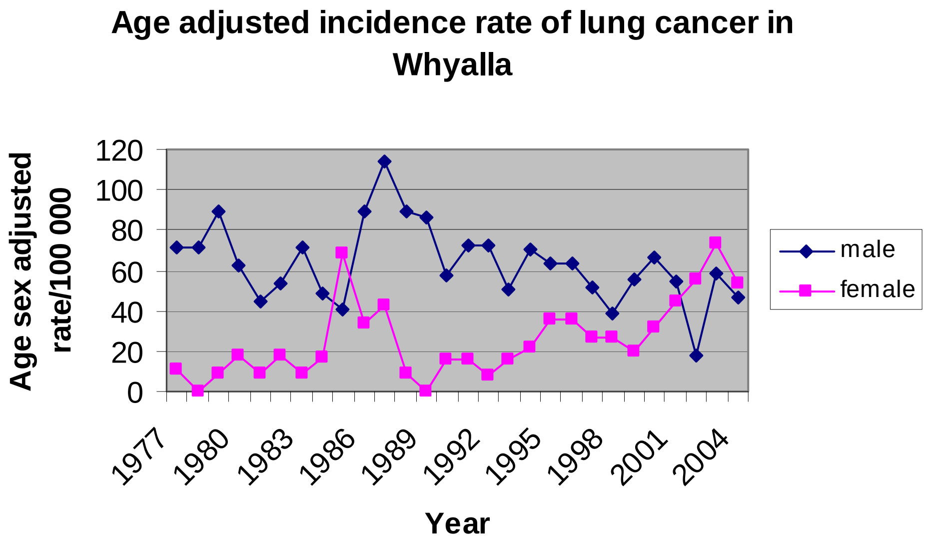


Figure 6 describes the actual lung cancer cases per postcode in Whyalla compared with the expected lung cancer cases (adjusted for population by age). The expected number of cases is displayed for the rest of the state, other metro areas and other country areas from 1977-2004. A higher than expected observed rate of lung cancer is seen across all postcodes, but particularly in postcode 5608, there has been an excess of lung cancer cases in Whyalla for both men and women over the 1977 to 2004 period. Postcode 5608 is Whyalla Norrie, which is situated on the western half of Whyalla, with the postcode closest to the plant being 5600 in Whyalla east.

Figure 6: Lung cancer observed and expected in Whyalla, 1977-2004

Post code	*Actual cases Whyalla (observed)*		*Expected cases*					
			State		*Metro*		*Country*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
5600	82	22	72.8	23.8	75.3	24.7	66.1	20.8
5608	135	55	82.1	28.3	84.8	29.2	75.0	25.4
5609	4	3	7.1	2.2	7.4	2.3	6.5	2.0

Although more adenocarcinomas were found as a proportion of the total lung cancers in Whyalla than comparison towns, this was not found to be significant. Overall, there was no significant difference between the distribution of histopathological types between Whyalla and comparison towns. The histopathological profile of the lung cancers is outlined in figure 7:

Figure 7: Histopathology of lung cancers 1999-2004

	Whyalla		*Comparison Towns*	
Histopathology	*Number*	*% of lung cancers*	*Number*	*% of lung cancers*
Adenocarcinoma	26	27.4	50	20.7
Squamous Cell Carcinoma	20	21.1	47	19.4
Large cell carcinoma	17	17.9	56	23.1
Small cell carcinoma	18	18.9	34	14.1
Other	14	14.7	55	22.7
Total	95	100	242	100

Age at first diagnosis of lung cancer was compared across the two groups, and it was found that the distribution of the ages at first diagnosis were the same for Whyalla and comparison towns, including the mean, median, 25th centile and 75th centile, and as such no further analysis was undertaken.

Primary liver cancers and bowel cancer were also examined, with no difference in adjusted rates across the comparison towns.

When examining cancers in Whyalla overall, there was no association between diagnosis of cancer and residence at time of diagnosis in the mid to highly dust affected zones. Due to the excess of lung cancers seen, this process was repeated for lung cancers. The geographical distribution of lung cancer in Whyalla in relation to the OneSteel plant was not associated with either mid or high density dust affected zones when compared with the non-dust affected zone.

Occupation data within the cancer registry could not be analysed as there were problems with apparent misclassification. All people are coded for their occupation at diagnosis, and given most people at cancer diagnosis are elderly, most are coded as pensioners. No information regarding previous occupation is recorded. As such, an excess of people were recorded as pensioners, and there was no data with regards to people who may have worked in the OneSteel plant.

5.2 Further analysis of the hospital separations data

The years of analysis for the hospital data were extended to include 1999/2000 financial year to 2004/2005 financial year (6 year period). Diseases found to be higher (statistically significant) in hospital separations data in Whyalla when compared with the comparison towns are displayed in figure 8. The diagnosis chronic bronchitis which was not significantly higher in Whyalla has been included to demonstrate that the increase in COPD and Emphysema is not due to misclassification bias in Whyalla.

Figure 8: Hospital separations for Whyalla adjusted for age and sex, 1999/2000 to 2004/2005 financial year (*explanatory notes for Figure 8 lie below the table).

Condition	*Observed*	*Expected*	*Ratio**	*SMR lower CI**	*SMR upper CI**	*Excess no. of cases**	*Rate ratio**	*SMR p-value**
Rest of D64 Other anaemias	210	146.1	1.44	1.25	1.65	64	1.59	0.0000
Chronic Bronchitis	23	31.5	0.73	0.42	1.07	Nil	0.69	0.1451
Emphysema	23	14.1	1.63	1.12	3.17	9	1.91	0.0363
COPD (excluding emphysema)	814	477.5	1.70	1.59	1.83	326	2.03	0.0000
Alcoholic liver disease	63	39.8	1.58	1.22	2.03	23	1.87	0.0008
Chronic hepatitis, not elsewhere classified	29	6.5	4.44	2.97	6.37	22	37.65	0.0000
Lung Cancer	229	165.4	1.38	1.21	1.58	63	1.52	0.0000
Liver Cancer	20	11.4	1.76	1.07	2.71	8	2.14	0.0262

* Ratio – the age and sex adjusted number of observed cases to the number of expected cases

* SMR lower CI and SMR upper CI - Ratio of observed to expected disease, adjusted for sex and age, with a 95% chance that the true value lies between the upper and lower confidence intervals

* Excess number of cases – The adjusted number of cases above what was expected

* Rate ratio – number of cases of disease in exposed (Whyalla) to the number of cases in unexposed (comparative towns).

* Standardised morbidity ratio p value- The probability that the difference in observed to expected disease, adjusted for sex and age, occurred by chance alone.

The data was further analysed specifically with respect to children under 15 years old, due to the physiologic increased vulnerability to inhaled toxins [(1)]. Asthma was considered separately for children under 15 years old, and although it was not significantly different in Whyalla to comparison towns in hospital separations data when all ages were considered, there was an increase in the adjusted ratio of asthma when children were considered separately (ratio of 1.23, $p<0.001$, excess of 54 separations, 23% more than expected). In addition, children were more likely to be admitted for respiratory infections (upper, lower and otitis media) in Whyalla than comparison towns (ratio 1.25, $p<.001$, excess of 140 separations, 25% more than expected).

