Infant mortality in Japan after Fukushima

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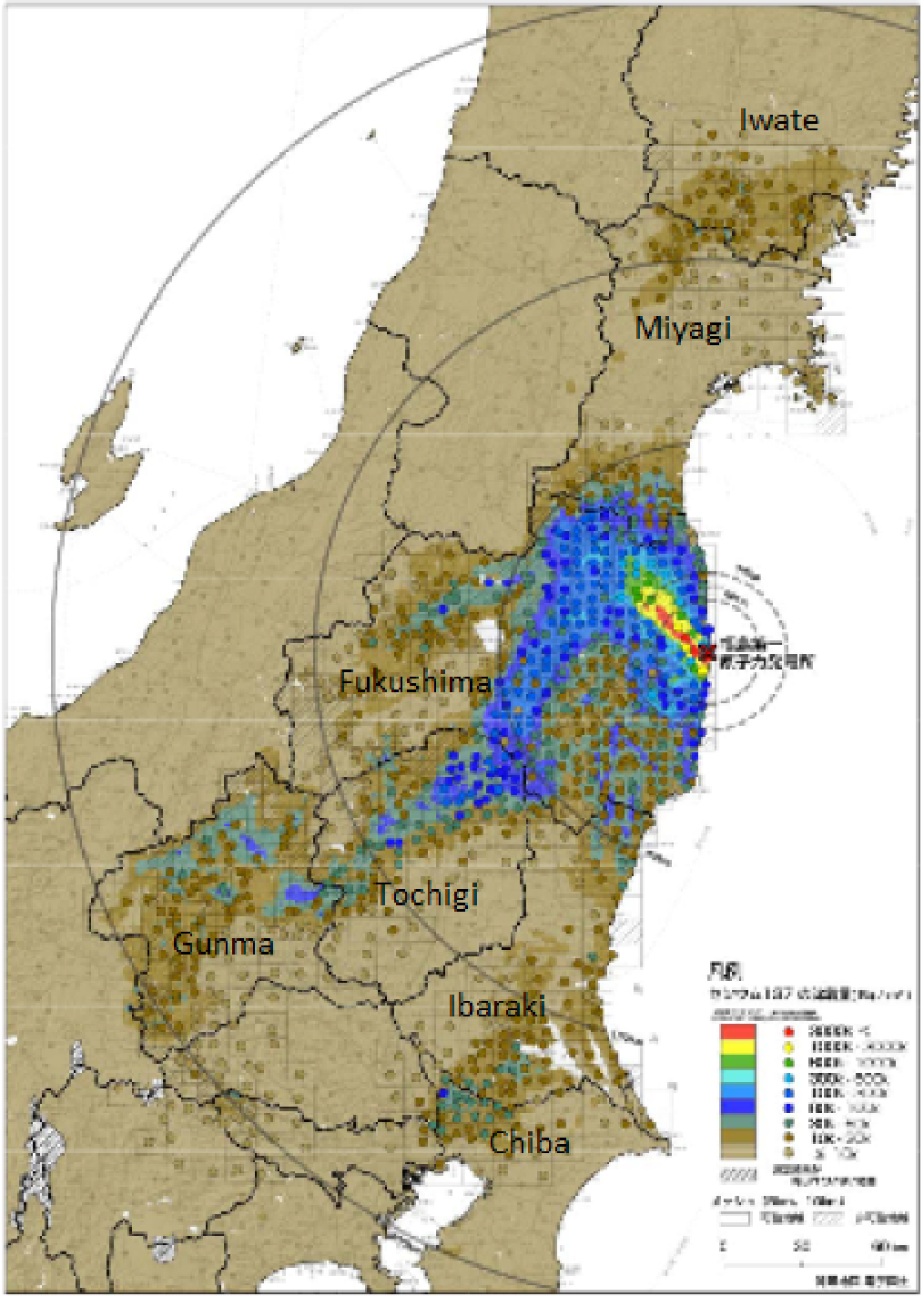
www.strahlentelex.de/Koerblein_infant%20mortality%20after%20Fukushima.pdf



Cesium soil contamination in the study region around Fukushima including the prefectures of Fukushima, Iwate, Miyagi, Gunma, Tochigi, Ibarki, 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 ís 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) -5.663988   0.024360 -232.514  < 2e-16 ***
t           -0.033917   0.002289  -14.814  < 2e-16 ***
feb         -0.004982   0.028604   -0.174  0.86172
mar         -0.021888   0.028236   -0.775  0.43824
apr         -0.010739   0.028875   -0.372  0.70996
may          0.008448   0.028534    0.296  0.76719
jun         -0.043618   0.029143   -1.497  0.13447
jul         -0.116444   0.029208   -3.987 6.70e-05 ***
aug         -0.088534   0.029078   -3.045  0.00233 **
