File # 203

Event history analysis - PTSD and cure models

DRU:Modeling Nuclear Disaster Risk:
The Effects of Risk Perception and Cumulative External Radiation Exposure to Caesium-137 on post-Chernobyl Psychosocial and Health Behavior Outcomes

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1 Research Questions

In this paper, we examine the nature of post-traumatic stress disorder (hereinafter, PTSD) among residents living in the area of a major nuclear meltdown. We also want to learn what risk factors were related to this form of psychological aftereffect. To determine this, we want to test hypothesis 3 that exposure to Chornobyl radiation is directly related to the onset of PTSD or its relapse. We also want to test hypothesis 6 that perceived Chornobyl health risk is related to the onset or relapse of PTSD. These are the core interests of this study and the focal points of this analysis. By focusing on these issues, we hope to glean a better understanding of what generates, aggravates, and buffers PTSD among the respondents surviving the Chornobyl meltdown in Kiev and Zhitomyr Oblasts of the Ukraine after Chornobyl.

2 Instruments and measures

We define PTSD according to a self-reported PTSD on a scale of 0 to 100 as with 100 as the highest level of severity, as those who have reported PTSD as a score of 5 or more on that scale.

3 Statistical Methods

The sample collection was described in the previous section on depression models. In this section, we focus on PTSD reported by residents of the Kiev and Zhitomyr Oblasts surrounding or adjacent to the epicenter of a major nuclear event. We examine the number of reported episodes of PTSD and the number of subjects reporting them as well as the number who reported having no PTSD. We examine the nature of the PTSD reported by the respondents. We examine the survival probability over time as well as the hazard and cumulative hazard rate over time.

We use life tables for males and females revealing this process of recurrent events, we test whether the survival probabilities are significantly different by gender, age-group, perceived risk group, and self-reported illness group using log rank and Wilcoxon tests.

We examine the survival probability over time, the hazard rate over time, and the cumulative hazard rate over time as well as the medians for such functions, after which we turn to developing models to explain the time till onset of PTSD, the hazard rate for PTSD, the number of relapses, and what buffers explain the

Table 1: General number of subjects, PTSD spells, half-years of risk in sample

```
         failure _d:  event == 1
   analysis time _t:  onstdate
  enter on or after:  time bgdate
  exit on or before:  time .
                 id:  id
```

Category	total	per subject mean	min	median	max
no. of subjects	468				
no. of records	930	1.987179	1	2	7
(first) entry time		40.44444	40	40	78
(final) exit time		79.75214	46	86	100
subjects with gap	0				
time on gap if gap	0	.	.	.	.
time at risk	18396	39.30769	6	46	60
failures	930	1.987179	1	2	7

length of time the respondent reports having been cured of PTSD, which we define as going for at least two years without reporting a relapse of the PTSD.

Because the parametric accelerated failure time models are very sensitive to violations of the model assumptions, we employ Cox proportional hazard regression models to develop male and female models for the three spells amenable to analysis, as warranted by a one-sided power analysis for the standard effect sizes with a power of at least 0.80.

We also develop a cure model explaining the length of time in a respondent reports having had no PTSD, provided that he has reported no PTSD for at least two years of study time, and provided that has had PTSD before. We consider such an individual to be cured of his PTSD and use the length of such cured time as a dependent variable for a gender-specific model that explains the temporal extent of the recovery.

We in conclusion will examine commonalities of the covariates that explain the hazard rates of PTSD and the factors explaining recovery with a view toward coming to conclusions and pointing to directions for future research.

4 PTSD sample

From a general description of the data, in Table 1, we observe 930 events of PTSD onset in 468 subjects. Although many subjects experience multiple events, the minimum number of maximum PTSD episodes was one.

Table 2 displays the breakdown of the PTSD by gender. There are 220 males and 248 females, with median survival times of 52 and 60, half-years, respectively.

In Table 3, we decompose the sample by three levels of age category, from 28 to 42, from 43 to 55, and from 55 to 84. The median survival times for each

Table 2: Gender breakdown of PTSD sample

gender	no. of subjects	50%	Std. Err.	[95% Conf.	Interval]
1. male	220	52	.2830358	52	56
2. femal	248	60	1.905904	54	62
total	468	56	.4480604	52	60

Table 3: Age distribution in the PTSD sample

agegp	no. of subjects	50%	Std. Err.	[95% Conf.	Interval]
28 thru	130	60	4.775837	52	66
43 thru	166	58	.7670502	52	62
56 thru	172	52	.4959284	52	56
total	468	56	.4480604	52	60

age category is listed. We note that the midpoint of number of events for each age category increases with the age level.

4.1 Total number of years of PTSD experience

It is interesting to examine the length of time that the respondents reported having experienced PTSD and subdivide it by both age group and gender, shown in Table 4. To illustrate the relationship, we generate box and spine plots, in Figures 1 and 2.

4.2 PTSD Recurrence

But these experiences of PTSD are not singular experiences. Most people who experience an episode or PTSD experience relapses of it as well. The number of relapses of PTSD reported by the respondents, when cross-tabulated with gender, is listed in Table 5. Please note that the frequency is the number of events recorded and not the number of subjects. What we can observe in this table is that most of the experiences appear to be covered in the first three occurrences of PTSD for most respondents, as illustrated in Figure 3.

4.3 PTSD by gender

Of course, we may examine whether our key variables, configured as discrete variables, explain a significant difference in the survival rates of PTSD from the recurrent episodes reported. We can test whether the PTSD survival probabilities differ by gender with log rank and/or Wilcoxon tests, in Table 6, as

