Cancer incidence and mortality and proximity to TV towers

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Abstract

Objective: To determine whether there is an increased cancer incidence and mortality in populations exposed to radiofrequency radiations from TV towers.
Design: An ecological study comparing cancer incidence and mortality, 1972-1990, in nine municipalities, three of which surround the TV towers and six of which are further away from the towers. (TV radiofrequency radiation decreases with the square of the distance from the source.) Cancer incidence and mortality data were obtained from the then Commonwealth Department of Human Services and Health. Data on frequency, power, and period of broadcasting for the three TV towers were obtained from the Commonwealth Department of Communications and the Arts. The calculated power density of the radiofrequency radiation in the exposed area ranged from 8.0 μW/cm ^{2} near the towers to 0.2 μW/cm ^{2} at a radius of 4 km and 0.02 μW/cm ^{2} at 12 km.
Setting: Northern Sydney, where three TV towers have been broadcasting since 1956.
Outcome measures: Rate ratios for leukaemia and brain tumour incidence and mortality, comparing the inner with the outer areas.
Results: For all ages, the rate ratio for total leukaemia incidence was 1.24 (95% confidence interval [CI], 1.09-1.40). Among children, the rate ratio for leukaemia incidence was 1.58 (95% CI, 1.07-2.34) and for mortality it was 2.32 (95% CI, 1.35-4.01). The rate ratio for childhood lymphatic leukaemia (the most common type) was 1.55 (95% CI, 1.00-2.41) for incidence and 2.74 (95% CI, 1.42-5.27) for mortality. Brain cancer incidence and mortality were not increased.
Conclusion: We found an association between increased childhood leukaemia incidence and mortality and proximity to TV towers.

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Introduction

The biological effects of low level electromagnetic fields and any relation to cancer causation are controversial. There have been several epidemiological studies of possible effects of extremely low frequency (50 Hz) fields, [1] but few have looked at radiofrequency radiations (RFR) (i.e., frequencies of 300 kHz to 300 GHz). Goldsmith, [2] in a recent review, concluded that there may be an association between RFRs and cancer; however, a World Health Organization review concluded that there is no clear evidence of detrimental health effects in humans exposed to RFR. [3]

An opportunity for studying the effect of RFR presents itself in northern Sydney, New South Wales, where three TV towers are sited in a triangle close to each other (Figure 1). The towers have been used to broadcast three TV services since 1956 and four since 1965. The channel frequencies range from 63 to 215 MHz; the wavelengths (ranging from 5 m to 1 m) are close to body reson ances and hence are maximally absorbed. [3]

We compared cancer incidence and cancer mortality for the three municipalities (Lane Cove, Willoughby and North Sydney -- population, 135 000) which immediately surround the TV towers (inner area) with data for six adjacent municipalities (Ryde, Ku-ring-gai, Warringah, Manly, Mosman and Hunters Hill -- population, 450 000) (outer area) (Figure 1), on the basis that the RFR becomes progressively weaker with the square of the distance from the towers across these municipalities. The control municipalities were selected because of the similar distance from the towers to their nearest borders, their resi dents having a similar upper-middleclass socioeconomic status, [4] and their areas being large enough for there to be a decrease in power density. Cancers of interest were leukaemia and brain tumour, especially in childhood, given findings from community studies of extremely low frequency (50 Hz) electro magnetic fields. [1] We had no prior knowledge of, nor had concerns been raised about, clusters of leukaemia cases in the areas close to the towers.

Methods

Radiofrequency radiation

Data for frequency and power of the RFR sources on the towers for the period 1956-1990 were obtained from the Commonwealth Department of Communications and the Arts [5] and are shown in Box 1.1. The TV signals are composed of 100 kW video amplitude modulated (AM) and 10 kW audio frequency modulated (FM) signals, on carrier frequencies which range from 63 to 215 MHz. The combined field strengths at increasing distances were calculated by the method of the United States National Council on Radiation Protection and Measurement [6] (Box 1). There were no TV repeater

stations in the inner or outer areas during the survey period.