The admissions to Whyalla hospital were examined for the number of individuals that contributed to the admissions in order to determine if there was a large number of individuals contributing to the excess admissions or a small number. These results are demonstrated in Figure 9.

Figure 9: Whyalla resident's hospital separations 1999/2000 to 2004/2005 financial year

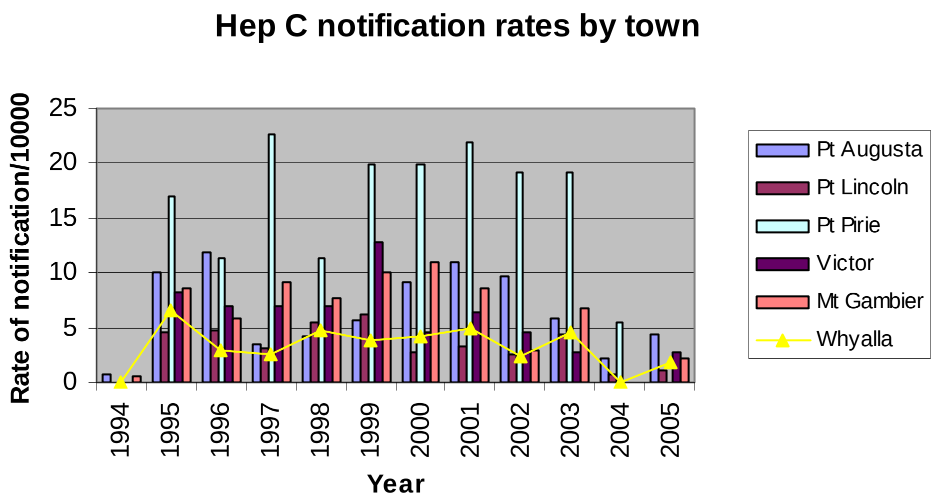
Condition	*Admissions to Whyalla Hospital*	*Persons*	*Whyalla residents admitted to hospital in SA outside of Whyalla*	*Expected no. of admissions for SA*
Rest of D64 Other anaemias	205	133	5	146
J43 Emphysema	22	22	1	14.1
J44 COPD (excluding emphysema)	793	268	21	477.5
J45 Asthma	253	190	14	319.5
K70 Alcoholic liver disease	56	40	7	39.8
K73 Chronic hepatitis, not elsewhere classified	29	27	0	6.5
Lung Cancer	144	76	85	165.4
Liver Cancer	16	10	4	11.4
Total	1502	745	-	-

To describe the prevalence of asthma in adults who are not necessarily admitted to hospital, age and sex adjusted data from the Health Omnibus study was examined. Adults in Whyalla were more likely (p=0.002) to have a self-reported confirmed diagnosis of asthma than in comparison towns. This increased diagnosis of asthma in Whyalla was still significant (p=0.049) when compared with Port Pirie and Port Augusta.

In examining the factors that were considered to be confounders (smoking, alcohol use and viral hepatitis) Whyalla was not found to be significantly more likely to have increased exposures to the confounding variables than the comparison towns. Specifically there was no significant difference in the adjusted rate of current versus ex-smoker/non smoker in Whyalla compared with the comparison towns. In addition, there was no significant difference in the adjusted rate of intermediate to high and very high alcohol use in Whyalla compared with the comparison towns. Definitions of the alcohol hazardous drinking categories are in Appendix 4.

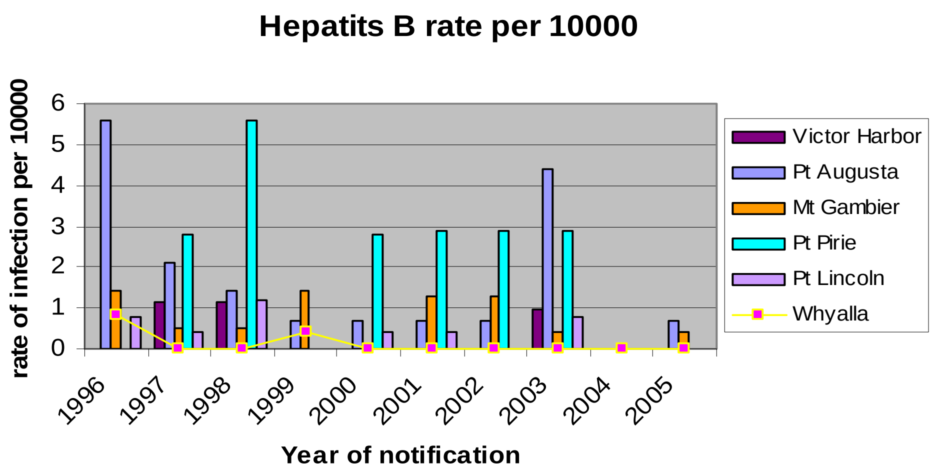
Similarly, Whyalla does not have an excess of Hepatitis C compared with the comparison towns, as demonstrated in Figure 10.

Figure 10: Hepatitis C notifications, Whyalla and Comparison towns



Both Hepatitis A and B have occurred in small numbers across Whyalla and comparison towns, and as such are unlikely to have contributed to the overall chronic liver disease burden. Figure 11 outlines Hepatitis B over time.

Figure 11: Hepatitis B notification rate per 10000



In examining mortality data for Whyalla 1999-2004, there was significantly more deaths in Whyalla from COPD (standardised mortality ratio of 1.86, 86% more than expected, $p<0.001$) and alcohol related liver disease (standardised mortality ratio of 2.27, 127% more than expected, $p=0.009$). This resulted in an excess 23 deaths from COPD, and an excess of 8 deaths from alcohol related liver disease. The standardised mortality ratio for pneumoconiosis was 3.25 (225% more than expected), but given the small numbers (2 in Whyalla, 2 in comparison towns) was not found to be significant.

The hospital separations data could not be analysed in relation to proximity to the OneSteel plant due to the limitation of available data sources. The smallest geographical unit in the available data is postcodes with the postcode adjacent to the plant (5600) covering approximately half of the town.

6. Discussion including limitations in the methodology

The more detailed analysis of Whyalla data has shown further evidence of an increased incidence of lung cancer, and probable increased incidence of COPD, asthma, chronic liver disease including alcohol related chronic liver disease, and asthma and respiratory infections in children. This increased adjusted rate of disease is also reflected in the Whyalla mortality data, that has shown significantly more deaths in Whyalla from COPD and alcohol related liver disease. Factors such as smoking, alcohol intake and viral hepatitis are not significantly different between Whyalla and comparison towns, and as such, these factors do not appear to explain the increase in the above diseases.