sep         -0.164554   0.029765   -5.528 3.23e-08 ***
oct         -0.083063   0.029160   -2.848  0.00439 **
nov         -0.035713   0.029313   -1.218  0.22310
dec          0.010151   0.028670    0.354  0.72329
study        0.035245   0.017070    2.065  0.03895 *
dmar11       1.172997   0.106606   11.003  < 2e-16 ***

Residual deviance: 191.33  on 207  degrees of freedom
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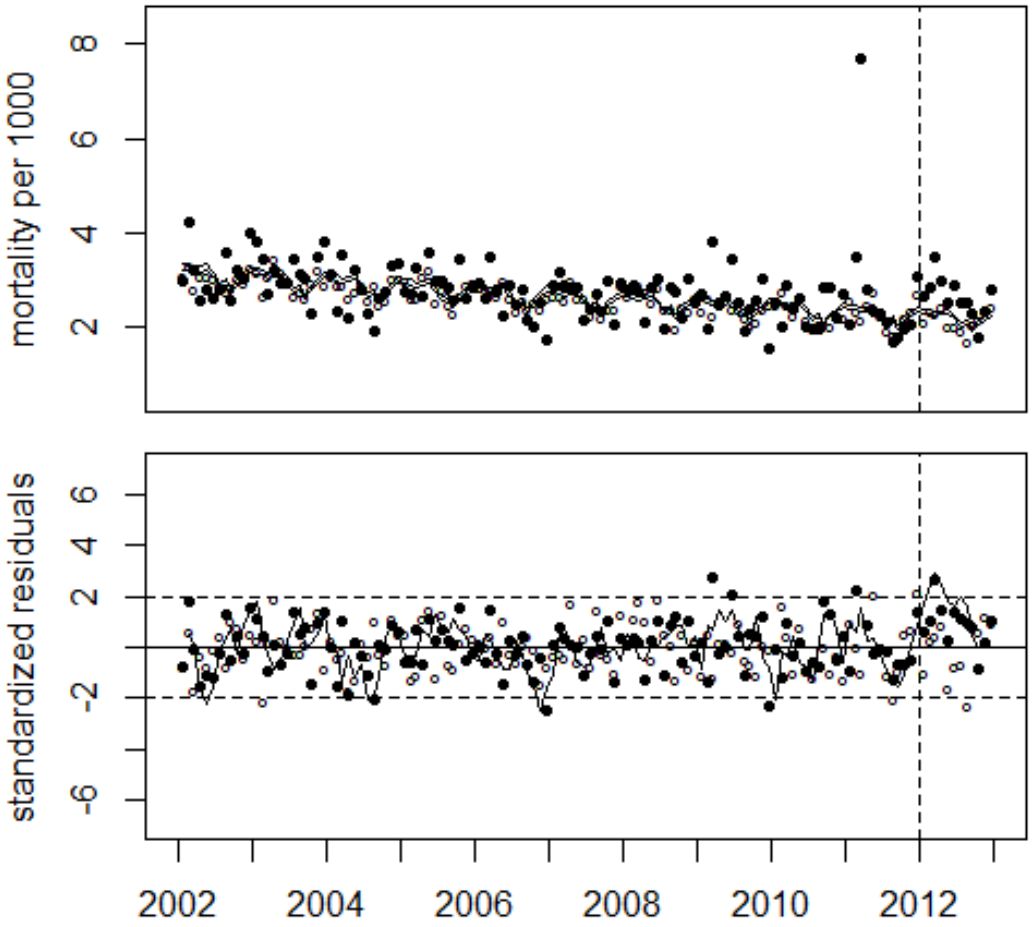
Results



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 ~ rate ratio.

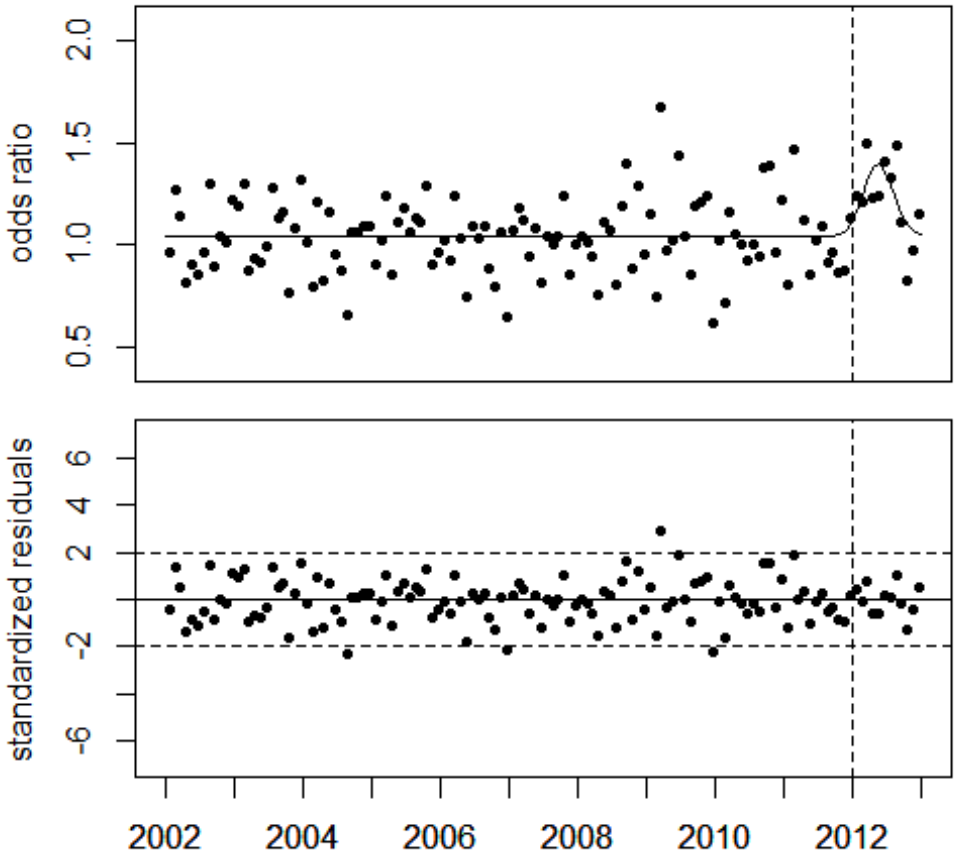
rate ratio = mortality rate in the study region, divided by mortality rate in control region (rest of Japan)

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:

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Regression model (R notation):
Formula:
p ~ 1/(1+1/exp(c1+c2*dmar11+
    c3/t/exp((log(t)-log(c4))^2/c5)))

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!