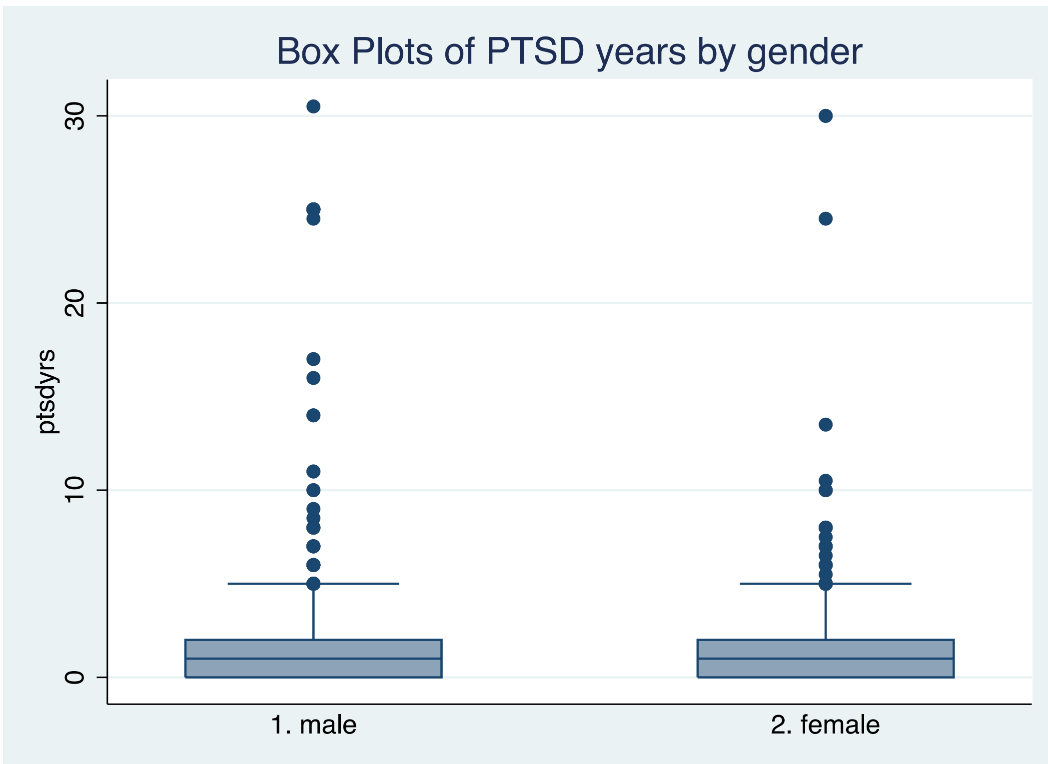

Figure 1: Length of PTSD experience in years reported by gender

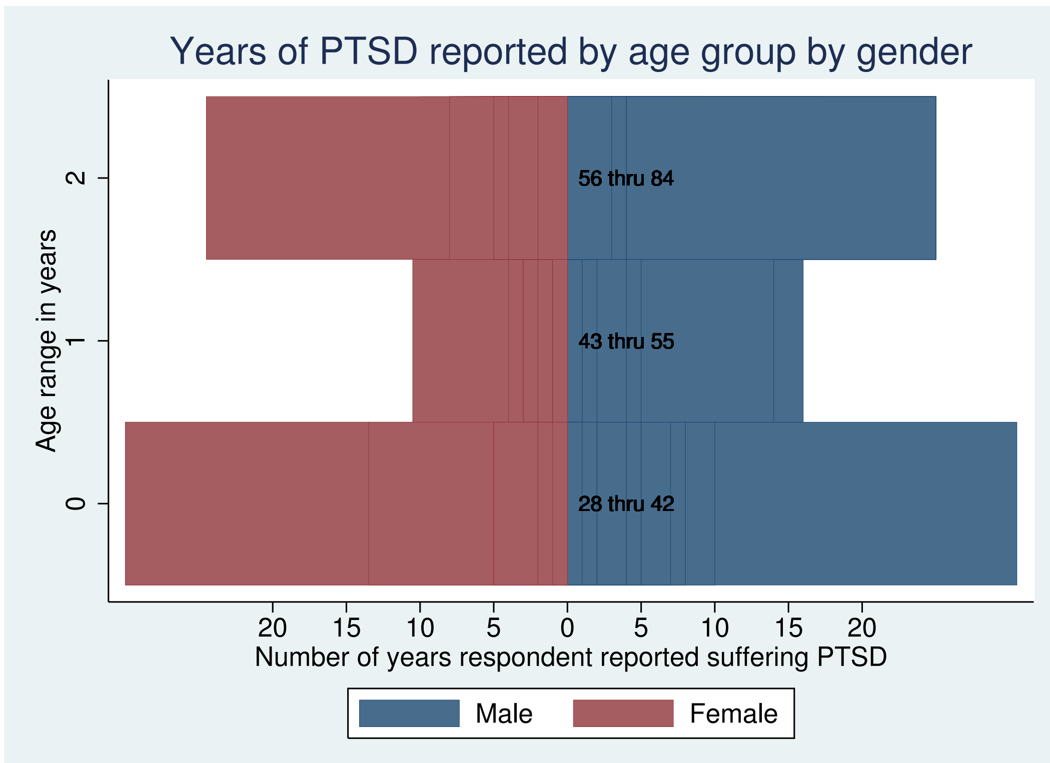

Figure 2: Length of PTSD experience in years reported by age category and gender

Table 4: Length of PTSD experience by gender and age-group

Table entries are cell frequencies and row percentages (Missing categories ignored)

	respondent´s gender and Age group					
	1. male			2. female		
ptsdyrs	28 thru 42	43 thru 55	56 thru 84	28 thru 42	43 thru 55	56 thru 84
0	111	91	77	93	111	99
	39.78	32.62	27.60	30.69	36.63	32.67
1	58	67	56	55	79	78
	32.04	37.02	30.94	25.94	37.26	36.79
2	24	37	38	27	50	61
	24.24	37.37	38.38	19.57	36.23	44.20
3	10	21	30	15	34	40
	16.39	34.43	49.18	16.85	38.20	44.94
4	7	10	18	7	28	18
	20.00	28.57	51.43	13.21	52.83	33.96
5	3	3	8	5	8	9
	21.43	21.43	57.14	22.73	36.36	40.91
6		4	4		3	3
		50.00	50.00		50.00	50.00
7	2	2	4		2	3
	25.00	25.00	50.00		40.00	60.00
8	1	2	4		2	2
	14.29	28.57	57.14		50.00	50.00
9			1			
			100.00			
10	1	1			3	1
	50.00	50.00			75.00	25.00
11		2				
		100.00				
13				1		
				100.00		
14		2				
		100.00				
16		1				
		100.00				
17			1			
			100.00			
24			1			1
			100.00			100.00
25			10			
			100.00			
30	1			2		
	100.00			100.00		

```
. emh ptsdyrs agegp, s(gender)
Extended Mantel-Haenszel (Cochran-Mantel-Haenszel) Stratified Test of Association
Correlation Statistic:
Q (1) = 25.6006, P = 0.0000
Transformation: Table Scores (Untransformed Data)
```
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Extended Mantel-Haenszel (Cochran-Mantel-Haenszel) Stratified Test of Association

Correlation Statistic:
Q (1) = 1.3914, P = 0.2382
Transformation: Table Scores (Untransformed Data)