Cancer

In this study, a significant increased risk of lung cancer was identified among women with a ratio of 2.0 (100% more than expected) over the five years from 1999-2004, although Figure 5 demonstrates that the excess of observed over expected adjusted rates of lung cancer in Whyalla have occurred in men as well as women (1977-2004). Women have been experiencing increased rates of lung cancer since 1977, while men have had a reducing lung cancer incidence over the same time period. This in part parallels the state trend for the increased incidence of lung cancer in women and a decline in lung cancer in men, with most of the increase in women occurring in the early 1990s [(19)]. Despite this trend for lung cancer rates in men and women to converge, in 2002 the risk for lung cancer in men in South Australia was 1 in 24, compared with 1 in 42 for women. Although it is possible that the trend for increasing incidence in women has been exaggerated in Whyalla due to the small numbers involved, this finding cannot be further adequately explained with the existing data. Importantly, the smoking rates in Whyalla are no higher than comparison towns and women have traditionally had a reduced rate of smoking compared with men. Women are also less likely to have had industrial occupational exposures and, as such, this rapid increase in lung cancer diagnosis in women warrants further exploration, along with exploration of the overall increase in lung cancers in both men and women.

Postcode 5608 has had the predominance of lung cancers over time in Whyalla, however the data was not able to be analysed to define the time period or year from which the lung cancer incidence is higher than expected. Considering the IRSD data in Figure 1, this suburb does have a lower index of relative disadvantage (lower socio-economic status), which could explain some of the excess lung cancer in this suburb relative to the other suburbs in Whyalla. It does not however explain Whyalla's higher rate of lung cancer compared with the comparison towns, as overall the towns have a comparable socio-economic status to Whyalla. Further analysis beyond the scope of this study is required to explore this result.

In addition, comparing Whyalla with Pt Augusta and Pt Pirie, towns considered to be dusty, found a smaller but still significant increase in lung cancers in Whyalla. This suggests that the excess cancer can not solely be explained by an increased exposure to crustal dust. In order for this increase in lung cancer to be understood further, a more detailed analysis beyond the scope of this study is required.

When analysing many of the diseases in this study, it is important to consider the long latency period required. Latency refers to the length of time between exposure to disease causing agents and the appearance of manifestations of the disease [(20)]. In illnesses such as lung cancer, chronic obstructive pulmonary disease and chronic liver disease, the latency period from exposure to disease can be greater than 20 years. A limitation of this study with regards to latency periods is the ecological study design used to describe the exposure for all people who have had lung cancer in Whyalla from 1999 to 2004, but using smoking data from only 1993-2004. Any exposure to lifestyle risk factors in the present may not clearly define the relationship to such exposures in the past. In addition, due to the constraints of the available data sources, population based statistics have been used to describe the potential for an individual case to have an associated confounder. This has significant limitations, as it is not necessarily the case that population based results are accurate on an individual level, a concept known as ecological bias.

No particular or group of particular lung cancer histopathological subgroups were identified that could account for the increased incidence of lung cancer seen in Whyalla. The numbers in general are small and may have reduced the power of the statistical tests that were applied, and therefore reduced the ability to find a dominant cancer/group of cancers.

Liver cancer was examined particularly in this study due to the strength of association reported in the literature between iron overload and primary liver cancer. In the cancer registry data there was no difference in the adjusted rate of primary liver cancer in Whyalla compared with the comparison towns. There was however an excess of hospital separations due to liver cancer in Whyalla residents, with 10 people accounting for 16 admissions in Whyalla, when 11.4 admissions were expected. It is likely that the small numbers involved in the cancer registry– 19 across comparison towns and 4 in Whyalla over the 5 year period, has reduced the power of the statistical test to analyse the data.

There are other potential confounders in this study, such as exposure to asbestos and other known environmental respiratory carcinogens that were unable to be controlled for due to the limitations of available data sources. Access to more detailed data, including a full occupational history and community surveys/environmental sampling would be required to analyse this issue further.

Dose-response relationship

There was no association identified between living closer to the OneSteel plant and an increased risk of having any cancer or of lung cancer. This finding is limited by the crude marker of exposure to red dust used in this study, with likely misclassification bias. A more ideal method to demarcate the different zones would involve objective measures of dust density and formal cut-off measures between the zones based on safety data from the literature. Due to limitations in available safety data, this more formal process of analysis has not been effectively undertaken internationally. Consequently, risk assessments have traditionally relied on more crude methods such as used in this study.

Limitations of the dose-response assessment

It might be presumed that if there was a health effect from the red dust, then increasing the dose of exposure by living closer to the OneSteel plant over a longer period of time would be associated with an increased incidence of ill health. Important limitations to this concept are:

- Length of time spent living in Whyalla – no information was available for this study regarding the length of time that cases lived in Whyalla (time of exposure), nor of the number of people who lived in Whyalla for some years and then moved away, becoming unwell out of Whyalla (total exposed population). These cases would have been excluded from this study. Although as described in 2.3 above, a large proportion of people live in Whyalla for long periods of time, this was not examined for individual cases. As such, there is great uncertainty in the completeness and accuracy of the information used in this study with regards to exposure to red dust.

- Working at the OneSteel plant – occupational history is important information that was unavailable. It is presumable that people who worked in the plant may have had high exposure to red dust. If these people did not live within the densely or moderately covered red dust zone, they will have been counted in this study as being at only low risk of exposure. This would have reduced the number of potentially exposed individuals in our analysis, and consequently reduce the power of this study to detect any significant difference in health outcomes for those exposed to high levels of dust.
- It is also feasible that a number of individuals may not live in the densely covered zone, but spend a large proportion of their time within the zone. Importantly, the Whyalla Primary School falls within the densely covered red dust zone.
- The person’s residence was recorded at the time of diagnosis, and did not necessarily reflect their residence during the latency period of the disease.
- Certain vulnerable individuals may have negative health outcomes from exposure to red dust at a low exposure level relative to the general population. The data was not sufficient to enable analysis of this issue in detail.

Hospital separations data

This study identified significantly higher adjusted rates of chronic hepatitis, alcohol related liver disease, COPD, asthma and respiratory infections in children, and other anaemias from hospital separations data in Whyalla. These diseases are biologically plausible in relation to iron rich dust, as described in the literature in Departmental research.

There was no difference in the prevalence of smoking and high and very high risk alcohol drinking in Whyalla compared with the comparison towns, and no more viral hepatitis. As such, these potential confounders cannot explain the increased incidence of disease as described above.

A key problem with hospital separations data is that unique identifiers are different for the same individuals in different hospitals. As such, it is impossible to determine if individuals are duplicated across different hospitals. Unfortunately the effect of counting individuals more than once could only be removed in the Whyalla hospital separations data, which demonstrated that most of Whyalla residents were admitted to hospital in Whyalla. With illnesses concerned with the liver, there were limited repeat admissions for any individual, strengthening the finding that these illnesses have a higher incidence in Whyalla than the comparison towns. In particular, the diagnosis of “Chronic hepatitis not elsewhere specified” had a ratio of 4.44 (344% more than expected) in Whyalla with all of the 29 admissions admitted to Whyalla hospital, from 27 individuals, when only 6.5 admissions were expected. The data from this table would ideally be compared with similar data from the other towns to understand if the number of admissions, the number of admissions per person, as well as the total number of individuals involved is different for Whyalla when compared with the comparison towns. This would particularly be required for COPD, which in Whyalla accounted for a higher mortality as well as for more admissions than comparison towns.