```
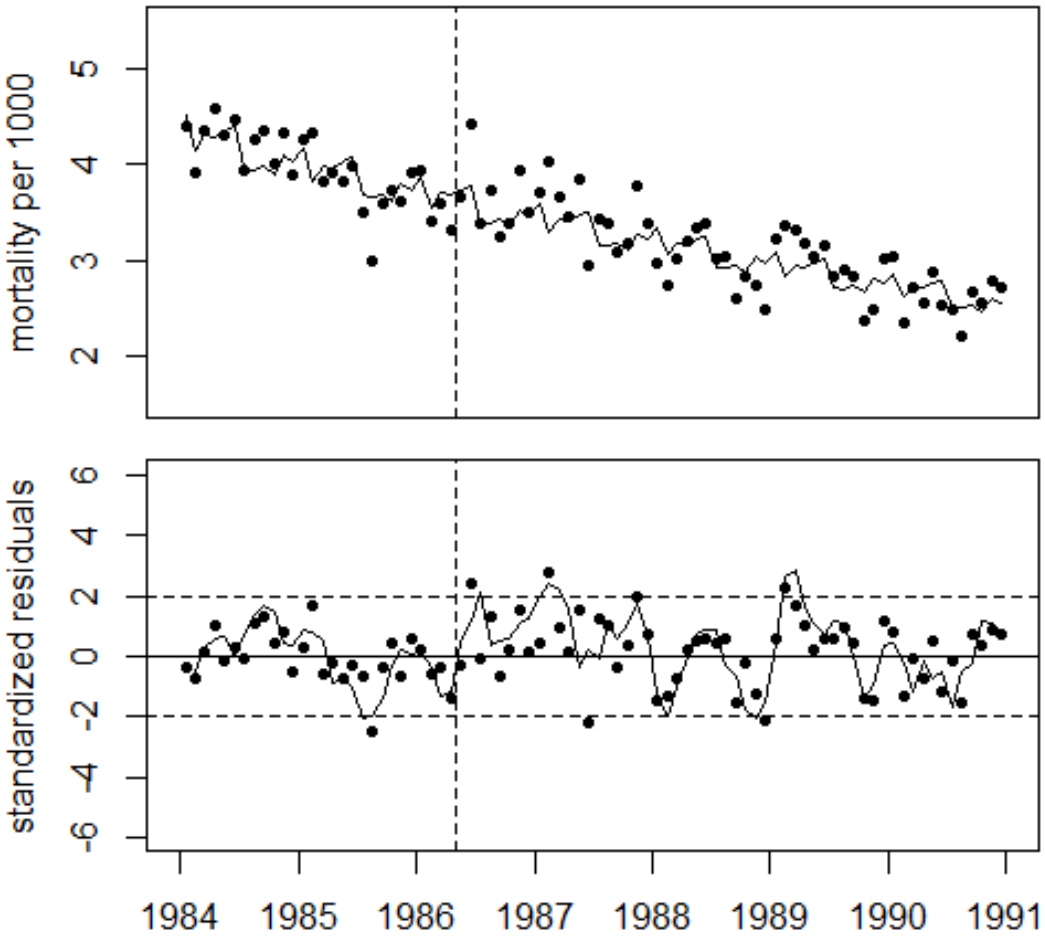

Excess in 2012 (bell-shaped term) is significant (*P*=0.009, F test with (3, 127) degrees of freedom)

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)

Early infant mortality (0-6 days) in West Germany after Chernobyl

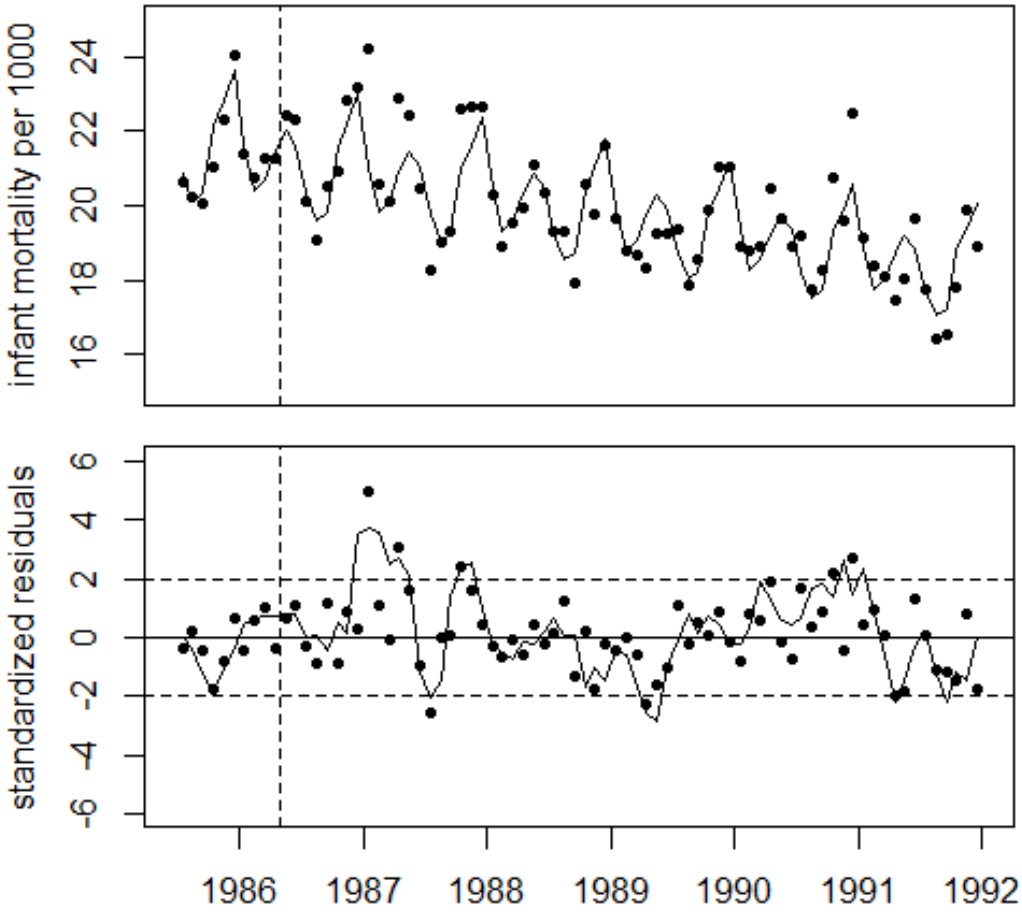


Regression model:
Linear logistic regression of the data in 1984-90 without 1987.
