

Response to the letter to the editor regarding

The Impact of Prenatal Exposure to Chernobyl Fallout in Finland

I would like to thank Anssi Auvinen and Teemu Siiskonen for their critique on my study. Their concerns can be categorized as follows:

1. The radiation doses from Chernobyl fallout in Finland were several orders of magnitude below those known to affect the development of the nervous system.
2. The analysis relied only on deposition of Cs-137 as an exposure indicator, which can be misleading due to low radiation doses and potential bias in exposure classification.
3. The analysis ignores doses from internal radiation, which can lead to inaccuracies and potential bias in exposure classification.
4. The analysis did not properly account for the gradual decrease in radiation exposure over time, making comparisons between consecutive cohorts problematic.

As a response, I would like to point out the following: First, although there is a limited number of research that has been able to reliably identify any statistically significant impact in relation to a substantially low exposure to radiation, studies such as Almond et al. (2009) and Black et al. (2019) exist. I would also like to highlight that the limited amount of existing research is precisely why also my study is relevant. The absence of evidence does not necessarily indicate evidence of absence.

In their 1997 research, Otake and Schull (1998) link exposure to relatively large degrees of radiation (Atomic bombings of Hiroshima and Nagasaki) with substantial neurological impacts, such as smaller head size (defined as head circumference of more than two standard deviations below the gender- and age-specific mean of the entire study population) and severe mental readiness. In my research, I estimated the impact of an exposure to much lower levels of radiation on matriculation examination performance. The quality of the data dictates the accuracy of the results. The number of observations in the data I use for estimating the impact in Finland is over 230 times larger than the one deployed in Otake and Schull (1998). Combined with the findings presented by Otake and Schull (1998), the observations in my study suggest that the magnitude of the negative impact is positively related to the dosage or level of exposure, which aligns quite nicely with the timely classic.

Regarding the concerns about potential measurement error in the independent variables and misclassification of the control and treatment groups (applies to the concerns 2 & 3), it is true that the data and the means of classification are likely to be imperfect. However, non-systematic measurement error in the independent variables, biases estimate towards zero, making them more conservative. In other words, if anything, my estimates are likely to be underestimates rather than overestimates. To exemplify, consider an experiment where the analyst had mistakenly randomized the control and the treatment groups, the averages would cancel each other out, and the observed impact would be zero. Similarly, the correlation between the volumes of a full water buckets and their measured weights approaches zero as we keep on adding random variation to the measured volumes.

With regards to the fourth concern presented by Auvinen and Siiskoinen, there seems to be some confusion about the identification strategy employed. The exposure from Chernobyl fallout was indeed not instantaneous, and the levels of radiation decreased gradually over time. The actual identification strategy relies on the interaction term between the temporal and spatial variation. In other words, the children within the in-utero cohort exposed to higher levels of radiation due to spatial variation are compared against the children within the in-utero cohort exposed lower levels of radiation.

Comparison between the in-utero cohort and the children born subsequently is only done as robustness analysis to show that the in-utero cohort does not differ from the rest of the sample when only the temporal variation is considered.

The in-utero cohort is defined the way that it consists of people who were exposed to the highest measured levels of radiation while their brain was increasingly radiosensitive and is motivated by Otake and Schull (1998). The assumption employed is a simplifying approximation that introduces a minor compromise in accuracy. Nevertheless, this assumption does not undermine the internal validity of the model as at most it results in underestimating the impact. Figure 6 reports the estimates as we move the definition of the in-utero cohort in time. It should be noted that the model includes indicator variables at the municipality and day of birth by year of birth level. The purpose of the indicator variables is to control any seasonality and areal differences. Table 2 reports the point estimates for the interaction term as more controls are introduced. Again, any classification error stemming from this simplification is likely to bias the estimates towards zero.

A possible threat to the strategy would be if the interaction between the spatial and temporal variation of irradiation were correlated with other performance-hindering phenomena. However, the fact that the empirical strategy relies on the interaction term of space and time allows for controlling the two independent dimensions, making the model fairly robust towards unobserved interference.

While there may be limitations to the study, I believe that the findings are significant and contribute to our broader understanding of the impact of low-level exposure to irradiation. I would like to bring to the attention of the field that there have been three studies with robust quasi-experimental identification methods, all consistently demonstrating the sensitivity of the in-utero stage to even low levels of radiation. Considering these findings, it may be worthwhile for the field to contemplate updating its perspectives on this matter. I want to thank Auvinen and Siiskoinen their comments and STUK for providing the fallout data, and I hope this response has adequately addressed the concerns that have been put forward so far.

Sincerely,
Matti Sipiläinen

References

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