Table 5: PTSD recurrence by gender

Key
frequency
row percentage
column percentage

ptsd episode number	respondent´s gender 1. male	2. female	Total
0	279 47.94 39.13	303 52.06 36.07	582 100.00 37.48
1	224 47.16 31.42	251 52.84 29.88	475 100.00 30.59
2	116 42.65 16.27	156 57.35 18.57	272 100.00 17.51
3	55 38.73 7.71	87 61.27 10.36	142 100.00 9.14
4	24 44.44 3.37	30 55.56 3.57	54 100.00 3.48
5	9 50.00 1.26	9 50.00 1.07	18 100.00 1.16
6	4 57.14 0.56	3 42.86 0.36	7 100.00 0.45
7	2 66.67 0.28	1 33.33 0.12	3 100.00 0.19
Total	713 45.91 100.00	840 54.09 100.00	1,553 100.00 100.00

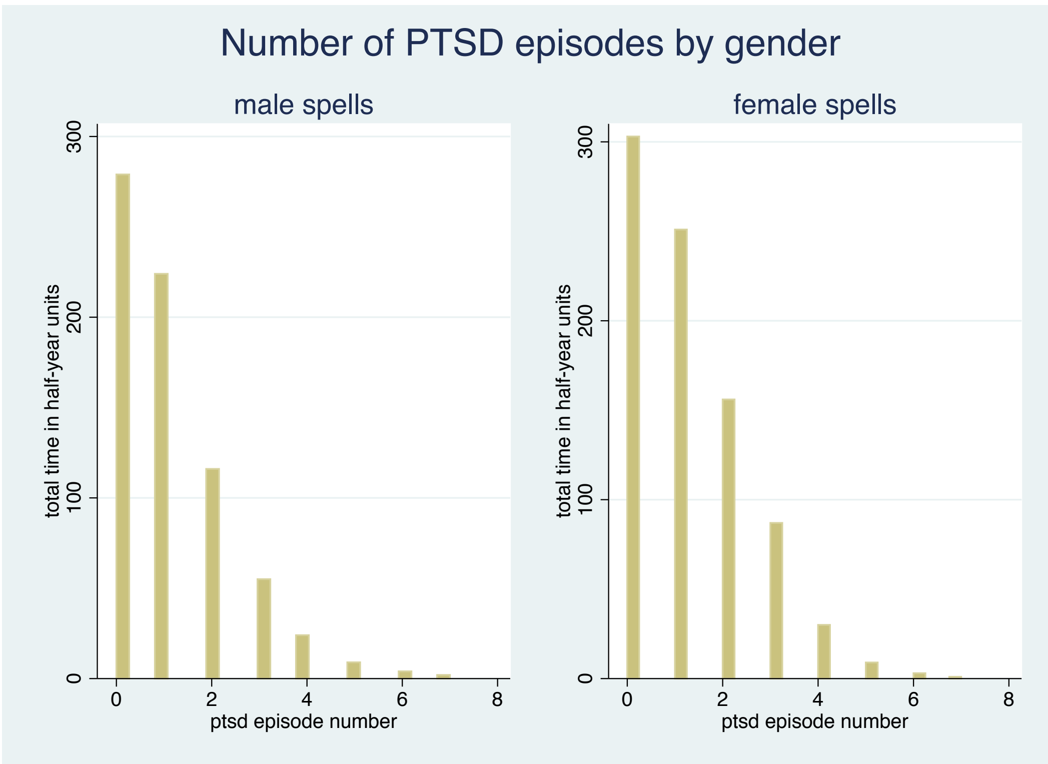

Figure 3: Number of male and female spells of PTSD reported

Table 6: Survival probability by gender

Log-rank test for equality of survivor functions

gender	Events observed	Events expected
1. male	423	422.59
2. female	507	507.41
Total	930	930.00
	chi2(1) =	0.00
	Pr>chi2 =	0.9749

Wilcoxon (Breslow) test for equality of survivor functions

gender	Events observed	Events expected	Sum of ranks
1. male	423	422.59	2764
2. female	507	507.41	-2764
Total	930	930.00	0
	chi2(1) =	0.40	
	Pr>chi2 =	0.5257	

depicted by Figure 4. The test results below indicate that there is not a statistically significant difference between male and female PTSD survival functions, shown in Figure 4.

4.4 PTSD by age category

If PTSD might be related to age group, there should be a significant difference among survival probabilities by age group. We apply both the log-rank and the Wilcoxon test to our survival probabilities divided by age group and we discover that there is a significant difference according to age group, and when we examine Figure 5 we may detect a clear difference between the upper and lower age group category confidence intervals, regardless of other overlaps. This indicates that age may be important in distinguishing PTSD, so we should alway use this variable as a control in other models we might attempt to build.

4.5 PTSD and reconstructed external dose

When we bifurcate the external exposure into high and low groups and apply the log-rank or Wilcoxon test to determine whether we do observe a significant difference of the survival probability associated with the difference among these two groups, as revealed in Table 8 with p-values that are highly significant. We can clearly observe the wide gap between the confidence intervals in support of this finding in Figure 6.