Cancer data

The NSW Cancer Registry maintains a comprehensive database allowing distinction between incidence and mortality, and giving residence at the time of report. [4] Data from the registry for 1972 to 1990 are available from HealthWiz [7] and were extracted by municipality, and for sex and age bands 0-14 years, 15-69 years and 70 years and over. The data are available only for the three-digit code categories identified by the *International classification of diseases, injuries and causes of death* , ninth revision (ICD-9). More refined data are not available for reasons of privacy. Cancer data from before 1972 are not available.

Statistical analysis

The data were analysed using a Poisson regression model, [8] in which the number of cases or deaths were regarded as Poisson random variables, whose mean is a product of the person-years (i.e., the sum of appropriate mid-year populations) pertaining to the observation and the functions of the explanatory variables. These models give rate ratio estimates for comparisons of interest, adjusted for the other variables. Interactions were examined, and the model tested for goodness-of-fit. We made adjustment for extra-Poisson variation, when necessary, using the "quasi-likelihood" method of McCullagh and Nelder. [9]

The explanatory variables fitted in these models were: age in years (0-14, 15-69, 70 and over), sex, calendar period (1972-1978, 1979-1984 and 1985-1990), and area ("inner" [close to the TV towers] and "outer" [more distant]) (Figure 1). For comparisons between the areas of interest and the whole of New South Wales, standardised incidence ratios (SIRs) and standardised mortality ratios (SMRs) were calculated. For these analyses the stratification was by calendar-year (19 separate years), age and sex. Confidence intervals were calculated by the "exact" method. [10]

Results

Box 2 shows the data structure used in the analysis; the leukaemia cases and person-years in each cell were obtained by summing across the years for that age-group and sex combination. The rate ratios comparing the inner with the outer areas are shown in Boxes 3 and 4. No increase in brain cancer incidence or mortality was found, but there was an increased leukaemia incidence and mortality in the municipalities close to the towers. The rate ratio for childhood leukaemia incidence (Box 4) was 1.58 (95% CI, 1.07-2.34) and for mortality was 2.32 (95% CI, 1.35-4.01). These rates were broadly consistent across the types of leukaemia; for lymphatic leukaemia, the rate ratio was 1.55 for incidence and 2.74 for mortality.

3: Rate ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in the population of the inner area compared with the outer area, adjusted for age, sex and calendar period

Cancer type	ICD-9 code	RR (95% CI)	Cases
Incidence			
Brain tumour	191	0.89 (0.71–1.11)	740
Total leukaemia	204–208	1.24 (1.09–1.40)	1206
Lymphatic leukaemia	204	1.32 (1.09–1.59)	536
Myeloid leukaemia	205	1.09 (0.91–1.32)	563
Other leukaemia	206–208	1.67 (1.12–2.49)	107
Mortality			
Brain tumour	191	0.82 (0.63–1.07)	606
Total leukaemia	204–208	1.17 (0.96–1.43)	847
Lymphatic leukaemia	204	1.39 (1.00–1.92)	267
Myeloid leukaemia	205	1.01 (0.82–1.24)	493
Other leukaemia	206–208	1.57 (1.01–2.46)	87

4: Rate ratios (RR) and 95% confidence intervals (CI) for cancer incidence and mortality in childhood (0–14 years) in the inner area compared with the outer area, adjusted for sex and calendar period

Cancer type	RR (95% CI)	Cases
Incidence		
Brain tumour	1.10 (0.59–2.06)	64
Total leukaemia	1.58 (1.07–2.34)	134
Lymphatic leukaemia	1.55 (1.00–2.41)	107
Myeloid leukaemia	1.73 (0.62–4.81)	19
Other leukaemia	1.65 (0.33–8.19)	8
Mortality		
Brain tumour	0.73 (0.26–2.10)	30
Total leukaemia	2.32 (1.35–4.01)	59
Lymphatic leukaemia	2.74 (1.42–5.27)	39
Myeloid leukaemia	1.77 (0.47–6.69)	11
Other leukaemia	1.45 (0.30–6.99)	9

Our analysis pooled data from the inner and outer municipalities. To see whether results *within* each municipality were similar, we performed tests of homogeneity for childhood leukaemia incidence and mortality. No significant heterogeneity was found ($P = 0.10$ for incidence and $P = 0.13$ for mortality).

We found no significant overall trends across time for brain cancer or leukaemia incidence, for all ages combined or for children alone. For children, there was a significant overall reduction in leukaemia mortality over time ($P = 0.008$), but no significant evidence of a change over time in the differences between the outer and inner areas in brain cancer or leukaemia incidence or mortality, for all ages combined or for children alone.