An additional problem with hospital separations data is that there may be a problem with the accuracy of the clinical diagnosis made, as it has not been standardised to a definition such as would be ideal in an epidemiological study. This was a particular problem with the category “other anaemias” which was found to be significantly higher in Whyalla resident hospital separations data. It is unclear how this may be classified by different hospitals/clinicians, so an analysis of this would require access to clinical records, to better understand what is meant by the category “other anaemias”.

Both COPD and alcohol related liver disease have contributed to an increased standardised mortality ratio in Whyalla, adding more evidence to the potential association between red dust and COPD and liver disease associated with alcohol. There is no issue of double counting individuals with mortality data, however it is likely to be incomplete. Over time there has been a net migration out of Whyalla, with the population size having reduced over time (2.3 above). As such, these results may underestimate the true increased mortality from various diseases in Whyalla.

Paediatric analysis

There are a number of physiological and behavioural factors that put children at increased risk from a toxin [(1)]. In relation to this study, children have potentially higher exposure to red dust via the inhalational route, given their higher respiratory rate compared with adults. This study has found a small but statistically increased hospital separation for asthma and respiratory infections. This is evidence for an increased disease burden in a vulnerable group in Whyalla, which is of particular importance given a primary school is in the vicinity of the heavily red dust effected zone.

Comparison with the Port Hedland study

The geographic analysis undertaken in the Port Hedland study enabled a more detailed analysis of the illnesses being studied in relation to the BHP plant than was possible in this study. In the event of future studies, this would be an integral analytical technique to employ to better understand the geographic distribution of illnesses in Whyalla.

Both Port Hedland and Whyalla residents had higher rates of admission for respiratory illnesses. Given the Port Hedland study analysed respiratory diseases in aggregate, it is not possible to make comparisons with the finding in this study of increased rates of COPD or of a range of respiratory illness in children.

The aggregating of gastrointestinal diseases into one category has also limited the ability to compare the finding in the Port Hedland study to the finding in this study of increased risk of liver disease in Whyalla. The intention of including gastro-intestinal diseases in the Port Hedland study was to act as a control for the respiratory illnesses being studied, which was unfortunate given the large amount of evidence in the literature for damaging affects of iron on the liver. In addition, the Pt Hedland study did not examine cancers and so no comparison can be made regarding the increased lung cancer finding in Whyalla.

Nuisance dust affects

The literature suggests that irritation effects to eyes, nose, throat and upper airways could be associated with red dust exposure. The available hospital separations data does not provide information about these potential effects of dust as they generally do not require hospitalisation. Perhaps more importantly, hospital separations data mostly reflects at least moderately severe illnesses, and as such, asthma that may be of a high prevalence in the community but not severe enough to be hospitalised would not be counted. It is likely that this was the case with the asthma analysis, with the data from the Health Omnibus study demonstrating that adults in Whyalla have a higher prevalence of asthma than the comparison towns.

It is likely that the health outcomes analysed in this study were undercounted to some degree. A number of chronic illnesses are sub-clinical in their early stages. In relation to this study, such illnesses include Haemochromatosis, some anaemias and early lung disease. These potentially important illnesses may not have been counted in hospital separations data, but may indicate significant health effects. In addition, there may have been a group of people with chronic illnesses who chose to leave Whyalla to be closer to tertiary care centres and as such would not be counted in Whyalla hospital separations data.

Conclusion

This report has described a number of areas of uncertainty that have limited the forming of firm conclusions. There are large information gaps, such as in exposure assessment and lack of definitive evidence in the literature regarding the toxicology of iron (and less so with dust). In addition, the ecological design of this study is inherently weak and is not able to establish causality.

Despite these limitations, this report has generated a number of hypotheses regarding possible adverse health effects from red dust that warrant further investigation. There are a number of factors that support further study. Firstly, the diseases found in this study to be of higher incidence in Whyalla are all highly statistically significant. In addition, there is reasonable evidence of biologic plausibility for the diseases found in relation to iron rich dust exposure and lastly, there is indirect evidence of environmental exposure to red dust according to the EPA air quality report and the Department of Health report [(13)]. Given that the confounders studied do not explain the increased disease burden, further studies that address the gaps described above would be required to definitively analyse potential health effects from Whyalla red dust.

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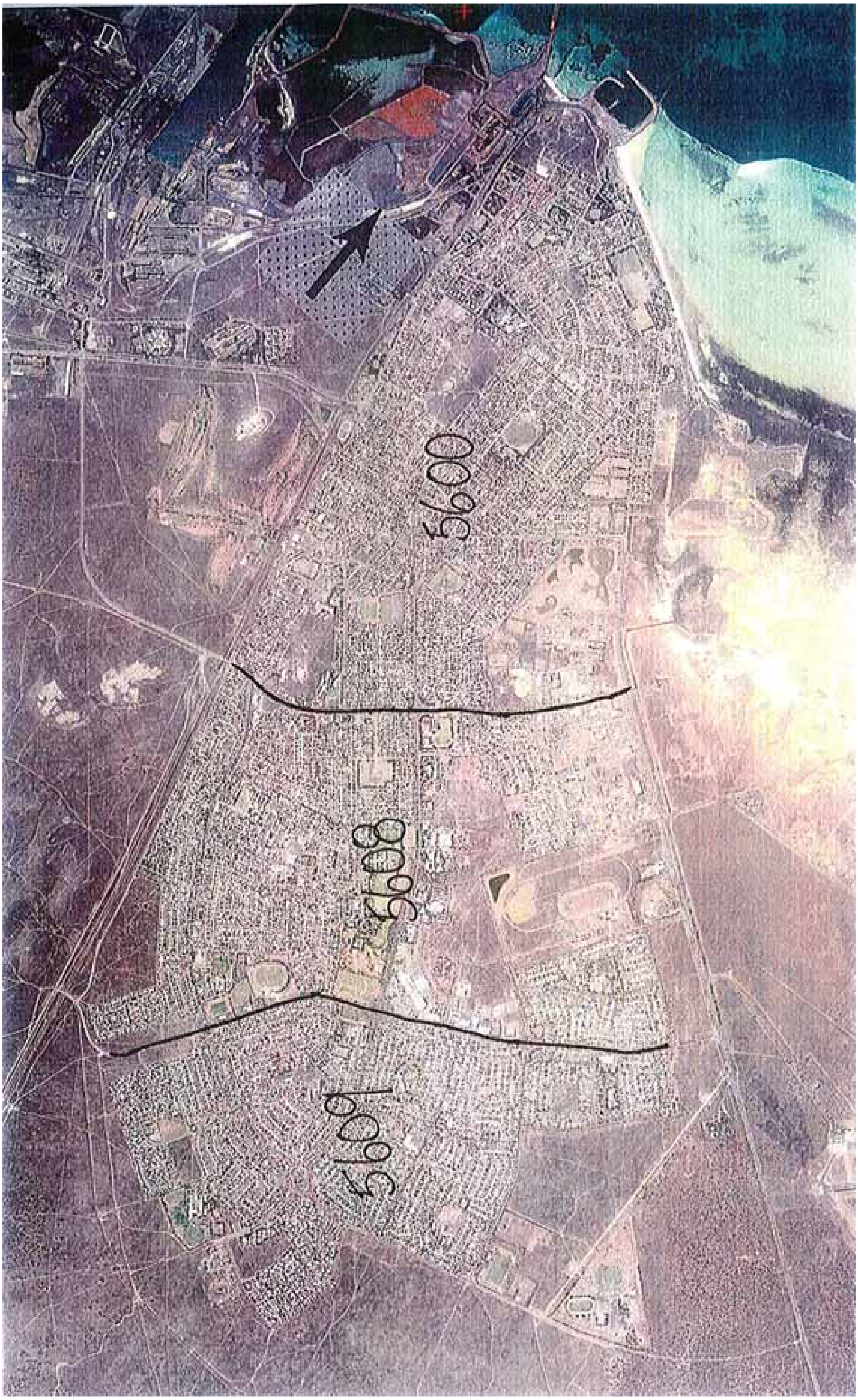
Appendix 1