But an association need not indicate a causation. It may be a by-product

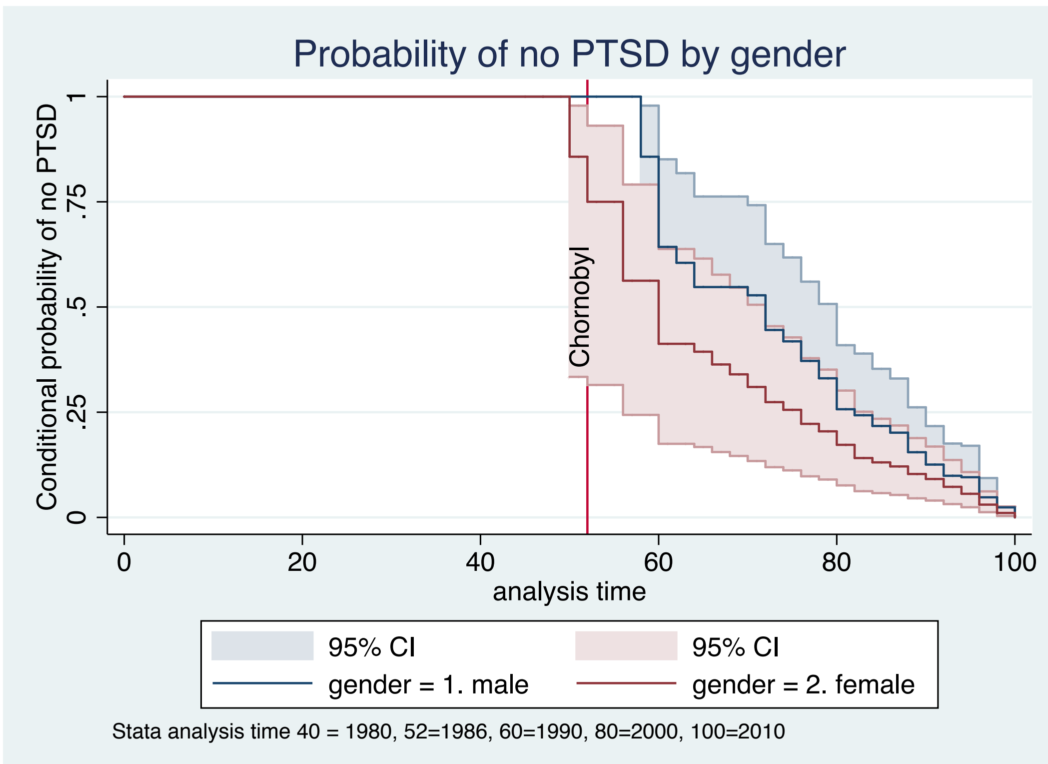

Figure 4: Comparison of survival functions by gender

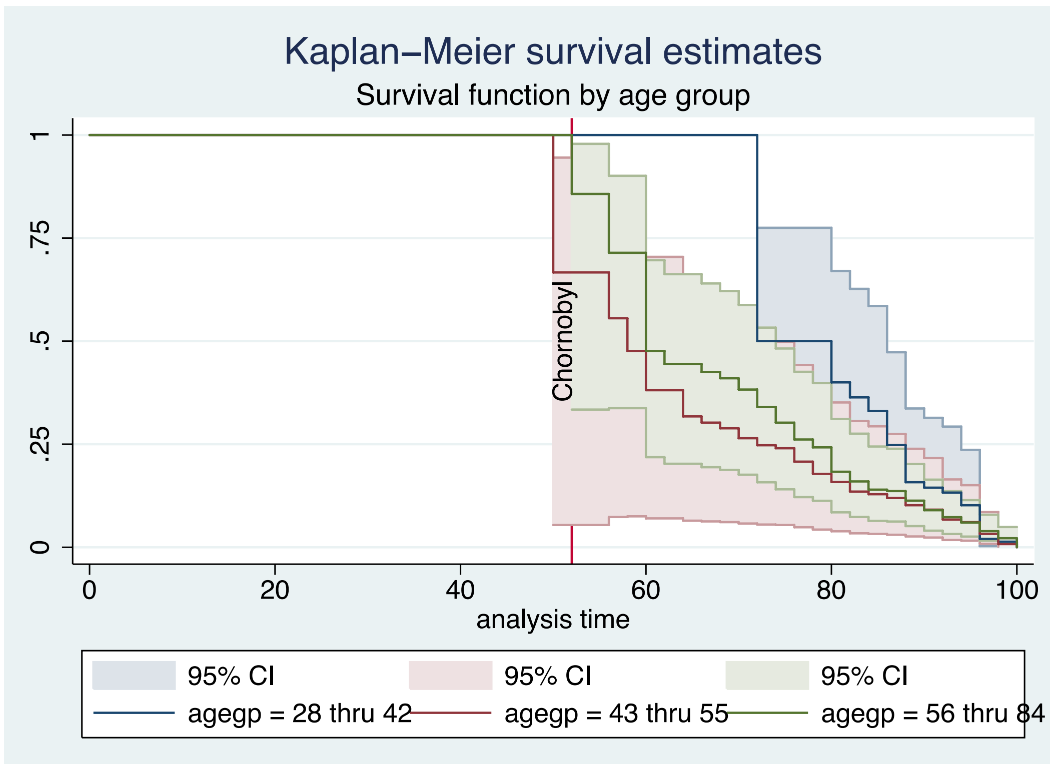

Figure 5: Comparison of survival functions by age group

Table 7: Testing survival function differences by age category

Log-rank test for equality of survivor functions

agegp	Events observed	Events expected
28 thru 42	216	246.14
43 thru 55	343	340.97
56 thru 84	371	342.89
Total	930	930.00
	chi2(2) =	7.99
	Pr>chi2 =	0.0184

Wilcoxon (Breslow) test for equality of survivor functions

agegp	Events observed	Events expected	Sum of ranks
28 thru 42	216	246.14	-11437
43 thru 55	343	340.97	-431
56 thru 84	371	342.89	11868
Total	930	930.00	0
	chi2(2) =	11.33	
	Pr>chi2 =	0.0035	

of antecedent, intervening effects, moderating, or other omitted variables generating this result. Moreover, if the total effect remains below the level that generates biological reactivity, such an association may be without a noticeable impact. For all of these reasons, a bivariate relationship may be only an indication of a possible effect; it is not sufficient evidence for such an effect. More testing of a multi-causal processes is necessary before we can draw any reliable inference of an effect from such a bivariate relationship.

4.6 PTSD by self-reported illness

We wonder whether the health of an individual during our waves of analysis may impact the survival functions. To test this proposition, we collapse the number of self-reported illness variables into three categories–less than 2, 2 to 4, 4 to 6 and then apply our log-rank and Wilcoxon test to determine whether there is any association between survival functions when they are divided among these categories. The answer, displayed in Table 9, reveals no significant distinction of one survival probability from another.

Table 8: Tests for differences in survival probability by reconstructed external dose group

Log-rank test for equality of survivor functions

cumdosewgp	Events observed	Events expected
low	435	340.66
high	495	589.34
Total	930	930.00
	chi2(1) =	57.62
	Pr>chi2 =	0.0000

Wilcoxon (Breslow) test for equality of survivor functions

cumdosewgp	Events observed	Events expected	Sum of ranks
low	435	340.66	37620
high	495	589.34	-37620
Total	930	930.00	0
	chi2(1) =	80.86	
	Pr>chi2 =	0.0000	

Table 9: PTSD by number of self-reported illnesses

Log-rank test for equality of survivor functions

illwgp	Events observed	Events expected
less than 2	771	769.67
two to four	125	126.17
four to six	34	34.16
Total	930	930.00
	chi2(2) =	0.02
	Pr>chi2 =	0.9909

Wilcoxon (Breslow) test for equality of survivor functions

illwgp	Events observed	Events expected	Sum of ranks
less than 2	771	769.67	3681
two to four	125	126.17	-2805
four to six	34	34.16	-876
Total	930	930.00	0
	chi2(2) =	1.41	
	Pr>chi2 =	0.4936	