11 dummy variables for February through December (January is the reference month)

Significant increases in June 1986 and in February 1987

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

Infant mortality (<1 year) in Poland after Chernobyl

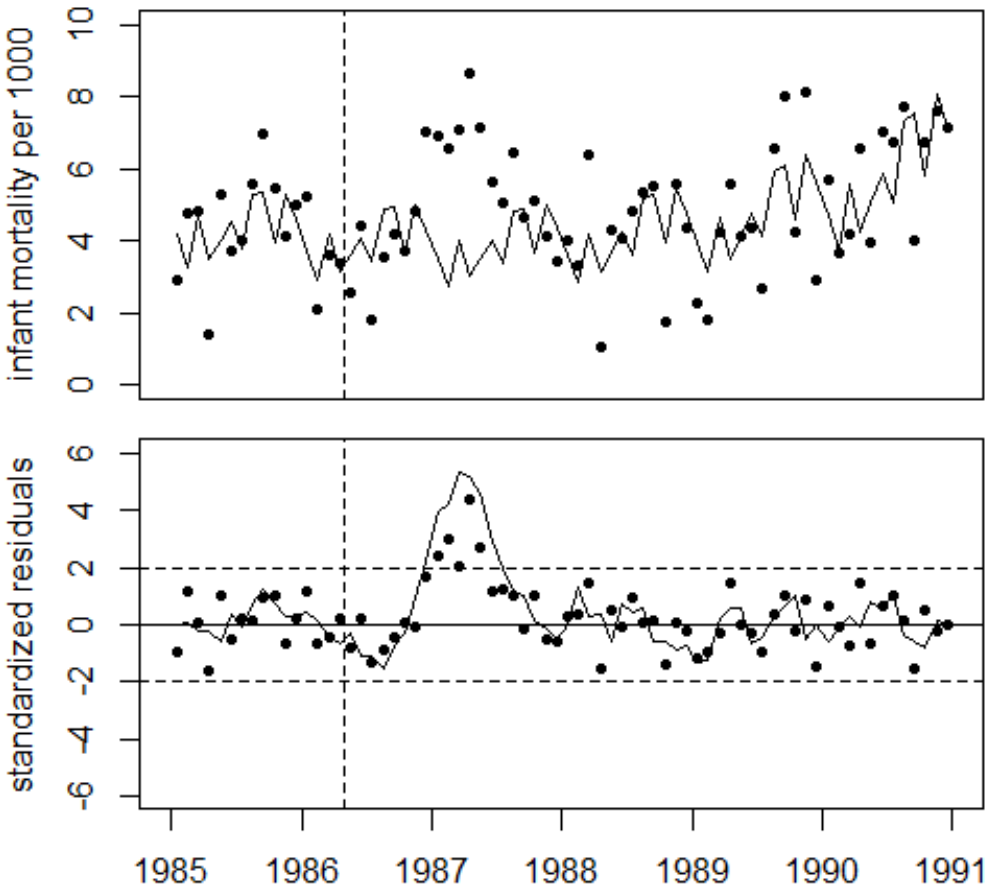


Regression model:
Linear logistic regression of the data in 1985-91 without 1987.