Aerial photo of Whyalla showing Whyalla postcode boundaries and the OneSteel plant (indicated by the arrow)



Appendix 2

Executive summary: Respiratory Hospitalisations in Port Hedland, 1993-2004: An exploratory geographical analysis

Exploratory Geographical Analysis of Hospital Admissions in the Port Hedland Township

January 2006

Suggested citation: Mullan N, Codde J & Van Buynder P 2006, *Respiratory Hospitalisations in Port Hedland, 1993-2004: An Exploratory Geographical Analysis*, Epidemiology Branch, Department of Health, Perth, WA.

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1. Executive Summary

In order to examine the possible impact of high background particulate levels on respiratory disease, the spatial variation in hospital admissions within the town of Port Hedland, Western Australia, over the years 1993 to 2004 was investigated. A descriptive analysis of the population and patients of interest was conducted, followed by an estimation of the risk of being admitted to hospital for respiratory, cardiovascular or digestive diseases as compared to the general Western Australian population, both before and after adjusting for some of the potentially confounding factors. Admissions for cardiovascular and digestive disease were compared with those for respiratory disease to aid the examination of confounders.

The study time frame, small population and the geographic size of the study region limited the ability of this project to examine each of the potentially confounding factors in detail. In addition, behavioural risk factor information such as smoking and lifestyle habits have not been included in the calculation of any risk estimate, and the presence of chronic disease conditions has not been considered. Other potential bias issues associated with remote rural community living may also be present.

The risk of being admitted to hospital across Census Collection Districts (CD) was estimated using a Standardised Rate Ration (SRR) and Bayesian model. The results indicate a geographical variation in the relative risk of respiratory hospitalisation compared to the Western Australian population, ranging from 0.5 (CI: 0.37, 0.64) to 6.59 (CI: 5.55, 7.75) across the Census CDs. This geographical variation was consistent across all 3 disease types investigated.

Table 1: Age, Gender and Race Adjusted Relative Risks of Hospital Admissions in Port Hedland Census Collection Districts 1993-2004

Census Collection District	Respiratory Admissions			Cardiovascular Admissions			Digestive Admissions		
	Relative Risk	2.50%	97.50%	Relative Risk	2.50%	97.50%	Relative Risk	2.50%	97.50%
5010902	**1.44**	**1.13**	**1.78**	1.20	0.91	1.56	1.03	0.81	1.29
5010903	**1.33**	**1.09**	**1.62**	**2.02**	**1.66**	**2.46**	**1.34**	**1.09**	**1.61**
5010904	**2.03**	**1.77**	**2.31**	**1.81**	**1.50**	**2.15**	**1.19**	**1.01**	**1.39**
5010905	0.91	0.73	1.12	1.08	0.86	1.33	0.93	0.77	1.10
5010906	**6.59**	**5.55**	**7.75**	**5.89**	**4.63**	**7.28**	1.31	0.88	1.80
5010908	0.87	0.71	1.03	1.05	0.86	1.26	**0.85**	**0.72**	**0.99**
5010909	**0.50**	**0.37**	**0.64**	**0.71**	**0.54**	**0.90**	**0.66**	**0.53**	**0.80**
5010910	**0.75**	**0.62**	**0.90**	0.90	0.74	1.08	0.90	0.77	1.03
5010911	**0.57**	**0.42**	**0.75**	0.88	0.67	1.12	**0.71**	**0.56**	**0.87**

bold indicates statistical significance

The hospital admissions modelled during this investigation showed that, although relative risks of respiratory admissions were significantly greater than those expected in the general Western Australian population in 4 of the Census CDs (5010902, 5010903, 5010904, 5010906), this increase is reflected across all disease types investigated in Census CDs 5010903, 5010904 and 5010906. A more significant relative risk in respiratory hospital admissions which is not reflected in cardiovascular and digestive admissions was seen in the most western Census CD of Port Hedland. These higher than expected hospital admissions could not be accounted for by demographic or social and economic factors included in the risk model. It is possible however, that there are other factors such as behavioural (eg smoking, exercise), environmental or occupational exposures influencing the development of this disease, as opposed to the cardiovascular or digestive diseases which cannot be identified within the parameters of this exploratory analysis.

Appendix 3

Map used to demarcate dense, mid and non-dust effected zones.

Dense zone collection districts:

4020701

4020702

Mid zone collection districts

4020703

4020704

4020705

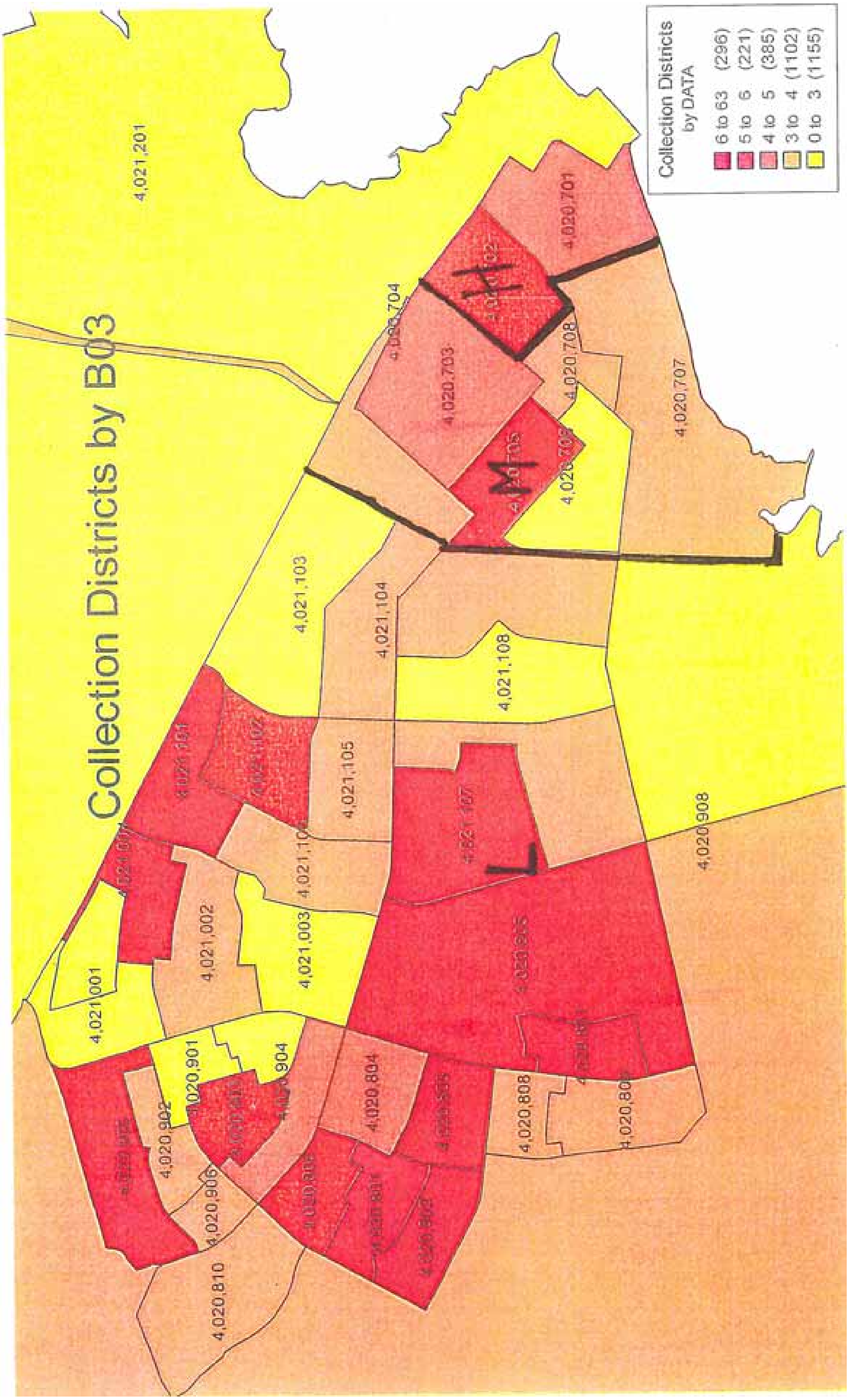
4020706

4020707

4020708

Please refer to the next page for a map of the Collection District areas in Whyalla (ABS census).

The transparency indicates H – high dust zone, M – mid dust zone and L – low dust zone


Collection Districts by B03
Collection Districts
by DATA
6 to 63 (296)
5 to 6 (221)
4 to 5 (385)
3 to 4 (1102)
0 to 3 (1155)
4,021,201
4,021,103
4,021,104
4,021,108
4,021,105
4,020,908
4,020,707
4,020,703
4,020,708
4,020,701
4,021,002
4,021,003
4,021,001
4,020,901
4,020,902
4,020,906
4,020,810
4,020,804
4,020,808
H
M
L

Appendix 4

Alcohol hazardous drinking categories

Description	*Risk*	
	Men	*Women*
Non-drinkers	None	None
Average daily intake of <3 drinks	None	Low
Average daily intake of 4 drinks or 9-12 drinks in any day	Low	Intermediate
Average daily intake of 5-8 drinks or occasional excess	Intermediate	High
Average daily intake of 9-12 drinks or frequent or great occasional excessive intake	High	Very High
Average daily intake of over 12 drinks	Very high	Very high

Appendix 5

Data tables

Persons usually resident in Whyalla postcodes (5600, 5608, 5609) v defined towns (Pt Lincoln, Pt Pirie, Pt Augusta, Mt Gambier, Victor Harbor)
Six years of data from 1999/2000 financial year to 2004/2005 financial year.

Whyalla	Condition	obs	exp	ratio	smrl95	smru9	smrprob	rr	l95ci	u95ci	prob	crude	asrate
Comparison	Other condition	189,884	196,689.7	0.97	0.96	0.97	0.0000	0.85	0.84	0.86	0.0000	39,663.78	39,264.27
Whyalla	Other condition	57,430	50,624.3	1.13	1.13	1.14	0.0000	1.18	1.16	1.19	0.0000	44,401.66	46,139.29
Comparison	A15,A16 Tuberculosis	2	2.3	0.87	0.26	3.80	0.8082	0.60	0.03	35.40	1.0000	0.42	0.43
Whyalla	A15,A16 Tuberculosis	1	0.7	1.44	0.02	8.04	0.9899	1.67	0.03	32.01	1.0000	0.77	0.71
Comparison	B20-B24 HIV	11	10.7	1.02	0.51	1.83	0.9805	1.11	0.29	6.19	1.0000	2.30	2.36
Whyalla	B20-B24 HIV	3	3.3	0.92	0.33	3.15	0.8147	0.90	0.16	3.41	1.0000	2.32	2.12
Comparison	B18 Chronic Viral Hepatitis	48	46.0	1.04	0.77	1.38	0.8101	1.23	0.63	2.63	0.6613	10.03	10.12
Whyalla	B18 Chronic Viral Hepatitis	11	13.0	0.85	0.48	1.62	0.7120	0.81	0.38	1.59	0.6613	8.50	8.23
Comparison	D55,D58 Haemolytic anaemias	23	19.8	1.16	0.74	1.75	0.5207	3.06	0.75	26.73	0.1595	4.80	4.79
Whyalla	D55,D58 Haemolytic anaemias	2	5.2	0.38	0.11	1.67	0.2087	0.33	0.04	1.32	0.1595	1.55	1.57
Comparison	D64.0 Hereditary sideroblastic anaemia	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Whyalla	D64.0 Hereditary sideroblastic anaemia	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Comparison	D64.1 Secondary sideroblastic anaemia due t	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Whyalla	D64.1 Secondary sideroblastic anaemia due t	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Comparison	D64.2 Secondary sideroblastic anaemia due t	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Whyalla	D64.2 Secondary sideroblastic anaemia due t	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Comparison	D64.3 Other sideroblastic anaemias	69	56.2	1.23	0.95	1.55	0.1094	.	4.13	.	1.0000	14.41	13.92
Whyalla	D64.3 Other sideroblastic anaemias	0	12.8	0.00	0.00	0.44	0.0000	0.00	0.00	0.24	0.0000	0.00	0.00
Comparison	D64.4 Congenital dyserythropoietic anaemia	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Whyalla	D64.4 Congenital dyserythropoietic anaemia	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Comparison	Rest of D64 Other anaemias	585	648.9	0.90	0.83	0.98	0.0116	0.63	0.53	0.74	0.0000	122.20	117.86
Whyalla	Rest of D64 Other anaemias	210	146.1	1.44	1.25	1.65	0.0000	1.59	1.36	1.87	0.0000	162.36	187.95
Comparison	D56 Thalassaemia	0	5.0	0.00	0.00	1.12	0.0143	0.00	0.00	0.18	0.0001	0.00	0.00
Whyalla	D56 Thalassaemia	6	1.0	5.76	2.10	12.54	0.0018	.	5.61	.	1.0000	4.64	5.69
Comparison	D46.1 Refractory anaemia with sideroblasts	0	0.8	0.00	0.02	7.04	0.9153	0.00	0.00	10.38	0.4204	0.00	0.00
Whyalla	D46.1 Refractory anaemia with sideroblasts	1	0.2	4.76	0.06	26.47	0.3773	.	0.10	.	1.0000	0.77	0.78
Comparison	Rest of D46 Myelodysplastic syndromes	207	197.4	1.05	0.91	1.20	0.5124	1.33	0.93	1.95	0.1285	43.24	41.91
Whyalla	Rest of D46 Myelodysplastic syndromes	36	45.6	0.79	0.57	1.12	0.1700	0.75	0.51	1.08	0.1285	27.83	31.54
Comparison	E80.0, E80.1 Porphyrias	0	0.8	0.00	0.02	7.09	0.9203	0.00	0.00	10.72	0.4313	0.00	0.00
Whyalla	E80.0, E80.1 Porphyrias	1	0.2	4.64	0.06	25.80	0.3856	.	0.09	.	1.0000	0.77	0.76
Comparison	E83.1 Haemochromatosis	26	24.4	1.06	0.70	1.56	0.8014	1.40	0.53	4.67	0.6597	5.43	5.43
Whyalla	E83.1 Haemochromatosis	5	6.6	0.76	0.33	1.98	0.7139	0.71	0.21	1.89	0.6597	3.87	3.87
Comparison	E83.0 Copper metabolism	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00