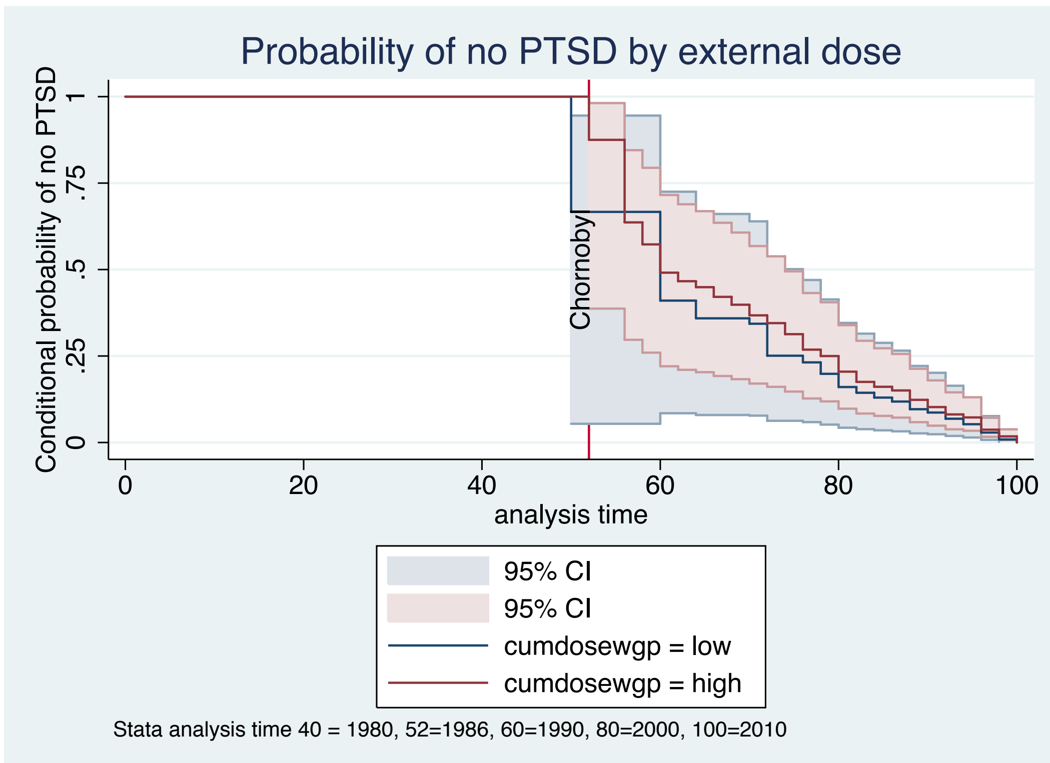

Figure 6: Comparison of survival functions by reconstructed external dose group of relatively low and high mSv category

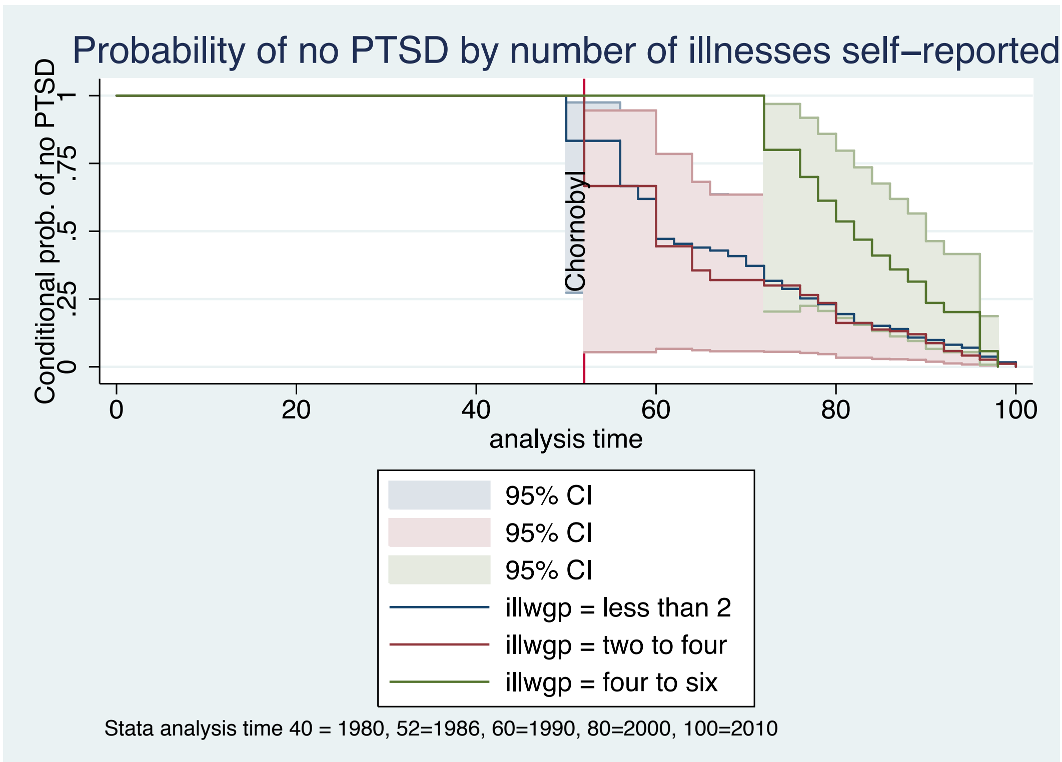

Figure 7: Comparison of survival functions by self-reported number of illness category

Table 10: Tests of the impact of perceived Chornobyl health risk

Log-rank test for equality of survivor functions

percRiskgp	Events observed	Events expected
low	247	236.26
medium	348	343.69
high	335	350.05
Total	930	930.00
	chi2(2) =	1.60
	Pr>chi2 =	0.4487

Wilcoxon (Breslow) test for equality of survivor functions

percRiskgp	Events observed	Events expected	Sum of ranks
low	247	236.26	6884
medium	348	343.69	-3519
high	335	350.05	-3365
Total	930	930.00	0
	chi2(2) =	3.20	
	Pr>chi2 =	0.2017	

4.7 Perceived Chornobyl health risk and PTSD

We test whether perception of Chornobyl health may impact the PTSD survival probability. We use the Logrank and Breslow test to perform a bivariate test. The statistically non-significant results, listed in Table 10 and displayed in Figure 8, are inconsistent with a significant difference between the survival functions.