11 dummy variables for February through December (January is the reference month)

Significant increases in January and April 1987

Upper panel: Infant mortality rates in Poland 1985-1991
Lower panel: Standardized residuals and 3-month moving average

Early infant mortality (0-6 d) in Zhytomir oblast (Ukraine) after Chernobyl



Regression model:
Logistic regression of the data in 1985-90 without 1987. Linear-quadratic time trend.
11 dummy variables for February through December (January is the reference month)

Significant increase in
December 1986 through July 1987

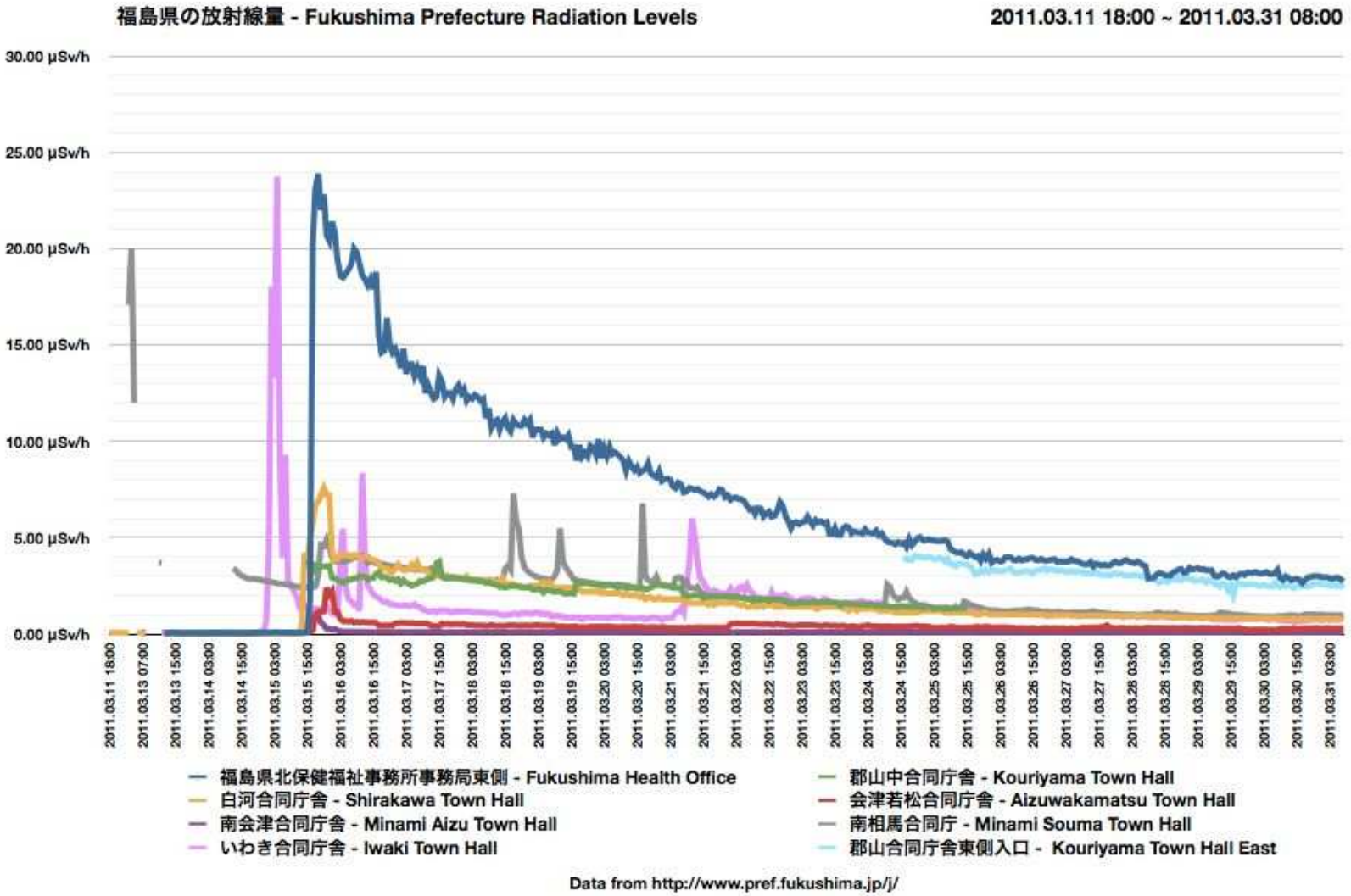
Upper panel: Infant mortality rates in Zhytomir, 1985-1990
Lower panel: Standardized residuals and 3-month moving average

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

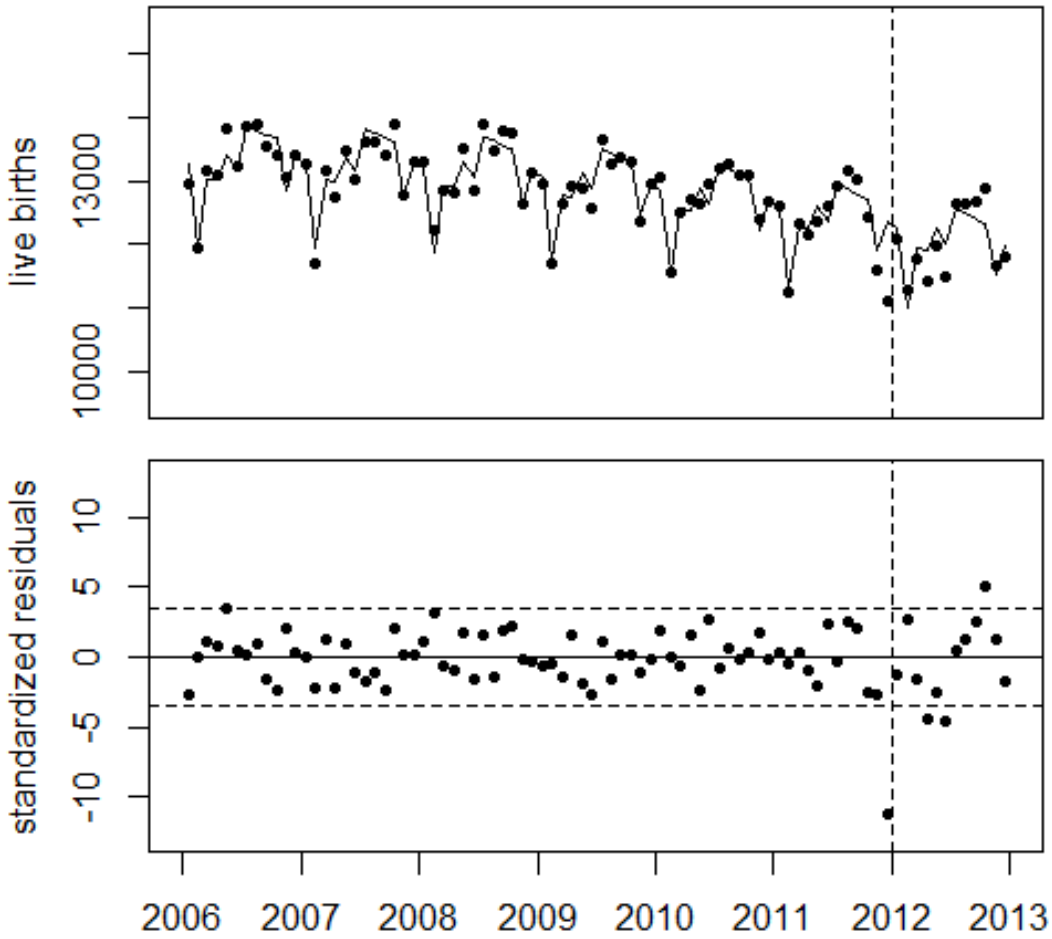
Decrease of live births 9 months after Fukushima:
early spontaneous abortions?

