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Comment on Swanson et al ion transport model as used in

Childhood cancer and exposure to corona ions from powerlines: an epidemiological test

by

J Swanson, et al,   J.Radiological Protection 31.10.14

Swanson et al [1] seek to test a corona ion hypothesis as a possible explanation for their findings of increased incidence of childhood leukaemia near powerlines.

Their test is based on a four-stage model outlined in section 3 on pages 887-880.

The idea is to sum up all the ion concentration arriving at the object point (birth address) from along the length of all lines within 600 m. In the model, the lines are replaced by point sources every 10 m along them.

The model represents the transport of corona ions from a point source to the birth address, by multiplying together four factors: source strength; a distance function; proportion of time the wind is in the right direction; and average wind speed.

In effect (apart from a fundamental error) the model treats the ion transport from each source point as if by linear convention from source to object. A better model might account for lateral diffusion related to wind speed and distance.

Figure 2 in [1] shows a model ion concentration profile perpendicular to a powerline, said to model "*the observed average variation of the concentration of ions with distance from the power line, when the wind is transverse to the line*".

To obtain the ion concentration from a point source, a further factor of 1/distance (i.e. 1/r) is applied.
The explanation is "*in order for them to sum (at distances that are large when compared to the separation of the individual points) to this overall variation*". That appears to be requiring a 1/r factor for point sources to enable line-integration to recover the Figure 2 model for the line.

However, that is an error, and it does not sum to the "overall variation", as a simple calculation shows.

The error seems to confuse convection point-sources with radiative point-sources. Two-dimensional radiation from a point would attenuate like 1/r over an increasing circumference, whereas convection (as reflected in the wind-rose model used) would be unidirectional and not attenuate in the same way.

Convection would have attenuation, e.g. by recombination and absorption, but that would be incorporated in the model already in Figure 2.

Leaving out the wind part of the calculation, by taking the wind factors to be uniformly 1, we can test the idea that the 1/r factor would enable the point source effects to "*sum … to this overall variation*". See the appended sketch for a diagram and mathematics. For the purpose of a simple test, take the "overall variation" as a function of distance d of the object point from a straight line to be

$$f(d) \quad = \quad 1 \text{ for } d<600 \text{ (m) and } 0 \text{ for } d>600$$

This is constant over a finite range, similar to Figure 2 and the same as the alternative calculation (Section 3.6). Then the distance function in the model (representing concentration at distance r from the source) would be f(r) / r. Integrating along a line of such sources for the concentration C at a point distant d from the line, gives

$$C \quad = \quad \int f(r) / r \; dx$$

where x is path length along the line. The non-zero range of the integrand is from –X to X, where $X^2 = 600^2 – d^2$. Symmetry can be used so that C is twice the integral from 0 to X. Hence:

$$C \quad = \quad 2 \, [\ln (x+r)]$$

where the bracket is taken between 0 and X, so

$$C \quad = \quad 2 \ln ((600+X) / d)$$

This result for C is certainly not the original overall variation, which was constant for d in the range 0 to 600. Here C falls from infinity at d = 0 to zero at d = 600. Even with the qualification "*at distances that are large when compared to the separation of the individual points*" the point source effects do not sum to the overall variation.

Further testing, both with the above piecewise constant model for f(d) and with the piecewise linear model in Figure 2, using a spreadsheet to sum effects from sources at 10 m intervals, confirms the fact that the point source effects fail to sum to the overall variation (or anything like it), and the 1/r factor fails to "work" as intended.

Distance d from line (m)	50	100	200	400	600
f(d) constant to 600 m	0.634	0.497	0.352	0.192	0.000
f(d) from Figure 2	0.597	0.457	0.312	0.130	0.000

Table 1 Calculated sums of effects from point sources

Note: The units for the model are arbitrary as acknowledged in [1]. The results show the shape of the calculated exposure profile which radically differs from the given f(d).

So, in short, the factor 1/r seems misconceived and should simply be removed. Whether that makes much difference in overall results is another matter, but it is an important issue for closer comparisons of this version of the corona hypothesis with a simple distance model. The use of the 1/r factor distorts the convection effect by greatly suppressing effects at longer distances, including the 200 to 600 m category relative to the 0 to 200 m category.

Returning to the idea of lateral diffusion, it might be argued that a radial (1/r) attenuation would apply by virtue of expansion in a narrow sector from the point source. But that is not how the wind rose part of the calculation is constructed. Such sector attenuation would require consideration of sectors from neighbouring sources along the line, within an upstream sector from the object point, as well as the distribution within sectors subtended at the object point; in effect this is already accumulated in the model in Figure 2 and does not require a further 1/r factor to be applied. So I cannot rescue the 1/r factor by appeal to sectors.

Another error in the use of physics is multiplying concentration by average wind speed along the relevant bearing, whereas wind speed may have the effect of elongating and thinning the plume.

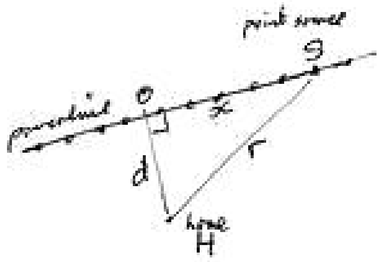
In order to test the corona hypothesis, it does seem perverse to base the test on the distances 0 – 200 m, which would more likely be confounded by other exposures, including magnetic fields. Granted, the original data for 200 – 600 metres, which would otherwise better isolate the effect to be tested, fail to show the decadal trend significantly, but this should signal the general unsuitability of the data for testing the corona hypothesis.

In the same way, reverting to using > 600 m (instead of > 1000 m) for the reference category also seems perverse, given the acknowledgement of ions measured even at “several kilometres away”. Surely retaining the previously used category of > 1000 m should be preferred for such a test.

Figure 5 seems, strangely, to compare a categorical RR with a trend RR, rather than like with like. The comment “*Because there are four quartiles of exposure, the trend RRs are plotted on an axis expanded by a factor of 4, to allow a very approximate visual comparison*” is not supported theoretically. If a further ad hoc expansion were applied, with a factor of about 2 to reflect the radically different reference categories, the graphs would give a much better appearance of matching.

I suspect that, given the rough approximation of the model and the potential for confounding, correcting the main error by removing the 1/r factor may not materially affect the inconclusiveness of the test. Even so, the authors and the journal might prefer to have a corrected calculation.

Appended sketch



test for case of (overall variation) as

$$f(d) = \begin{cases} 1 & \text{for } d < 600 \\ 0 & \text{for } d > 600 \end{cases}$$

Concentration C at H from point source S is then (by Swanson's model)

$$f(r)/r$$

$$r^2 = d^2 + x^2$$

when $r = 600$ let $x = X$

ie $X^2 = 600^2 - d^2$

summing over the line,

$$C = \int_{-\infty}^{\infty} f(r)\,\frac{1}{r}\,dx$$

$$= \int_{-X}^{X} \frac{1}{r}\,dx = 2\int_{0}^{X} \frac{1}{r}\,dx$$

$$= 2\left[\ln(x+r)\right]_0^X$$

$$= 2\ln\left(\frac{X+600}{d}\right)$$

Check – differentiate

$$\frac{d}{dx}\ln(x+r) = \frac{1}{x+r} \times \left(1 + \frac{2x}{2r}\right) = \frac{1}{r}\ \checkmark$$