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COMMENTARY

The human sex odds at birth after the atmospheric atomic bomb tests, after Chernobyl, and in the vicinity of nuclear facilities: comment

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Abstract The recent claim made in this journal that nuclear bomb tests and the Chernobyl disaster caused distortions in the secondary sex ratio is shown to be a likely artifact of data mining, misused statistics, and misreading of the evidence. In particular, the concept of statistical "significance" and its limitations do not seem to be fully understood, and important confounding factors have not been accounted for.

Keywords Radiation · Misused statistics · Sex odds

> Torture numbers, and they'll confess to anything.
> Gregg Easterbrook

1 Introduction and summary

This commentary takes issue with a recent paper by Scherb and Voigt (2011) and the claims produced therein as to a causal relationship between ionizing radiation and the secondary sex ratio. While there is a statistical cottage industry, mainly based in Germany, which churns out papers to that extent by the dozens, none of such claims holds water when examined without prejudice and using sound statistics. First of all, the proxies used for exposure—closeness to nuclear facilities, time dummies for nuclear bomb tests, and the Chernobyl disaster—are rather inaccurate measures of human exposure to ionizing radiation. In particular, radiation produced by man-made sources is dwarfed in most regions of the earth by natural sources such as cosmic rays, gamma rays from the Earth, radon decay products in the air, and various radionuclides found naturally in food and drink. (United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000): "For most individuals, this exposure exceeds that from all man-made sources combined" (p. 84).

And even if one should accept man-made radiation as the culprit, medical X-rays are certainly more important than nuclear fallout from bomb tests or radiation emitted by nuclear facilities during regular operations. So if one were seriously interested in a potential causal relationship between such exposure and the sex odds at birth, one should perhaps regress the odds on the number of X-ray examinations the parents had undergone prior to conception or their professional occupation: It is well known that civilian airline pilots suffer consistently with elevated levels of exposure to ionizing radiation, and it would certainly be of interest to learn whether this transmits into the sex of their children.

Then there is an impressive list of factors which indeed are known to affect the sex odds at birth (see for instance Jacobsen et al. (1999) or Mathews and Hamilton (2005), among many others): Race and income of the parents, birth order, age of mother, age gap among parents, dietary habits of the parents, body temperature at the time of conception, and so on. Not taking into account such confounders renders any statistical analysis invalid on its own. For instance, has anybody ever checked whether, for the data set considered here, the average age of mothers has been constant across time and space?

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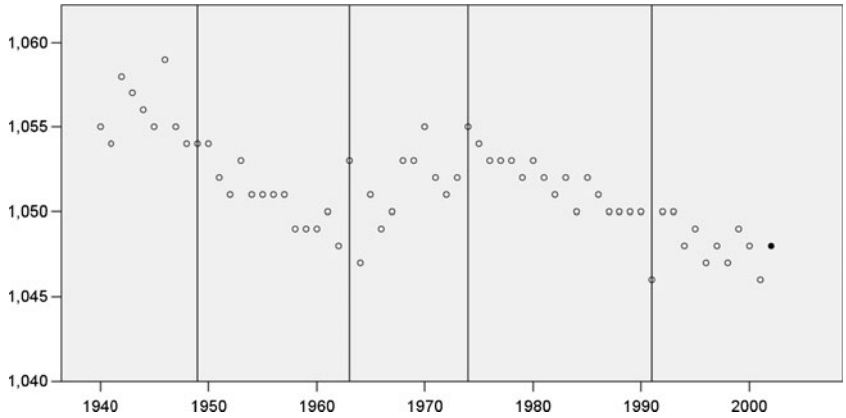

Fig. 1 Sex odds at birth in USA, 1940–2002

This failure to properly account for confounding factors is further aggravated by various intra-statistical shortcuts and inconsistencies in a literature that has some years ago decided, as the Scottish poet Andrew Lang once put it—to use statics as a drunken man uses lampposts, for support rather than for illumination. In a recent paper (Krämer and Arminger 2011), I show that the popular claim that nuclear power plants induce an excess incidence of leukemia among children dissolves completely once important confounding factors are accounted for. In fact, and ceteris paribus, there appears to be less leukemia close to nuclear facilities than elsewhere in some countries. And the present letter argues that the claim by Scherb and Voigt (2011) as to the detrimental effects of man-made radiation is likewise not supported by the data once some distorting bias in modeling the data is removed.

First, Scherb and Voigt (2011) misread the results of a statistical test of significance. A significant statistical test only means: if the null hypothesis were true—a big if—then the tail probability of the observed event would be less than a pre-chosen level of significance. And this rather modest claim is even further compromised by its extreme dependence on the size and on the generation of the sample and by the common practice of disguised multiple testing, i.e., doing lots of tests and reporting only the most "significant" results, and the ensuing understatement of the true probability of an error of the first kind ("data mining"). This issue is further elaborated in Section 2 below. See also Ziliak and McCloskey (2008) or Krämer (2011).

