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**Comments on "Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil" by A. C. Dode et al. Science of the Total Environment 409 (2011) 3649–3665**

Dode et al. (2011) report an apparent increase in "accumulated incidence rates" of cancer deaths in residents living within 500 m from a cellular base station (BS). This report has provoked considerable discussion by the public and media, if not by health agencies themselves. This letter calls attention to major weaknesses in the study that prevent any conclusions about possible health effects from living near a cellular base station.

The authors conducted a statistical analysis of locations of cellular base stations in relation to residences of individuals who had died from any form of cancer during 1996–2006 in Belo Horizonte, Brazil. This city of 2 million residents is divided into nine sanitary districts of roughly similar area but with greatly varying numbers of cellular base stations.

For each "eligible death by neoplasia" during 1996–2006, the authors determined the distance from the decedent's home to "the location of the first transmitter antenna of the mobile phone network to which the resident was possibly exposed", and the total population in the same area, and aggregated the results in 100 meter intervals from the transmitter (Table 1, from Table 5 of Dode et al.). "Compared to the total population mortality rate", the authors conclude, the relative risk in this "area [closest to the transmitter] was 1.35."

The authors do not clearly describe how they obtained the results shown in Table 1 (their Table 5), how they avoided double-counting residents in overlapping 1-km radii surrounding different base stations, or even what is "the base station" to which they refer in the caption to their Table 5, nor do the authors provide a rationale why distance to the "first licensed transmitter" within 1 km of a house should be a useful proxy measure for radiofrequency field exposure to an individual, given the presence of many other sources of radiofrequency energy in the environment (including many base stations erected subsequent to the first transmitter within 1 km of a decedent's residence and not considered in their analysis).

In an attempt to shed light on Table 1, we listed the same data in Table 2 showing mortality rates per area section, which is a more useful measure of risk than a cumulative distribution over the entire population. Table 2 shows a very rapid falloff in population and population density with distance from "the base station". This cannot plausibly represent the population in any specific location in the city. More likely, Table 1 shows the cumulative distribution of distances from the decedents' homes to the "first transmitter antennas" within 1 km of each home, not (as the text suggests) the numbers of decedents within a given distance of any particular station. If so, each row in the table includes individuals that are widely scattered throughout the city. The closer-in rings would over-represent individuals living in the central area (with by far the highest density of base stations) and the outer segments would over-represent individuals living in more remote districts with fewer and more widely spaced base stations.

Dode et al. write that the cancer death rates varied considerably in different districts of the city, from 58.3 per 10,000 residents in Centro-Sul (a central district with 12% of the population and 40% of the base stations in 2006) to 20.5 per 10,000 in Barreiro (an outlying district with 11% of the total population but only 5% of the base stations). Consequently, any tendency to over-sample residents in the central district would introduce bias that could easily explain the trends in Table 1.

Alternately, one might argue that the higher cancer death rate in Centro-Sul is caused by its larger numbers of base stations. However, that would be a difficult argument to make persuasively in an ecologic study such as this, which did not measure the "exposure" to individual decedents, and relied on a highly questionable proxy measure of "exposure". Dode et al. do not adjust their data for age, which further clouds their interpretation. Dode et al. write that Centro-Sul, with the highest cancer death rate, is the "richest region of the city" most of whose residents are "highly educated and belong to the middle and upper classes." Perhaps the higher mortality rate in Centro-Sul simply reflected a relatively older population in the district.

But there is an even larger problem. The time period of their cancer data, 1996–2006, coincided with the time of rapid buildout of the cellular telephone system. Dode et al. included in their analysis "only the deaths of those who were exposed since the first license date of the BS" within 1 km of each decedent's residence. They did not adjust their data for the length of time over which the base station had been present. Consequently, the number of "accumulated deaths" around each station would vary for the trivial reason that the stations were installed at different times. In the likely event that the cellular telephone network was initially built out with a denser grid of base stations in the central vs. outlying districts, then more residents of Centro-Sul would have lived close to a base station for longer times than in outlying districts, with more "accumulated deaths" simply because of longer accumulation times — regardless of any true variation in cancer death rate.

Dode et al. make claims that are puzzling and, on face value, biologically implausible: (1) residence close to a base station increases risk of death for all forms of cancer whereas exposure to a carcinogen would be expected to increase only specific neoplasms; (2) the effect appears after only brief exposure whereas tumors have latencies of many years after initial exposure to a carcinogen; and (3) the "number of deaths by neoplasia" (Fig. 16 of Dode) falls off dramatically after 1–2 years of exposure.

