The Trajectory of psychosocial anxiety after the Chornobyl nuclear accident in Ukraine

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Abstract

Our objectives were to examine predictive parameters of psychological impacts, resulting from the Chornobyl accident, on residents living in the oblasts of Kiev and Zhitomyr. We tested drivers for psycho-social depression based on estimates radiological dose received from radioactivity release during the accident and the perception of increased health effects associated with this radiation. To obtain a representative sample of individuals, we attached computer generated random numbers to area codes provided by the telephone company. In January 2009, Russia created an intervening crisis by interrupting supplies of natural gas to the Ukraine. We employed scenario forecasting to circumvent crisis effects that could otherwise undermine the internal validity of our study.

State space methods were used to model and graph trajectories of psycho-social depression reported by male and female respondents. Results of the dose reconstruction process revealed that the dose received by this population was too low to identify pathological disease or injury. From our empirical analysis, we found that the psychological impacts of the nuclear incident stemmed from perceived

Introduction

The accident at the Chernobyl nuclear power plant in 1986 was the most severe in the history of the nuclear power industry.

Radioactive debris was expelled at the time of the initial thermal explosions and for the following 10 days during the ensuing graphite fires. It has been estimated that approximately 10^{17} Bq of ^{137}Caesium (^{137}Cs) was released. For comparison, this fallout is 10% of that released from all atmospheric nuclear weapons tests and about 10 times that of Fukushima (MacLaughlin, 2011]. The long duration of the release and changing meteorological conditions dispersed of radioactivity in many different direction, depositing the largest concentrations of radioactivity in Belarus, Ukraine and the Russian Federation.

Radioactivity was irregularly dispersed over much of Europe, leaving Hot Spots next to Cold Spots. Data from extensive measurements were compiled into maps in the Atlas of Cesium Deposition on Europe following the Chernobyl Accident published by the European Commission(DeCorte et al, 1998}.

