Infant mortality in Japan after Fukushima

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www.strahlentelex.de/Koerblein_infant%20mortality%20after%20Fukushima.pdf
Cesium soil contamination in the study region around Fukushima including the prefectures of Fukushima, Iwate, Miyagi, Gunma, Tochigi, Ibaraki, and Chiba.

Source: Press communication by MEXT (Ministry for Education and Research), September 12, 2012
Analysis of monthly infant mortality rates

- Combined regression of data from study region and control region (2 x 132 = 264 data points)
- Linear temporal trend (variable t)
- Regression uses data from January 2002 through March 2011
- Seasonal effects are modeled by 11 dummy variables for February through December (January is the reference month)
- Dummy variable „study“ denotes the data from the study region
- A dummy variable „dmar11“ indicates March 2011
- Altogether 15 parameters needed: intercept, t, feb-dec, study dmar11
fm <- glm(y~t+feb+mar+apr+may+jun+jul+aug+sep+oct+nov+dec+
study+dmar11,binomial)

Coefficients:

|            | Estimate | Std. Error | z value | Pr(>|z|) |
|------------|----------|------------|---------|----------|
| (Intercept)| -5.664   | 0.0243     | -232.5  | < 2e-16  *** |
| t          | -0.034   | 0.0023     | -14.8   | < 2e-16  *** |
| feb        | -0.005   | 0.0286     | -0.17   | 0.862    |
| mar        | -0.022   | 0.0282     | -0.77   | 0.438    |
| apr        | -0.011   | 0.0289     | -0.37   | 0.709    |
| may        | 0.008    | 0.0285     | 0.29    | 0.767    |
| jun        | -0.044   | 0.0291     | -1.49   | 0.134    |
| jul        | -0.116   | 0.0292     | -3.98   | 6.70e-05 *** |
| aug        | -0.088   | 0.0291     | -3.04   | 0.0023   ** |
| sep        | -0.165   | 0.0298     | -5.52   | 3.23e-08 *** |
| oct        | -0.083   | 0.0292     | -2.85   | 0.0043   ** |
| nov        | -0.036   | 0.0293     | -1.22   | 0.223    |
| dec        | 0.010    | 0.0287     | 0.35    | 0.723    |
| study      | 0.035    | 0.0171     | 2.07    | 0.0390   * |
| dmar11     | 1.173    | 0.1066     | 11.00   | < 2e-16  *** |

Residual deviance: 191.33 on 207 degrees of freedom
Results

Regression model:
Combined regression of data from the study region and the data from Japan without the study region
11 dummy variables for February through December (January is the reference month) and a dummy variable for March 2011

- 3.2-fold increase in March 2011 ($P<0.0001$), 65 excess infant deaths
- Significant 50% increase in March 2012
  55 excess infant deaths in 2012

Upper panel: Infant mortality rates in the study (black dots) and control region (open circles)
Lower panel: Deviations of observed from expected odds ratios (standardized residuals) and 3-month moving average
Alternative approach: analysis of the odds ratios

For rates $<< 1$: odds ratio $\sim$ rate ratio.
rate ratio = mortality rate in the study region, divided by mortality rate in control region (rest of Japan)

Advantage:
No time trend, no seasonal effects, dummy „study“ is now the intercept

Possible effect from radiation exposure modeled by a bell-shaped excess term (3 parameters: effect size, peak position, half-width)

Altogether only 5 parameters
Results:

Regression model (R notation):
Formula:
\[ p \sim \frac{1}{1+1/\exp(c_1+c_2*d_{mar11}+c_3/t/\exp((\log(t)-\log(c_4))^2/c_5))} \]

| Estimate | Std.Error | t value | Pr(>|t|) |
|----------|-----------|---------|----------|
| c1       | 0.0413    | 0.0156  | 2.649    | 0.0091   |
| c2       | 1.2450    | 0.1222  | 10.19    | 0.0000   |
| c3       | 3.6680    | 1.2630  | 2.903    | 0.0044   |
| c4       | 12.370    | 0.0884  | 139.9    | 0.0000   |
| c5       | 0.0007    | 0.0005  | 1.207    | 0.2298   |

Deviance = 110.8 (df = 127) good model fit!