Radiation dose rate in the first month following the accident



Objective:

To test a possible decrease of live births 9 months after Fukushima



Upper panel: Trend of live births and regression line

Lower panel: Standardized residuals

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

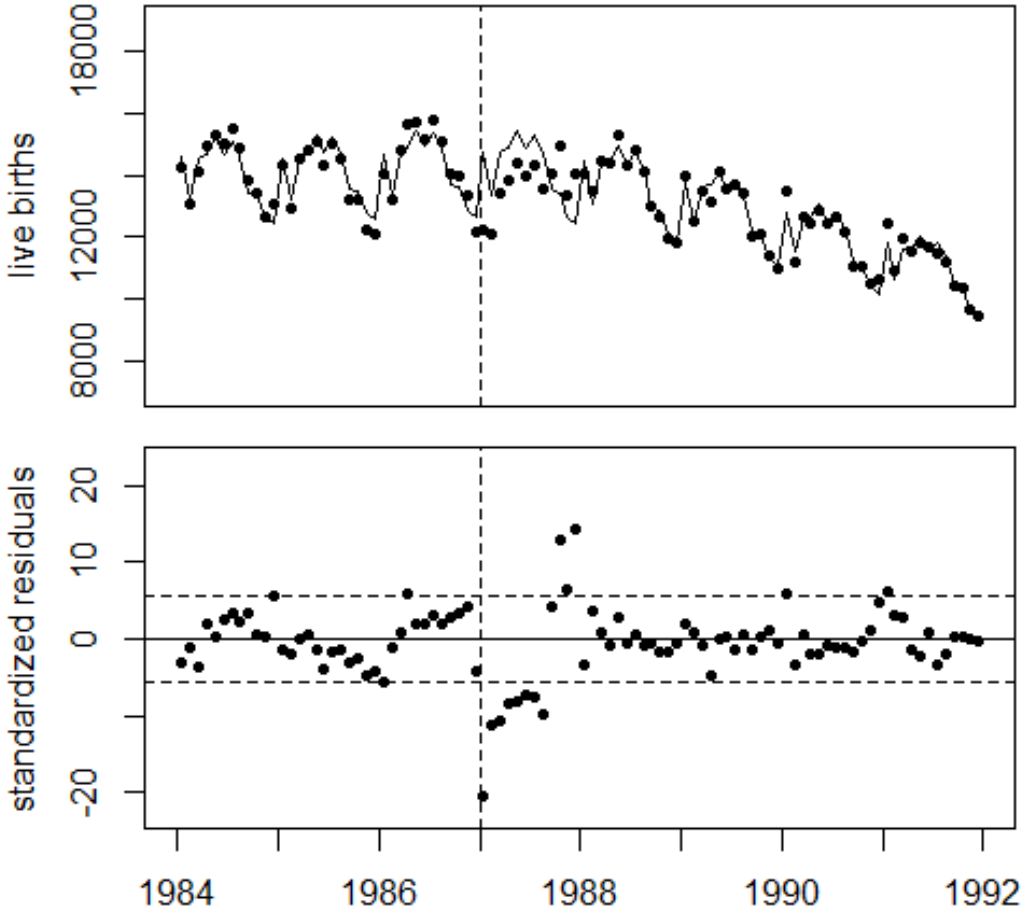
- 10% drop of live birth in Dec 2011 (P<0.0001), 1247 missing births
- no significant deviation in Nov 2011 or in Jan 2012

Birth deficit in the prefectures of the study area: Greatest effects in Fukushima, Miyagi, and Tochigi

Prefecture	%change	*P* value	birth deficit
Iwate	-5.2%	0.1567	39
Miyagi	-18.1%	<0.0001	274
Fukushima	-15.3%	0.0002	190
Gunma	-6.8%	0.1009	86
Tochigi	-11.3%	0.0061	151
Ibaraki	-6.7%	0.0026	129
Chiba	-8.8%	0.0002	382
study region	-10.1%	5.8E-7	1251
rest of Japan	-3.0%	0.0459	2329
all of Japan	-4.0%	0.0090	3572

Objective:

To test a possible decrease of live births 9 months after Chernobyl



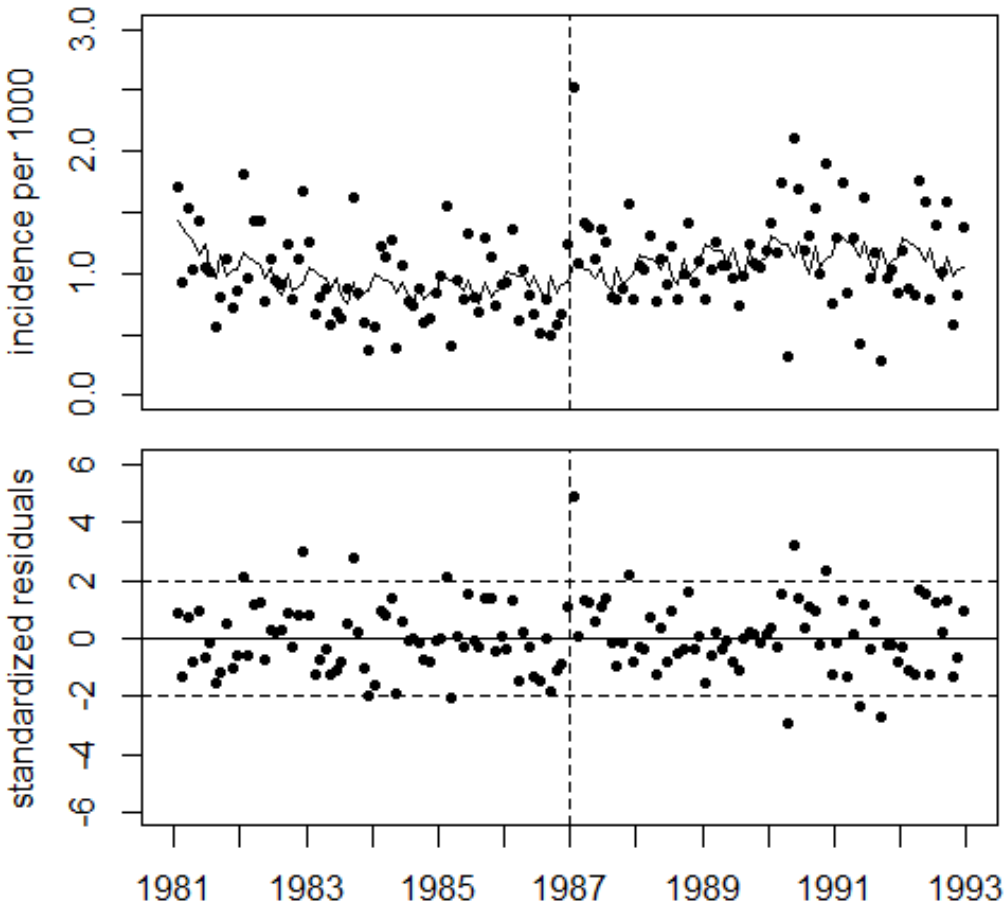
Upper panel: Trend of live births and regression line