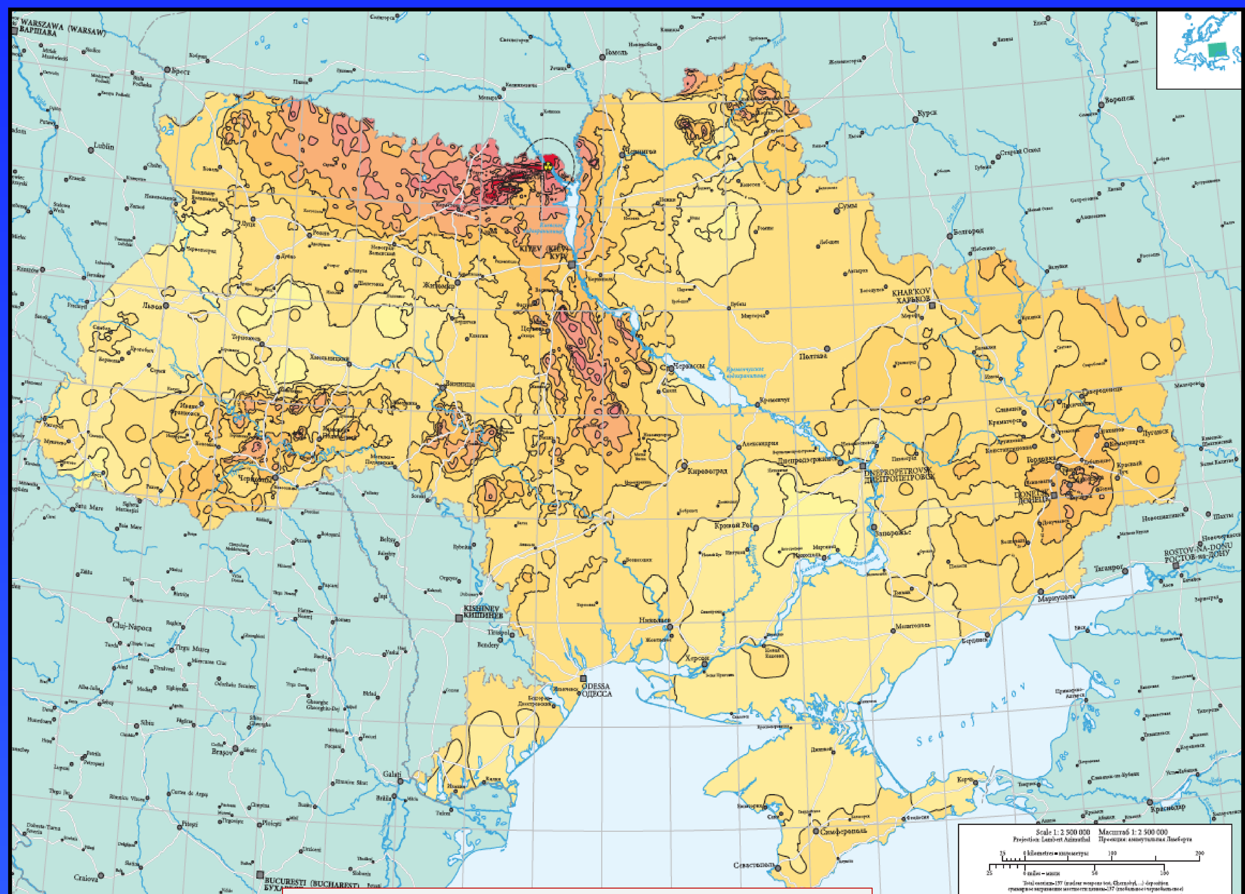

Figure 1: ^{137}Cs deposits in Ukraine

Research Objectives

1. To empirically test whether dose to individuals from external sources of ionizing radiation released during the accident was a significant variable in predicting the temporal pattern of psycho-social depression in the population residing in Kiev and Zhitomyr Oblasts in Ukraine.

2. To empirically test whether the perceived health risk associated with radiation from the Chornobyl accident was a significant variable in predicting the trajectory of psycho-social depression in that population.

3. To develop a state space model to predict psycho-social depression after a nuclear incident.

4. To devise a protocol for circumventing the impact of major non-Chornobyl-related intervening variables that could confound analysis of the trajectory of self-reported depression following the Chornobyl accident

Methods

- Representative sampling:} with a randomized telephone survey in Kiev and Zhitomyr oblasts.
- Random digit dialing:} Computer generated random numbers were attached to Ukrainian area codes to form phone numbers. One person per household was interviewed.
- Four callbacks at different times of day were tried.
- Pilot study of 100 separate respondents in late 2008.
- An Independent auditing group assured voluntary reporting and no undue guidance before data were uploaded.
- After data were cleaned, datasets were personally de-identified} to assure confidentiality in accordance to U.S. Heath Information Privacy Act requirements prior to analysis.

Statistical Analysis

State space models with augmented Kalman Filters were applied to model the trajectory of gender specific trajectories of psycho-social anxiety.

Transition equation: $$\alpha_{t+1} = T\alpha_t + R\eta_t$$

Measurement equation: $$y_t = Z\alpha_t + G\varepsilon_t$$

where α_t denotes the state vector at time t, which stacks the local level over a local slope over regressors and intervention dummy variables, T is a transition matrix, η_t is a vector of innovations, and R selection matrix of zeros and ones. In the measurement equation y_t is the observed time series under study, while Z is a factor loading matrix and ε_t is a measurement error vector and G is a selection matrix.

Male Measurement Model:

Male Measurement Model was a local linear trend model: They also contained level shifts and event impact blips as follows:

$$\begin{aligned} &MaleAnxiety_t \\ &= \ 0.019 Level_t - 0.001 Slope_t^{\dagger} \\ &\quad + 0.255 MalePerceivedRisk_t^{***} \\ &\quad - 0.154 LevelShift1987_t^{**} + 0.041 LevelShift2004_t^{***} + \varepsilon_t \end{aligned}$$

Female Measurement Model:

Female Measurement model was also a local linear trend model with the following included parameters:

$$\begin{aligned} &FemmaleAnxiety_t \\ &= \ 0.072 Level_t^{***} + 0.003 Slope_t^{\dagger} + 0.228 FemPerceivedRisk_t^{***} \\ &- 0.185 Levelshift1987_t^{***} - 0.023 blip1989_t^{**} - 0.018 Levelshift1992_t^{*} \\ &+ 0.022 blip2000_t^{*} + 0.024 Levelshsift2002_t^{**} + \varepsilon_t \end{aligned}$$