4.8 Discussion of Bivariate test results

We note that only two of the above bivariate tests statistically significantly distinguish between survival probabilities, and they are age group and reconstructed external dose group. This means that we should probably include age group in our survival models, whether or not it appears to be statistically significant. Because bivariate models control neither for omitted variable bias or intervening variables, we need to test our hypotheses with a more sophisticated multiple association model, such as a type of survival regression.

In most of these tests, we notice a precipitous drop in the survival probability of the groupings at the time of Chornobyl. It is clear that Chornobyl had some effect on these survival probabilities from the graphs. Such a drop in the probability of not experiencing PTSD is indicative of a massive traumatic experience. For the mass public to experience such an event must have been terrifying to many people at the time. This drop is survival probability was

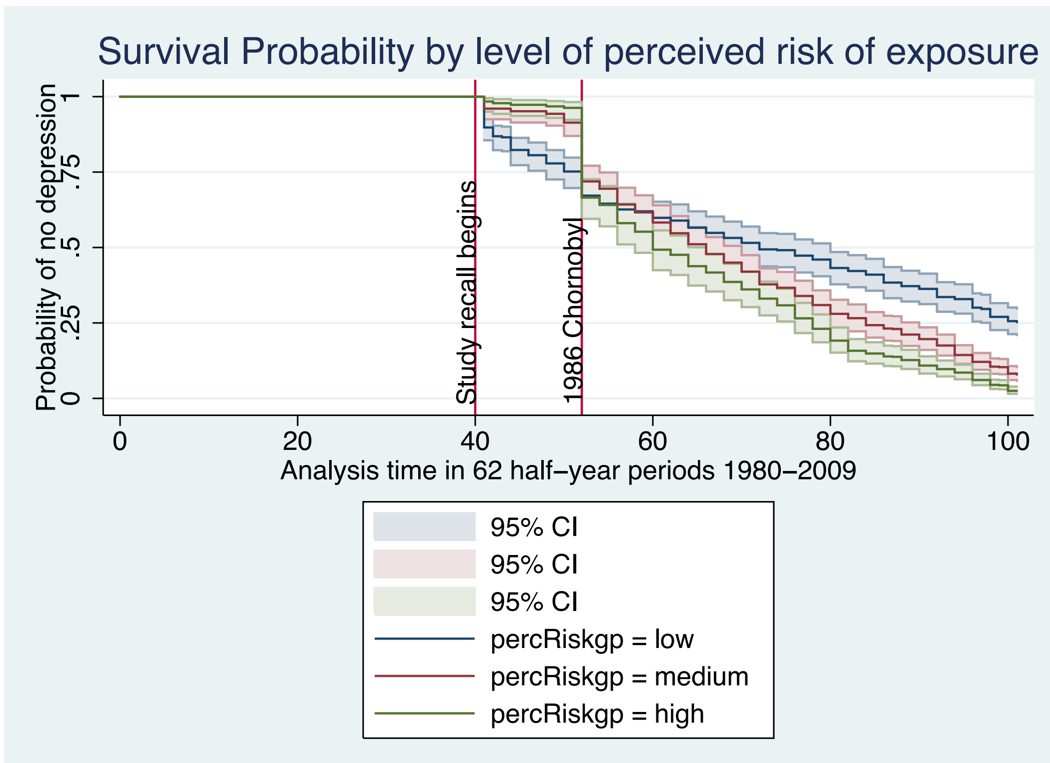

Figure 8: Comparison of survival functions by perceived Chornobyl health risk group

statistically significant with respect to age group differences as well as actual exposures to external dose, even if both of those survival probabilities were below the level of biological reactivity.

If this actual difference in external dose carried over to perceived Chornobyl health risk, however, we should have observed that as well, unless it was masked by the omission of variables from the analysis. Alternatively, we might conclude that PTSD is not directly associated with perceived Chornobyl health risk over time. This would be an anomaly that could be explained by omitted variable bias and the lack of a closed system over time, in which other concerns may be entering into the minds of respondents, which we did not fully address–such as details of the economic, financial, and political problems.

5 The Cox proportional hazards regression model

We have found that the parametric survival models are very sensitive to model fit. Deviations of the Cox-Snell residuals from an optimal diagonal line divulges a failure of functional form that is too often the case. We found this in the case of our depression models and would like to use models whose assumptions are fulfilled by our data. In a previous analysis, not shown here, we found that the data generally do not fit such models, but in the analysis below, in which we apply the Cox regression models, we will demonstrate that all of the model assumptions are fulfilled by our data.

5.1 Model Building strategy

In general we followed a general to specific model building strategy. We always include an age or age group variable because this was statistically significant in our bivariate tests. Otherwise, we always include the cumulative external dose variable or the perceived Chornobyl health risk index (with Cronbach alpha reliability coefficients of 0.90 for men and 0.91 for women) either in continuous or collapse form. We begin with a general unrestricted model (GUM) and then proceed through two trimmings to conserve power. We entered, sociodemographic covariates, major negative life event covariates, daily stressors and hassles, measured of physical and mental health, health behaviors, help impacts on self and on the family, beliefs about the social milieu and environment, pollution, radiation in general, and Chornobyl in particular. We also included dummy variables to capture the changes in PTSD surrounding the great global financial crisis of 2008, and the Russian gas cut-off of January 2009, which is widely known to have impacted many of the Ukrainian factories.

We then employed the Sauerbrei and Royston (1999) multivariable fractional polynomial program to test the linearity assumption of our model and to remove the non-significant covariates. We made sure that all of the variables selected in the final model were also selected by that software.

We always include the age or age group variable, whether or not it appears to be statistically significant to help control for life-cycle effects. We always include the reconstructed cumulative external dose variable to test the hypothesis of whether this is related to these sequelae or not. We also always include the external dose (cumdosewgp) and the perceived Chornobyl health risk variable (percRiskgp) to test the hypotheses that PTSD

Each spell or episode was modeled independently to discover what factors could explain or predict it, so that we made no presumptions of a hierarchical structure in so doing. The results are found in the tables below.

5.2 Parameters tested

6 The Male proportional hazards regression model

6.1 Omnibus measures

We report the findings for the parameter estimates of the male and female Cox regression models. We provide as measures of fit the pseudo-R^2 as R_p^2, per Nagelkerke the formula [1, 193-195] for which is

$$R_p^2 = 1 - exp\left[\frac{2}{n}(ll_0 - ll_p)\right] \tag{1}$$

We also present the deviance as a measure of lack of fit, and show that the models fulfill the linearity and proportional hazards assumptions. Using these models, we proceed to test our research questions about the significance of covariates in predicting the hazard rates for males and females.