Whyalla	Condition	obs	exp	ratio	smrl95	smru9:	smrprob	rr	l95ci	u95ci	prob	crude	asrate
Whyalla	E83.0 Copper metabolism	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
Comparison	I81,I85 Portal Vein	65	61.3	1.06	0.82	1.35	0.6687	1.39	0.74	2.82	0.3663	13.58	13.43
Whyalla	I81,I85 Portal Vein	12	15.7	0.76	0.44	1.42	0.4253	0.72	0.35	1.35	0.3663	9.28	9.67
Comparison	J40-J42 Chronic Bronchitis	140	131.5	1.06	0.90	1.26	0.4824	1.46	0.93	2.37	0.1059	29.24	28.53
Whyalla	J40-J42 Chronic Bronchitis	23	31.5	0.73	0.49	1.13	0.1451	0.69	0.42	1.07	0.1059	17.78	19.59
Comparison	J43 Emphysema	52	60.9	0.85	0.65	1.14	0.2801	0.52	0.31	0.90	0.0184	10.86	10.53
Whyalla	J43 Emphysema	23	14.1	1.63	1.03	2.45	0.0363	1.91	1.12	3.17	0.0184	17.78	20.11
Comparison	J44 COPD (excluding emphysema)	1,769	2,105.5	0.84	0.80	0.88	0.0000	0.49	0.45	0.54	0.0000	369.52	356.90
Whyalla	J44 COPD (excluding emphysema)	814	477.5	1.70	1.59	1.83	0.0000	2.03	1.86	2.21	0.0000	629.34	724.06
Comparison	J45 Asthma	1,223	1,170.5	1.04	0.99	1.11	0.1298	1.25	1.09	1.43	0.0008	255.47	256.03
Whyalla	J45 Asthma	267	319.5	0.84	0.74	0.95	0.0028	0.80	0.70	0.91	0.0008	206.43	204.75
Comparison	J60-J65 Pneumoconioses	9	9.0	1.00	0.46	1.90	0.9152	1.01	0.21	9.59	1.0000	1.88	1.81
Whyalla	J60-J65 Pneumoconioses	2	2.0	0.99	0.30	4.35	0.6498	0.99	0.10	4.79	1.0000	1.55	1.80
Comparison	K70 Alcoholic liver disease	128	151.2	0.85	0.71	1.01	0.0596	0.53	0.39	0.73	0.0001	26.74	26.59
Whyalla	K70 Alcoholic liver disease	63	39.8	1.58	1.22	2.03	0.0008	1.87	1.36	2.55	0.0001	48.71	49.75
Comparison	K71 Toxic liver disease	2	4.7	0.42	0.13	1.85	0.2970	0.13	0.01	0.94	0.0419	0.42	0.42
Whyalla	K71 Toxic liver disease	4	1.3	3.14	0.85	8.05	0.0823	7.43	1.06	82.13	0.0419	3.09	3.10
Comparison	K73 Chronic hepatitis, not elsewhere classifie	3	25.5	0.12	0.04	0.40	0.0000	0.03	0.01	0.09	0.0000	0.63	0.62
Whyalla	K73 Chronic hepatitis, not elsewhere classifie	29	6.5	4.44	2.97	6.37	0.0000	37.65	11.67	193.14	0.0000	22.42	23.34
Comparison	K74 Fibrosis and cirrhosis of liver	62	60.6	1.02	0.78	1.31	0.8921	1.12	0.62	2.18	0.8204	12.95	12.79
Whyalla	K74 Fibrosis and cirrhosis of liver	14	15.4	0.91	0.55	1.61	0.8524	0.89	0.46	1.61	0.8204	10.82	11.37
Comparison	Other K70-K76 Chronic Liver	109	111.0	0.98	0.81	1.19	0.9026	0.92	0.61	1.43	0.7445	22.77	22.46
Whyalla	Other K70-K76 Chronic Liver	30	28.0	1.07	0.72	1.53	0.7614	1.09	0.70	1.64	0.7445	23.19	24.45
Comparison	Lung Cancer	645	708.6	0.91	0.84	0.98	0.0164	0.66	0.56	0.77	0.0000	134.73	130.84
Whyalla	Lung Cancer	229	165.4	1.38	1.21	1.58	0.0000	1.52	1.30	1.77	0.0000	177.05	198.97
Comparison	Liver Cancer	39	47.6	0.82	0.60	1.14	0.2351	0.47	0.27	0.84	0.0116	8.15	7.95
Whyalla	Liver Cancer	20	11.4	1.76	1.07	2.71	0.0262	2.14	1.19	3.77	0.0116	15.46	17.04

whyalla	children <15	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0	Respiratory illness other than asthma	3128	3367.8	0.93	0.90	0.96	0.0000	0.74	0.69	0.79	0.0000	3080.6	3071.4
1	Respiratory illness other than asthma	1190	950.2	1.25	1.18	1.33	0.0000	1.35	1.26	1.44	0.0000	4097.8	4141.2
0	Asthma	754	807.7	0.93	0.87	1.00	0.0590	0.76	0.66	0.87	0.0001	742.6	742.0
1	Asthma	284	230.3	1.23	1.09	1.39	0.0007	1.32	1.15	1.52	0.0001	978.0	980.5