Lower panel: Standardized residuals

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



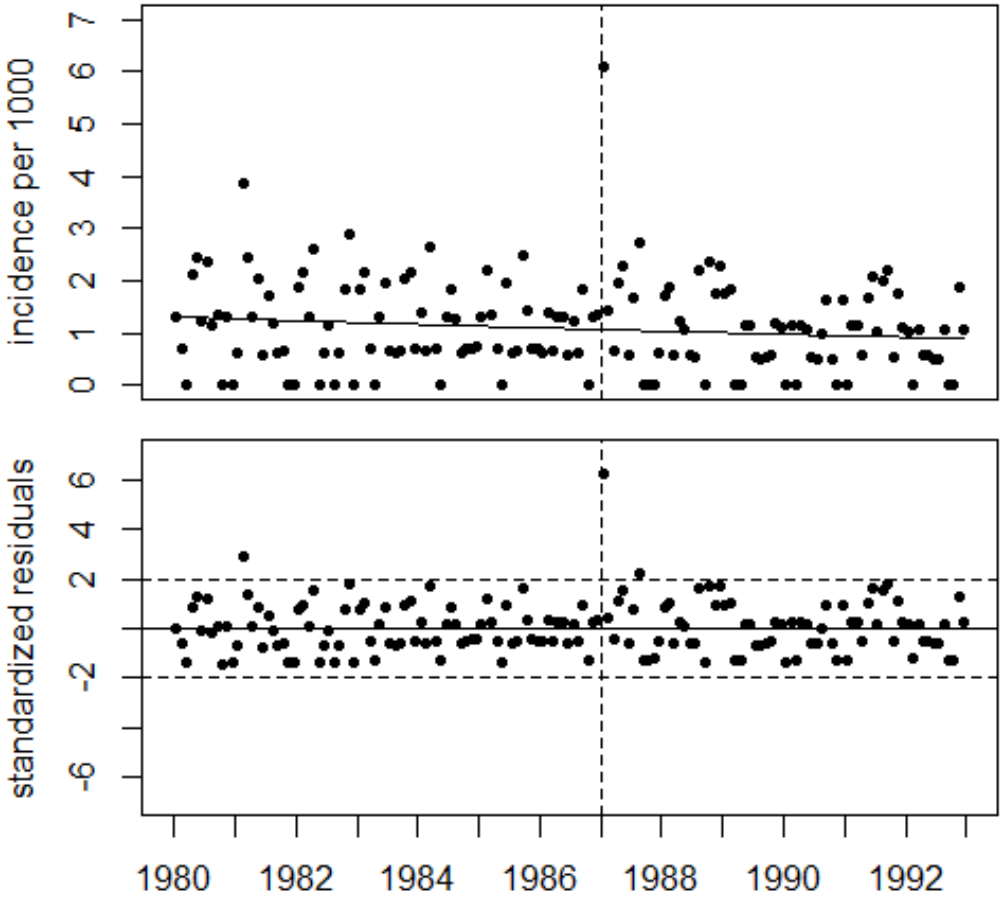
Upper panel: Trend of tisomy 21 incidence
Lower panel: Standardized residuals

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 incídence in January 1987 (*P*=0.0004)

From: Zatsepin I, Verger P, Robert-Gnansia E, Gagnière B, Tirmarche M, Khmel R, Babicheva I, Lazjuk G. Down syndrome time-clustering in January 1987 in Belarus: link with the Chernobyl accident? Reprod Toxicol. 2007 Nov-Dec;24(3-4):289-95.

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



Upper panel: Trend of tisomy 21 incidence
Lower panel: Standardized residuals

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 incídence in January 1987 (*P*<0.0001)

From: Sperling K, Pelz J, Wegner RD, Dörries A, Grüters A, Mikkelsen M. Significant increase in trisomy 21 in Berlin nine months after the Chernobyl reactor accident: temporal correlation or causal relation? BMJ. 1994 Jul 16;309(6948):158-62.

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