6.2 The male model for episodes one through three

6.2.1 Episodes 1 2 and 3

The coefficients (not the hazard rates) of the male model presented in Tables 14 through 17, representing trimmed models, revealing only parameter estimates statistically or almost significant at the 0.05 level. In general, almost significant at the .05 level means that p $\leq$ 0.15. With more than 2500 variables in the dataset, we present the trimmed model. But the variables tested as covariates are found in Tables 11, 12, and 13.

6.3 Parameter estimates

In the next section we refer to the relative hazard, which is the hazard relative to the baseline hazard. The baseline hazard is similar to the constant and is unknown and assumed to be unimportant in this interpretation. If we subtract one and multiply by 100, we obtain the percent impact.

Table 11: Table of covariates tested

variable name	type	display format	value label	variable label
agegp	float	%10.0g	ag	Age group
educ	byte	%38.0g	q25nu	highest educational level the respondent have completed
marrw	float	%15.0g	LABH	cohabitation/marital status
childw	float	%9.0g		number of children
inc1w	float	%15.0g	LABJ	Income is not sufficient for basic neccessities
inc2w	float	%15.0g	LABJ	Income is just sufficient for basic neccessities
inc3w	float	%15.0g	LABJ	Income is sufficient for basics plus extra purchases/savings
inc4w	float	%15.0g	LABJ	Income allows to comfortably afford luxury items
deaw	float	%9.0g		Total number of death experienced in time period
sepaw	float	%9.0g		Total number of separations experienced in time period
illw	float	%9.0g		Total number of illnesses experienced in time period
movew	float	%9.0g		Total number of moves experienced in time period
shjobw	float	%9.0g		Percentage of strains and hassles related to job
shfamw	float	%9.0g		Percentage of strains and hassles related to family
shrelaw	float	%9.0g		Percentage of strains and hassles related to relationships
suprtw	float	%9.0g		Level of support (in percent) from partner
phlthw	float	%9.0g		level of general physical health
mhlthw	float	%9.0g		level of general psychological/mental health
smokw	float	%9.0g		number of cigarettes per week
liqw	float	%9.0g		number of spirits per week in
beerw	float	%9.0g		nuber of beers per week in
toxic	byte	%8.0g		all radioactive materials remain toxic for thousands of years (% of agree)
repair	byte	%8.0g		* body has capability to repair tissue damage caused by exposure (% of agree)
healthef	byte	%8.0g		* a person exposed to any radiation likely to suffer from (% of agree)
saferad	byte	%8.0g		there is no safe level of radiation (% of agree)

Continued in the next table ...

Table 12: Covariates tested – part 2

variable name	type	display format	value label	variable label
goodrad	byte	%8.0g		small doses can actually improve one´s health(% of agree)
kzunder	byte	%8.0g		people in k/z underestimate the risks assoicated with radiation (% of agree)
icdxcnt	float	%9.0g		count of icdx illnesses
CSsocspt	float	%9.0g		Coping social support subscale
CSavoid	float	%9.0g		Coping Avoidance subscale
WHPel	float	%9.0g		Wtd Health Profile Pt 1 Energy Level Subscale
WHPer	float	%9.0g		Wtd Health Profile Emotional reaction Pt 1 subscale
WHPsleep	float	%9.0g		Wtd Health Profile Sleep Pt 1 subscale
WHPsociso	float	%9.0g		Wtd Health Profile Social Isolation Pt 1 subscale
WHPpa	float	%9.0g		Wtd Health Profile Physical Ability Pt 1 Subscale
HP2work	float	%9.0g	hp2fmt	Nottingham Health profile subscale Part2: paid employment
HP2hmcare	float	%9.0g	hp2fmt	Hlth profile Pt2: Home cleaning, cooking and repairs
HP2probsoc	float	%9.0g	hp2fmt	Hlth profile Pt2: Hlth causing probs with social life
HP2pbfhm	float	%9.0g	hp2fmt	Hlth profile Pt2: Hlth causing probs with family members at home
HP2sxlife	float	%9.0g	hp2fmt	Hlth profile Pt2: Hlth causing probs with sex life
HP2inthob	float	%9.0g	hp2fmt	Hlth profile Pt2: Hlth probs interfering with interests & hobbies
HP2vacatn	float	%9.0g	hp2fmt	Hlth profile Pt2: Hlth probs interfering with vacations
BSIsoma	float	%9.0g		Basic symptom inventory obsessive compulsive subscale
BSIoc	float	%9.0g		Basic Symptom Inventory Obsessive compulsive subscale
BSIips	float	%9.0g		Basic symptom invenstory interpersonal sensitivity subscale

Continued in the next table ...

Table 13: Covariates tested – part 3

variable name	type	display format	value label	variable label
BSIdep	float	%9.0g		Basic symptom inventory Depression subscale
BSIanx	float	%9.0g		Basic symptom inventory Anxiety subscale
BSIphanx	float	%9.0g		Basic symptom inventory phobic anxiety subscale
BSIhos	float	%9.0g		Basic symptom invenstory hostility subscale
BSIpar	float	%9.0g		Basic symptom invenstory Paranoia subscale
BSIpsyc	float	%9.0g		Basic symptom inventory Psychoticism subscale score
cumdosewgp	float	%9.0g	cdg	Avgcumdosew bifurcated into low and high
percRiskgp	float	%9.0g	prg	Perceived risk group level
fcrisis2008	float	%9.0g		Global financial crisis of 2008
y2009	float	%9.0g		Year 2009

```
. label list
ag:
           0 28 thru 42
           1 43 thru 55
           2 56 thru 84
q25:
           0 0. not answered
           1 1. did not graduate high school
           2 2. graduated high school
           3 3. technical degree
           4 4. did not finish college/bachelor´s
           5 5. graduated college/bachelor´s
           6 6. finished specialist/master´s degree
           7 7. doctor of science/phd
           8 8. doctor of medicine/md
LABJ:
           0 0. not selected
           1 1. selected
prg:
           0 low
           1 medium
           2 high

cdg:       0 0.low
           1 1.high
```

6.3.1 Covariates significantly impacting two or almost two episodes

It is noteworthy that none of the covariates significantly predicted all of the episodes. Therefore, we begin with those covariates that were significant at least two episodes. We will address these impacts the order of their increasing percent impact on the increase of the relative hazard of PTSD. In other words, the order of presentation will be from those covariates that buffer the most against PTSD to those risk factors that aggravate it the most, sorting on the first first episode impact. Having abundance of income (inc4w) buffers the most and is associated with a 75.3% reduction in PTSD in the first episode and and an 85.5% reduction of PTSD in the third episode. The impact of health problems on home care (HP2hmcare) was the second covariate that was a buffer. Avoidance coping (CSavoid) came third with impacts also on the first and third episode, with a reversal of impact from the first to the third episode. It had a 4.5% reduction in the hazard in the first episode and an 9.4% increase in the hazard PTSD the third episode. Partner support (suprtw) had a 1.19% reduction in hazard in the first episode and almost a 1 % reduction in hazard in the second episode. For some anomalous reason, familial stresses and hassles (shfamw) had a 0.5 % reduction of hazard in the first episode but a 1.4% reduction of relative hazard in the third episode.