J10-18 J20-22 (lower) J00-06 (upper) and H65-66 (otitis media) J45-46 (asthma)

Death rates for people dying while resident in Whyalla v defined towns (Pt Pirie, Pt Augusta, Pt Lincoln, Mt Gambier, Victor Harbor)

whyalla	conditn	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0.00	A15, A16 Tuberculosis	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	A15, A16 Tuberculosis	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	B20-B24 HIV	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	B20-B24 HIV	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	B18 Chronic Viral Hepatitis	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	B18 Chronic Viral Hepatitis	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	D55, D58 Haemolytic anaemias	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D55, D58 Haemolytic anaemias	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	D64.0	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D64.0	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	D64.1	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D64.1	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	D64.2	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D64.2	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	D64.3	1	0.8	1.25	0.02	6.95	0.9050	.	0.01	.	1.0000	0.25	0.25
1.00	D64.3	0	0.2	0.00	0.07	27.94	0.3603	0.00	0.00	156.87	1.0000	0.00	0.00
0.00	D64.4	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D64.4	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	Rest of D64 Other anaemias	3	2.5	1.20	0.24	3.51	0.9081	.	0.08	.	1.0000	0.76	0.71
1.00	Rest of D64 Other anaemias	0	0.5	0.00	0.03	11.08	0.7781	0.00	0.00	12.03	1.0000	0.00	0.00
0.00	D56 Thalassaemia	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D56 Thalassaemia	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	D46.1	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	D46.1	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	Rest of D46 Myelodysplastic syndromes	3	2.5	1.19	0.24	3.48	0.9188	.	0.08	.	1.0000	0.76	0.71
1.00	Rest of D46 Myelodysplastic syndromes	0	0.5	0.00	0.03	11.55	0.7526	0.00	0.00	12.66	1.0000	0.00	0.00
0.00	E80.0, E80.1 Porphyrias	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	E80.0, E80.1 Porphyrias	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	E83.1 Haemochromatosis	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	E83.1 Haemochromatosis	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	E83.0 Copper metabolism	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	E83.0 Copper metabolism	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	I81, I85 Portal Vein	1	0.8	1.18	0.02	6.55	0.8618	.	0.00	.	1.0000	0.25	0.23
1.00	I81, I85 Portal Vein	0	0.2	0.00	0.09	36.86	0.2849	0.00	0.00	219.38	1.0000	0.00	0.00

whyalla	conditn	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0.00	J40-J42 Chronic Bronchitis	3	4.2	0.71	0.26	2.44	0.7902	0.28	0.03	3.41	0.3654	0.76	0.71
1.00	J40-J42 Chronic Bronchitis	2	0.8	2.51	0.28	9.05	0.3769	3.51	0.29	30.65	0.3654	1.86	2.48
0.00	J44 COPD	107	130.1	0.82	0.68	1.00	0.0423	0.44	0.31	0.63	0.0000	26.93	25.56
1.00	J44 COPD	50	26.9	1.86	1.38	2.45	0.0001	2.26	1.58	3.19	0.0000	46.41	57.85
0.00	J45 Asthma	12	10.5	1.14	0.59	1.99	0.7291	2.81	0.42	120.24	0.5239	3.02	2.93
1.00	J45 Asthma	1	2.5	0.41	0.09	2.93	0.5864	0.36	0.01	2.40	0.5239	0.93	1.04
0.00	J60-J65 Pneumoconioses	2	3.4	0.59	0.18	2.59	0.6850	0.18	0.01	2.51	0.2291	0.50	0.47
1.00	J60-J65 Pneumoconioses	2	0.6	3.25	0.37	11.73	0.2531	5.50	0.40	75.88	0.2291	1.86	2.57
0.00	K70	15	22.8	0.66	0.40	1.14	0.1108	0.29	0.13	0.65	0.0022	3.78	3.77
1.00	K70	14	6.2	2.27	1.24	3.81	0.0094	3.46	1.55	7.69	0.0022	12.99	13.05
0.00	K71	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	K71	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	K73	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
1.00	K73	0	0.0	.	.	.	.	.	.	.	1.0000	0.00	0.00
0.00	K74	8	7.2	1.11	0.48	2.19	0.8584	2.01	0.27	89.30	0.8664	2.01	1.98
1.00	K74	1	1.8	0.55	0.12	3.99	0.9234	0.50	0.01	3.71	0.8664	0.93	0.99
0.00	Other K70-K76 Chronic Liver	6	6.5	0.93	0.43	2.22	0.9406	0.70	0.13	7.11	0.9317	1.51	1.47
1.00	Other K70-K76 Chronic Liver	2	1.5	1.32	0.15	4.76	0.8905	1.42	0.14	7.97	0.9317	1.86	2.09

Cancers for persons who were resident in Whyalla at the time of diagnosis (postcodes 5600 5608 5609) v defined towns (Pt Pirie, Pt Augusta, Pt Lincoln, Mt Gambier, Victor Harbor) 1999-2004

Lung

whyalla	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0.00	242	274.2	0.88	0.78	1.00	0.0518	0.58	0.46	0.75	0.0000	51.64	49.76
1.00	95	62.8	1.51	1.22	1.85	0.0002	1.71	1.34	2.18	0.0000	73.62	85.34

Liver

whyalla	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0.00	19	18.7	1.02	0.61	1.59	0.9920	1.09	0.36	4.40	1.0000	4.05	0.04
1.00	4	4.3	0.93	0.38	2.72	0.8526	0.92	0.23	2.76	1.0000	3.10	0.04

Bowel

whyalla	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0.00	378	382.0	0.99	0.89	1.10	0.8625	0.95	0.75	1.20	0.6675	80.66	0.78
1.00	92	88.0	1.05	0.84	1.28	0.6940	1.06	0.83	1.33	0.6675	71.29	0.82

Cancers for persons who were resident in Whyalla at the time of diagnosis (postcodes 5600 5608 5609) v defined dusty towns (Pt Pirie, Pt Augusta) 1999-2004

Lung

whyalla	obs	exp	ratio	smrl95ci	smru95ci	smrprob	rr	l95ci	u95ci	prob	crude	asrate
0.00	89	109.8	0.81	0.66	1.01	0.0473	0.63	0.47	0.85	0.0025	50.19	48.69
1.00	95	74.2	1.28	1.04	1.56	0.0229	1.58	1.17	2.13	0.0025	73.62	76.87