Because a small part of Hunters Hill projects close to the TV towers (Figure 1) and there is a potential confounder there (a factory which used radium until the 1970s in Hunters Hill), the data were analysed excluding Hunters Hill. The incidence rate ratio for childhood leukaemia was 1.56 (95% CI, 1.09-2.22), and for all ages was 1.23 (95% CI, 1.06-1.43).

5: Childhood (0–14 years) cancer incidence and mortality, comparing the inner and outer areas with the whole of New South Wales

Type of cancer	Inner area				Outer area			
	Cases				Cases			
	Obs	Exp	SIR/SMR	95% CI	Obs	Exp	SIR/SMR	95% CI
Incidence								
Brain tumour	12	9.1	1.3	0.7–2.3	52	43.4	1.2	0.9–1.6
Leukaemia	33	18.6	1.8	1.2–2.5	101	88.8	1.1	0.9–1.4
Mortality								
Brain tumour	4	4.1	1.0	0.3–2.5	26	19.7	1.3	0.9–1.9
Leukaemia	19	7.9	2.4	1.4–3.7	40	38.7	1.0	0.7–1.4

Obs = observed; Exp = expected; SIR = standardised incidence ratio; SMR = standardised mortality ratio; CI = confidence interval.

Childhood cancer incidence and mortality (brain cancer and leukaemia) for the inner and outer areas were compared with cancer incidence and mortality data for the whole of New South Wales (Box 5). There was no difference for cancer of the brain. Leukaemia incidence and mortality were significantly increased in the inner area, but incidence and mortality data for the outer area were similar to data for the State as a whole.

Discussion

This ecological study found an association between residential proximity to TV towers and increased incidence of childhood leukaemia.

Study biases

Studies of this type are prone to biases.

1. *Comparison of the inner and outer areas:* Socioeconomic class has been associated with leukaemia, with a positive association with higher socio economic status. However, all muni cipalities considered in the inner and outer areas are ranked in the top two socioeconomic quintiles; further, two out of three of the inner municipalities are in the top quintile, and four out of six of the outer municipalities are in the top quintile. [4] Moreover, for New South Wales as a whole there is no evidence of a socioeconomic

gradient for leukaemia. [4]

There are small pockets of light industry in the surveyed municipalities, but they are mainly residential. The area closer to the TV towers is subject to much higher traffic density than the outer area, and exhaust fumes contain small traces of benzene, a proven leukaemogen. [11] However, a causal relationship between exhaust fumes and childhood leukaemia has not been established; [11] in occupational studies benzene exposure is related predominantly to acute myeloid leukaemia, [12] but we found an increased incidence/mortality of lymph atic leukaemia in the inner areas.

2. *Confounding variables affecting individuals* can not be adjusted for. The few recognised causes of leukaemia include ionising radiation, cytotoxic drugs and some uncommon genetic conditions. [13] The only known potential community exposure to ionising radiation in the study area is a factory in Hunters Hill that used radium until the 1970s. There are no high voltage power lines traversing the inner area, but one traverses the outer area and runs along the border between Lane Cove and Ryde in a national park.

Individual (household) exposure cannot be determined, and therefore local enhancements and attenuations of RFR **,** which might influence dose-response calculations, cannot be allowed for. Usually, exposures in flats and houses will be lower than those for free space, such as gardens, parks and schoolyards.

3. *Population movement* cannot be adjusted for. Thus, miscalculations arise if people move out of, or into, particular areas for selective reasons (e.g., treatment of cancer is offered at Royal North Shore Hospital, which is in the inner area). This would not influence incidence, but could influence mortality data if patients with cancer came to live closer to the hospital for ease of access. However, it appears most childhood leukaemia cases attend children's hospitals not in the study area. A linkage study of cases could resolve this. On the other hand, social mobility would tend to obscure effects that have long latency periods. Duration of residence would need to be determined in a more detailed study.