Where † indicates a non-significant slope component and *** indicates significance at ($p<0.001$), ** ($p<0.01$), *($p<0.05$). Starting values for the filter included a non-informative prior and zero mean. The models were estimated with maximum likelihood by the BFGS algorithm using a diffuse prior distribution with the software package Stamp 6.4 (Koopman, Harvey, Doornik and Shepard) in Durbin and Koopman (2000)

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Results

Summary of effective dose received by the sample population from external sources of penetrating gamma rays shown in Figure 1

	Ending Date		
	12/31/1986	12/31/1996	12/31/2009
Lowest value of External Dose received by an individual (mSv)	0.0074	0.036	0.047
Largest value of External Dose received by an individual (mSv)	28.0	30.0	31.0
95th Quantile of External Dose received in the sample (mSv)	0.037 - 1.4	0.14 - 3.4	0.19 – 4.4
Average value of External Dose received in the sample (mSv)	0.38	0.93	1.2
Median value of External Dose received in the sample (mSv)	0.28	0.69	0.91
Geometric Mean value of External Dose received in the sample (mSv)	0.23	0.61	0.84
Estimated Average value of External Dose from Natural Background (mSv)	0.33	5.3	12.0

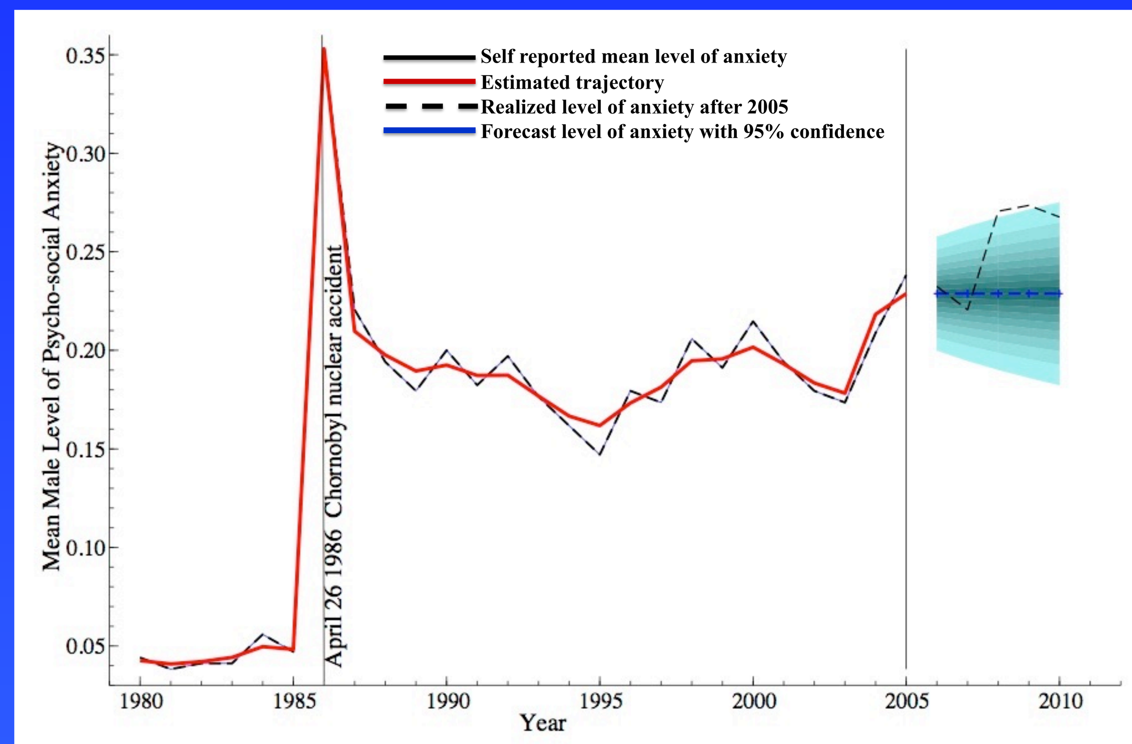

Figure 2, Trajectory of Male psycho-social anxiety of the sample Ukrainian population