Even more important is what I have elsewhere (Krämer 2011) called an Error of the Third Kind, by which I mean mistaking a rejected null as proof that the alternative is true. "The atmospheric atomic bomb tests fallout affected the human sex odds at birth overall, and the Chernobyl fallout had a similar impact on Europe and parts of Asia" (p. 698). A claim like that can never be based simply on a statistical test of significance!

My main point, however, is that not even statistical significance obtains. In particular, the impressive p values produced by Scherb and Voigt (2011) are all wrong. Take the significant downward trend of the US sex ratio prior to the partial test ban treaty in 1963. Other than claimed by Scherb and Voigt, this trend is not "uniform" and the estimated slope estimate is not based on millions of data points, but exactly 13. And why confine the data set to the years 1950–1963? Atmospheric nuclear testing continued until 1974 (France) or 1980 (China). Using alternative subperiods, even a positive trend can be obtained, as I show in Section 2.

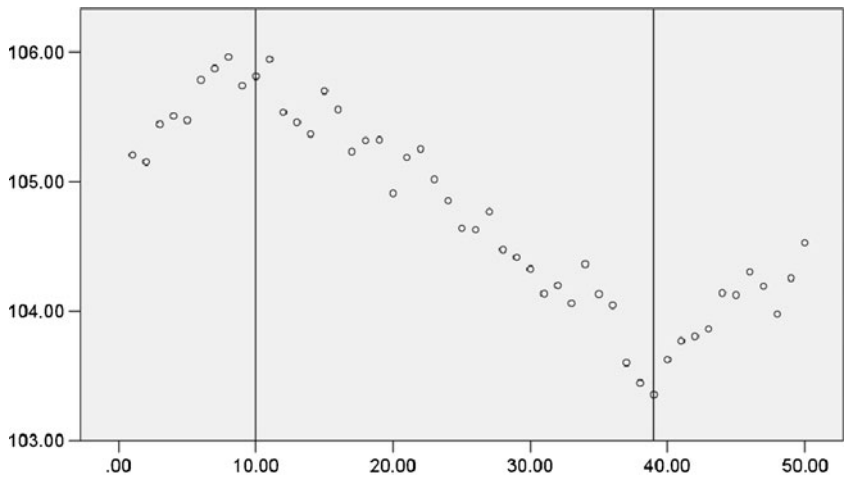

Fig. 2 Fifty successive observations of an AR(1) process with a mean of 1.05

The second data set analyzed by Scherb and Voigt covers 39 European countries from 1975–2007. Again, by judiciously choosing a null hypothesis one would like to reject, lots of "effects" can be shown to exist at high levels of statistical significance. Taking Table 1 in Scherb and Voigt (2011, p. 702) as a point of departure, there is for instance a highly positive effect of living on the shores of the Mediterranean, independently of any exposure to ionizing radiation: the average sex ratio there is 1.070, which is highly significantly larger than elsewhere ($p<0.01$). On the other hand, regressing the sex ratio on the number of characters in a country's name yields a negative effect and so on. In fact, there does not appear to exist any natural limit to the number of effects which can, with sufficient effort and using this same dataset, be unearthed.

2 Some pitfalls in fitting trends

Figure 1 is drawn from data in Mathews and Hamilton (2005). It depicts the sex odds at birth in USA from 1940 up to 2002. Only the time period 1950–2002, with various subsections, indicated by perpendicular lines in the diagram, is used by Scherb and Voigt (2011). In particular, the 1950–1963 interval is used to support the claim that there was a uniform downward trend in the sex odds prior to the atomic test ban treaty in 1963.

Now there are several inconsistencies in the Scherb–Voigt argument. For instance, if it were true that ionizing radiation from atmospheric bomb tests has "caused" the increase in the sex odds, why then should this increase have started only after the (partial) test ban treaty? China and France continued atmospheric bomb tests long after that. And while it might well be true that human exposure to radioactive fallout peaked in 1963, has it been larger before or afterwards? Assuming considerable fallout already in the 1950s, and expanding the time window from 1950–1963 to 1950–1970, lets the negative trend which presumably comes with less radiation completely disappear. In fact, the slope of the estimated trend line is then even positive!

The second "trend" claimed by Scherb and Voigt to construct evidence for radiation-induced differential developments in Europe and in USA covers the period 1975–2002. Scherb and Voigt argue that the odds were decreasing in USA, but not in Europe. But again, extending the observation period leftwards makes this negative trend disappear very quickly as well.

The point of course is that it is quite inappropriate, from a statistical point of view, to fit linear trends to short time series of the type considered here. Figure 2 depicts 50 successive observations of a stationary AR(1)-process with a mean of 1.05 (this appears to be the long-term worldwide average of the sex odds at birth) and autocorrelation of 0.9, and a variance similar to that of the sex odds in Fig. 1. Although all observations have the same mean of 1.05, it is trivial to find trends of all sorts for subintervals if one wants to find them. And this is exactly what Scherb and Voigt (2011) have done.

3 Conclusion

The statistical evidence advanced in Scherb and Voigt (2011) to support their claim that man-made ionizing radiation affects the sex odds at birth is not convincing. Rather, it appears that standard rules of statistical reasoning have been bent to make the data fit a prearranged hypothesis.

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