To shed some light on Fig. 16, we accessed the same database on base stations used by Dode et al., from the website of the national telecommunications agency Anatel (http://www.anatel.gov.br). The database lists 813 base stations in Bel Horizonte with "dates of first license" through the end of 2006. This is about 5% lower than the 856 stations mentioned by Dode et al. for the same time period; perhaps some of the stations in the database had been decommissioned after Dode et al. conducted their analysis.

Examining the locations of base stations in the database using Google Maps and Google Street View illustrates clearly the difficulties with Dode's analysis. For example, one centrally located neighborhood identified as Centro in the database had 8 cellular base stations

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**Table 1**
"Mortality rates by neoplasia in the Belo Horizonte municipality, according to distance from the BS".
From Table 5 in Dode et al., 2011.

| Distance, meters | Deaths total | Population total | Mortality rate per 10,000 | Relative risk |
|---|---|---|---|---|
| Up to 100 | 3569 | 821,890 | 43.42 | 1.35 |
| 200 | 4977 | 1,237,368 | 40.22 | 1.25 |
| 300 | 5950 | 1,602,869 | 37.12 | 1.15 |
| 400 | 6432 | 1,796,604 | 35.80 | 1.11 |
| 500 | 6724 | 1,934,032 | 34.76 | 1.08 |
| 600 | 6869 | 2,030,093 | 33.83 | 1.05 |
| 700 | 6947 | 2,055,325 | 33.80 | 1.05 |
| 800 | 6989 | 2,086,712 | 33.49 | 1.04 |
| 900 | 7000 | 2,107,277 | 33.21 | 1.03 |
| 1000 | 7044 | 2,148,327 | 32.78 | 1.00 |
| Total in Belo Horizonte municipality | 7191 | 2,238,332 | 32.12 | 1.00 |

in 1999 (the largest number of any identified neighborhood in the city at that time). These were located a few hundred meters to the west and roughly parallel to a major road (Av. Alfonso Pena) along a 2 km distance (between Av. Brasil and Av. Amazonas). All of the antennas were located on the tops of tall buildings in densely populated areas, in most cases next to busy streets.

This pattern is typical of early buildout phases of cellular phone networks around the world, which were mostly directed at providing service to users in automobiles and consequently were located near major roads. Most of the antennas in central city locations would have been mounted on the roofs of tall buildings overlooking busy streets. Most of those in outlying areas would be located in commercial or industrial areas where possible, and mounted on towers (which was confirmed by inspecting selected sites using Google Street View).

Centro is hardly typical of the rest of Bel Horizonte. Av. Alfonso Pena, a major thoroughfare traversing the commercial heart of the city, forms the western boundary of a large park (Parque Municipal Américo Renné Gianne). Photographs of the area (Google Street View, posted online at http://www.emfandhealth.com) show that the avenue along that stretch has a number of clearly upscale high rise apartment buildings, many with panel (directional) antennas for cellular base stations on their roofs. A typical radiation pattern from such an antenna is shown in Fig. 3 of Dode. When mounted in a customary manner on the roof of a building, such an antenna would radiate nearly all of its energy in a beam directed parallel to the ground away from the building and not into the building itself, and consequently would not create any appreciable RF radiation exposure to the residents.

It is reasonable to assume that the residents of the high rise apartment buildings in this affluent area would be older on average than other residents in the city, and have a higher cancer mortality rate simply due to age. The failure to correct for age is consequently a major weakness in the study.

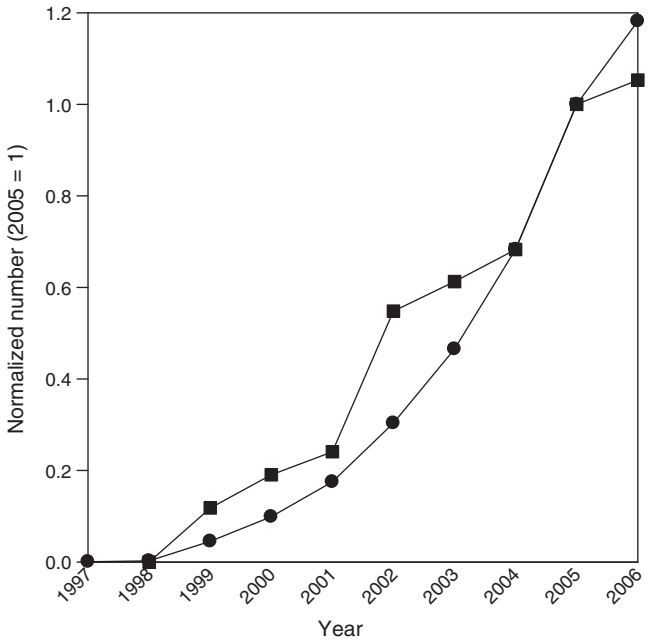


**Fig. 1.** (●) Increase in total number of base stations in Belo Horizonte Brazil from mortality data (Fig. 16 of Dode et al.); (■) cumulative number of base stations from the Anatel database. Both results normalized to their respective values in 2005.