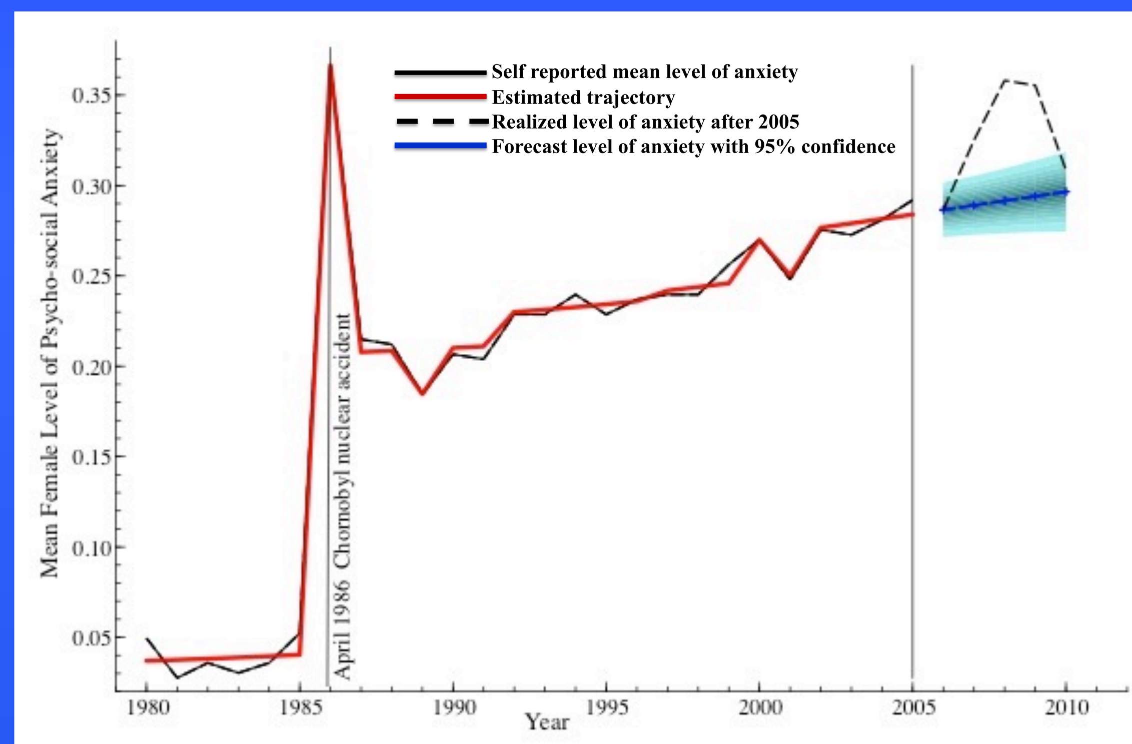

Figure 3, Trajectory of Female psycho-social anxiety of the sample Ukrainian population

Figures 2 and 3 show the mean values of anxiety for males and females before and after the Chornobyl accident. The forecasting period begins in 2005. The two curves before 2005 show the data from our survey (Black) and results from the filtering processes in the models (Red), The curves after 2005 show the forecasted estimates of anxiety (Blue) and the realized values from our survey (Black). Structure in the curves conceivably attributed to intervening political and economic factors are described below.

- Male and female psycho-social anxiety peak in 1986 at time of accident
- Both trajectories decline thereafter but never reach pre-Chornobyl levels.

(Intervening political and economic events)

Before 2005
- 2000: Termination of reactor operations
- 2002: Ukrainian government violates sanctions relating to trade with Iran.

After 2005
- 2006: Natural gas supplies interrupted in dispute with Russia.
- October 2008: Global economic recession increases anxiety levels for women.
- Jan 1, 2009, Interruption of natural gas supply severely impacts economy.

Discussion

1. Absorbed dose received from external radiation related to the Chernobyl accident is not a significant predictor of the trajectory of psycho-social anxiety either for males or females.

2. The perceived risk related to radiation from the Chornobyl accident is the main predictor of psycho-social anxiety for both males and females.

3. We are able to circumvent impacts of potentially confounding variables by reverting to an earlier point of forecast origin and forecasting from 2005 through 2010.

4. We were able to develop a state space model that reliably forecasts psycho-social anxiety after a nuclear event.