Migration to new towns has been suggested as a confounding factor in childhood leukaemia clusters, [14] with viral spread to susceptible persons, but the areas surveyed in this study are long established. Greaves, [15] using a similar argument, postulated that fewer infectious stimuli in early postnatal life, with later infection at a critical period, may play a major role in precipitating acute lymphoblastic leukaemia. According to this theory, less dense populations mean less exposure to infections early in life and higher rates of leukaemia. However, of the areas surveyed the inner area is the more densely populated (2818 per km ^{2} , compared with 1378 per km ^{2}). [16]

Effects of radiofrequency radiation

The calculated exposure levels of 8.0 to 0.2 μW/cm ^{2} in the inner area are very low compared with the Australian Standard [17] public exposure level of 0.2 mW/cm ^{2} . The mechanism whereby such low energies could cause biological effects is a matter of intense research. A recent report by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) concluded that reliance on thresholds for heat build-up in setting the Australian safety standard may be insufficient. [18] The TV frequencies considered, because of their wavelengths in relation to body heights, are close to body resonance, [3] leading to maximum absorption by both adults (including pregnant women [19]) and children.

However, in considering any biological effects, regard must be given to the modulations (50 Hz to 5 MHz) as much as to the carrier wave. The key video modulation frequencies are pulsed at 50 Hz and 15.6 kHz. Many and conflicting reports have been published about possible biological effects at low energy levels with low frequency amplitude modulations. [3,18,20,21] Stuchly et al. found that 60 Hz low-level fields may act as promoters of cancer. [22] It has been suggested that the biological effects may be on the cell membrane rather than the genetic material, [23] and that low energy signals are detected through non-linear mechanisms, such as stochastic resonance. [24]

The disparity between our calculations and the measured power densities could result from various mechanisms, including absorption of the signal and cancellation due to reflections, especially as the minimum of one signal is unlikely to coincide with the minimum of another, even being different for the audio and vision signals of one channel. An extensive measurement program is needed to develop detailed contour maps to better define dose-response relationships. Techniques such as isotonic regression could be used; this enables effects of a point source on a surrounding community to be analysed. [25]

The new services since 1980 will have increased the power density due to Tower 1 by four times, most of this being due to ultra high frequency (UHF) TV (526-533 MHz) and FM radio. A number of other services, such as mobile phone and paging services, may have also been established in the surveyed areas. However, these are of much lower power and/or use different carrier frequencies and/or modulations to the TV broadcast services.

Radiofrequency radiation and cancer?

An association between RFR and childhood leukaemia has not been reported previously. None of the previous studies of RFR has looked at exposure of such a large population (including children) for so long a time to frequencies of maximal body absorption.

A study of people working on TV towers did not find evidence of chromosome damage, [26] and among 32 cases of neoplasms of the blood in Telecom Australia employees (retiring for medical reasons or dying) there was no excess in radiocommunication occupations (Hocking, unpublished data). A small study from Honolulu (Hawaii), where broadcast towers are also situated in populated areas, compared census tracts with towers with those without towers and found a non-significant standarised incidence ratio of 1.5 for all types of leukaemia. [27] A preliminary report of a small area study of leukaemia near 20 TV/FM

transmission sites in the United Kingdom found a decline in incidence of adult leukaemia with distance, but concluded that "the results give, at most, no more than weak support for an association between residence near transmitters and leukaemia risk". [28] However, that study was restricted to adult leukaemia and incidence, whereas our most significant results were for childhood leukaemia incidence and mortality.

The time trend for childhood leukaemia incidence has remained fairly stable, consistent with a constant exposure, and the reduction noted in the childhood leukaemia mortality rate most likely reflects improvements in treatment. If RFR exposure is a relevant (causal) factor, classification of population into inner and outer areas is a proxy for the appropriate exposure variable, which would tend to bias the rate ratios towards the null (i.e., towards no effect) due to non-differential misclassification. This is relevant to the irregular natural boundaries of the municipalities (Figure 1). Analysis by postcode or census collector units would yield more refined data in relation to distance from the towers. Finally, our observation of a more marked association between proximity to TV towers and leukaemia mortality than incidence (Box 4) could be of biological interest if a putative exposure not merely caused the disease but influenced its progression.

Conclusion

The calculated levels of RFR in the areas with increased childhood leukaemia incidence and mortality are substantially below the current Australian public safety standard. More detailed studies (e.g., relating cases to power density contours) are required to replicate any association and to look for dose-response relationships before any conclusions can be drawn.

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