The second fatal weakness is the presentation of data in terms of "cumulative deaths" (deaths per 1000 residents summed over varying time intervals) rather than death rate (deaths per 1000 residents per year). These buildings were among the first in the city to receive antennas on their roofs, and consequently many residents of the area will have lived for relatively long times near (in many cases directly beneath) the cellular antennas. Other areas in the city, as shown in Fig. 8 of Dode, were relatively bereft of base stations even as late as 2006.

Thus, two factors will lead to higher "accumulated deaths" in residents of these buildings in the uncorrected (for age and for accumulation time) data compared to residents elsewhere in the city. Moreover, this illustrates the difficulty of using proximity to a base station as a proxy measure of RF exposure. The residents of a building with antennas on its roof will be at zero distance from the antennas (as reckoned by geotagging) but receive essentially no RF exposure (since the beams are directed away from the buildings).

Fig. 16 in Dode et al. shows a sudden increase in cancer mortality with "duration of exposure since the date that the first antenna in each analyzed [census district]", followed by a decrease after 2 years, which is biologically implausible. But there is a simple explanation. Assuming that the cancer mortality rate (per 1000 residents per year) is constant in time and not related to proximity to base stations, it is easy to back out the rate of increase in base stations in the city

**Table 2**
Data from Table 1 by area of each segment.

| Radius "from base station", meters | Area of segment (m^2) | Population in area segment | Population density in area segment (residents per 100 sq. meters) | Number of cancer deaths in area segment | Mortality per 10,000 residents in segment |
|---|---|---|---|---|---|
| Up to 100 | 3.14E+04 | 821,890 | 2616.16 | 3569 | 43.4 |
| 100 to 200 | 9.42E+04 | 415,478 | 440.84 | 1408 | 33.9 |
| 200 to 300 | 1.57E+05 | 365,501 | 232.69 | 973 | 26.6 |
| 300–400 | 2.20E+05 | 193,735 | 88.10 | 482 | 24.9 |
| 400–500 | 2.83E+05 | 137,428 | 48.61 | 292 | 21.2 |
| 500–600 | 3.46E+05 | 96,061 | 27.80 | 145 | 15.1 |
| 600–700 | 4.08E+05 | 25,232 | 6.18 | 78 | 30.9 |
| 700–800 | 4.71E+05 | 31,387 | 6.66 | 42 | 13.4 |
| 800–900 | 5.34E+05 | 20,565 | 3.85 | 11 | 5.3 |
| 900–1000 | 5.97E+05 | 41,050 | 6.88 | 44 | 10.7 |

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from Fig. 16. For example, selecting mortality data from 1996 to 2006 from individuals who had lived for 9–10 years within 1 km of a station narrows the focus to base stations built during 1987–1997, most of which would have been built in 1997. Extending this calculation in turn to each successive "exposure time" in Fig. 16 yields results that closely track the increase in cumulative numbers of stations throughout the city as recorded in the database (Fig. 1). Almost certainly, the trends in Fig. 16 of Dode are a trivial reflection of the growing number of base stations in the city, and not a real biological effect.

Despite the fact that cellular base stations first began to appear in the city in large numbers in the early 2000's, the authors examined mortality data over the 1996–2006. For reasons that they do not clearly describe, Dode et al. included less than one-third of the total cancer deaths reported in the city during this period (7191 vs. 22,493). Perhaps this is related to the dearth of base stations for much of the time period of their data. In any event, disregarding a large majority of the cancer deaths from the analysis without rigorous justification is an obvious potential source of bias.

In May 2006, the World Health Organization published a Fact Sheet on base stations and wireless technologies that concludes "Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects."[1] Despite the obviously strong feelings of the authors about the issue, this weak study does not prompt a revision of this conclusion.

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World Health Organization Fact Sheet 304 Base Stations and Wireless Technologies. Available on the Internet at http://www.who.int/mediacentre/factsheets/fs304/en/index.html.

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[1] WHO Fact Sheet 304 Base Stations and Wireless Technologies: http://www.who.int/mediacentre/factsheets/fs304/en/index.html.

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