Upper panel: Ratio of infant mortality rates in the study and control region (odds ratio)
Lower panel: Deviations of observed from expected odds ratios (standardized residuals)

Excess in 2012 (bell-shaped term) is significant (\( P=0.009 \), F test with (3, 127) degrees of freedom)
Early infant mortality (0-6 days) in West Germany after Chernobyl

Upper panel: Early infant mortality rates in West Germany, 1984-1990
Lower panel: Standardized residuals and 3-month moving average

Regression model:
Linear logistic regression of the data in 1984-90 without 1987.
11 dummy variables for February through December (January is the reference month)

Significant increases in June 1986 and in February 1987
Lower panel: Standardized residuals and 3-month moving average

Regression model:
Linear logistic regression of the data in 1985-91 without 1987. 11 dummy variables for February through December (January is the reference month)

Significant increases in January and April 1987
Early infant mortality (0-6 d) in Zhytomir oblast (Ukraine) after Chernobyl

Upper panel: Infant mortality rates in Zhytomir, 1985-1990
Lower panel: Standardized residuals and 3-month moving average

Regression model:
11 dummy variables for February through December (January is the reference month)

Significant increase in December 1986 through July 1987
Summary

- Significant increase of infant mortality, starting 9 months after Fukushima, in Japanese prefectures near Fukushima ($P=0.009$)
- 55 excess infant deaths in 2012
- No increased infant mortality in the rest of Japan
- Similar effects observed in several countries (Germany, Poland, Ukraine) after Chernobyl
Decrease of live births 9 months after Fukushima: early spontaneous abortions?
Radiation dose rate in the first month following the accident
Objective:
To test a possible decrease of live births 9 months after Fukushima

Regression model:
Poisson regression of live birth data (Jan 2002-Dec 2011) from the study region with 11 dummy variables for February through December (January is the reference month) and a dummy variable for December 2011

- 10% drop of live birth in Dec 2011 ($P<0.0001$), 1247 missing births
- no significant deviation in Nov 2011 or in Jan 2012

Upper panel: Trend of live births and regression line
Lower panel: Standardized residuals
Birth deficit in the prefectures of the study area:
Greatest effects in Fukushima, Miyagi, and Tochigi

<table>
<thead>
<tr>
<th>Prefecture</th>
<th>%change</th>
<th>P value</th>
<th>birth deficit</th>
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<tbody>
<tr>
<td>Iwate</td>
<td>-5.2%</td>
<td>0.1567</td>
<td>39</td>
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<tr>
<td>Miyagi</td>
<td>-18.1%</td>
<td>&lt;0.0001</td>
<td>274</td>
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<td>Fukushima</td>
<td>-15.3%</td>
<td>0.0002</td>
<td>190</td>
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<td>Gunma</td>
<td>-6.8%</td>
<td>0.1009</td>
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</tr>
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<td>Tochigi</td>
<td>-11.3%</td>
<td>0.0061</td>
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<td>Ibaraki</td>
<td>-6.7%</td>
<td>0.0026</td>
<td>129</td>
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<tr>
<td>Chiba</td>
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<td>0.0002</td>
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<td>study region</td>
<td>-10.1%</td>
<td>5.8E-7</td>
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<td>rest of Japan</td>
<td>-3.0%</td>
<td>0.0459</td>
<td>2329</td>
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<tr>
<td>all of Japan</td>
<td>-4.0%</td>
<td>0.0090</td>
<td>3572</td>
</tr>
</tbody>
</table>
Objective:
To test a possible decrease of live births 9 months after Chernobyl

Regression model: Poisson regression of live birth data (Jan 1984-Dec 1991) from the study region with 11 dummy variables for February through December (January is the reference month) and a dummy variable for January 1987. The data for 1987 is omitted from the regression.

- 16.8% drop of live birth in Jan 1987 ($P<0.0001$), 2482 missing births
- no significant deviation from the trend in Dec 1986
- decreased birth rate in Feb-Aug 1987
Down Syndrome (DS) peak in Belarus in January 1987 after Chernobyl

Regression model:
Logistic regression of trisomy 21 incidence data with 11 dummy variables for February through December (January is the reference month), a 3rd degree polynomial for the time trend, and a dummy variable for January 1987.

2.3-fold increase of DS incidence in January 1987 ($P=0.0004$)

Down Syndrome (DS) peak in West Berlin in January 1987 after Chernobyl

Regression model:
Logistic regression of trisomy 21 incidence with a linear time trend and a dummy variable for January 1987.

5.7-fold increase of DS incidence in January 1987 ($P<0.0001$)

Summary

- Drop of live births in December 2011, 9 months after Fukushima
- Decrease of live births limited to a single month
- Effect greatest in prefectures with highest cesium soil contamination
- Effect cannot be attributed to public worry alone: Public worry would be expected to last at least for some months.
- Immediately after fertilization, the zygote is extremely sensitive. Radiation damage to the zygote from the high initial radiation spike can trigger early spontaneous abortions which manifest as a drop of live births 9 months later.
- Increase in trisomy 21 observed in January 1987 in Belarus and West Berlin