Anxiety (BSIanx) was the sole risk factor in male PTSD. A unit rise in anxiety is associated with a 9.5% rise in PTSD in the first episode and and a 7.57% rise in PTSD in the second episode.

6.3.2 Hypothesis related parameter estimates

Among the risk factors for increasing the relative hazard are being middle or older in age and being widowed. Hypothesis 6 states that perceived health risk directly predicts PTSD. From the male tables, we observe that perceived Chornobyl health risk appears to be associated with a negative impact on the relative hazard insofar as membership in the middle risk group (percRiskgp b= -1.217***) but the higher level category (2.percRiskgp b=- .591) is not quite significantly related Hypothesis 3 postulates that cumulative external radiation dose directly predicts PTSD. Being in the higher level group of external exposure is almost but not quite significantly related (cumdosewgp b1 = -.338) in the first episode and unrelated in subsequent episodes. In Table 20, we summarize these effects in a more complete fashion.

6.4 Assessment of the male model

The male model for spells one, two, and three fulfilled the proportional hazards assumptions, as shown by the global test results for each of the three episodes in Table 18 and the linearity test for continuous variables indicated by the results of the multivariable fractional polynomial program of Royston and Sauerbrei(1999) displayed in Table 19. The only recommended polynomial transformation was that for age and what was recommended did not significantly improve upon

Table 14: Male model episodes 1, 2, and 3 for recurrent PTSD by spell

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
0b.agegp	0.000	0.000	
	(.)	(.)	
	(.)	(.)	
1.agegp	0.732**	-0.322	
	(2.82)	(-1.10)	
	(0.005)	(0.273)	
2.agegp	1.286***	0.222	
	(5.41)	(0.85)	
	(0.000)	(0.397)	
2b.educ	0.000		0.000
	(.)		(.)
	(.)		(.)
3.educ	-1.068*		1.280**
	(-2.30)		(2.94)
	(0.021)		(0.003)
4.educ	-1.797*		1.845
	(-2.44)		(1.48)
	(0.014)		(0.140)
5.educ	-1.542**		1.154**
	(-2.94)		(3.23)
	(0.003)		(0.001)
6.educ	-1.669***		0.507
	(-3.54)		(1.00)
	(0.000)		(0.317)
8.educ	-5.516***		
	(-6.89)		
	(0.000)		
2b.marrw	0.000	0.000	
	(.)	(.)	
	(.)	(.)	
3.marrw	0.310	0.231	
	(0.88)	(0.22)	
	(0.378)	(0.826)	
5.marrw	-1.383*	-0.057	
	(-2.47)	(-0.05)	
	(0.014)	(0.960)	
6.marrw	0.800#	-0.800	
	(1.65)	(-0.65)	
	(0.098)	(0.518)	

Continued in the next table ...

Table 15: Male model episodes 1, 2 and 3 for recurrent PTSD by spell- pt. 2

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
inc1w	-0.722#	-0.583	
	(-1.68)	(-1.11)	
	(0.093)	(0.265)	
inc2w	-1.323***		
	(-3.86)		
	(0.000)		
inc3w	-1.201**		
	(-3.24)		
	(0.001)		
inc4w	-1.399*		-1.930***
	(-2.50)		(-5.32)
	(0.013)		(0.000)
deaw	-0.215*	-0.056	0.167
	(-2.20)	(-0.43)	(0.97)
	(0.028)	(0.664)	(0.330)
shjobw	0.013***		
	(4.05)		
	(0.000)		
shfamw	-0.005#	-0.002	-0.014**
	(-1.88)	(-0.74)	(-2.99)
	(0.061)	(0.461)	(0.003)
shrelaw	0.010***		0.008#
	(3.55)		(1.90)
	(0.000)		(0.057)
suprtw	-0.012***	-0.010**	
	(-5.05)	(-2.96)	
	(0.000)	(0.003)	
phlthw	0.008	0.019***	
	(1.64)	(3.48)	
	(0.100)	(0.001)	
toxic	-0.002		
	(-0.81)		
	(0.421)		
healthef	0.008*	0.004	
	(2.42)	(0.87)	
	(0.015)	(0.385)	
saferad	-0.002	0.004	
	(-0.96)	(1.59)	
	(0.338)	(0.112)	
icdxcnt	-0.112#	-0.001	
	(-1.89)	(-0.01)	
	(0.059)	(0.990)	

Continued in the next table ...

Table 16: Male model episodes 1, 2, & 3 for recurrent PTSD by spell- pt. 3

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
CSavoid	-0.046*		0.090*
	(-2.11)		(2.08)
	(0.035)		(0.038)
WHPer	-0.016#		
	(-1.95)		
	(0.051)		
WHPpa	0.024***		0.002
	(3.95)		(0.26)
	(0.000)		(0.792)
HP2hmcare	-0.750***	0.046	-1.031**
	(-3.52)	(0.15)	(-3.22)
	(0.000)	(0.879)	(0.001)
BSIanx	0.091**	0.073*	
	(3.11)	(2.25)	
	(0.002)	(0.024)	
0b.percRiskgp	0.000	0.000	0.000
	(.)	(.)	(.)
	(.)	(.)	(.)
1.percRiskgp	-1.217***	-0.082	-0.121
	(-5.21)	(-0.26)	(-0.30)
	(0.000)	(0.793)	(0.762)
2.percRiskgp	-0.591#	-0.017	-0.186
	(-1.81)	(-0.05)	(-0.50)
	(0.070)	(0.959)	(0.614)
0b.cumdosewgp	0.000	0.000	0.000
	(.)	(.)	(.)
	(.)	(.)	(.)
1.cumdosewgp	-0.338#	-0.353	0.112
	(-1.65)	(-1.42)	(0.33)
	(0.099)	(0.157)	(0.740)
childw		0.380*	
		(2.04)	
		(0.042)	
sepaw		0.394	
		(0.80)	
		(0.425)	
illw		-0.113	
		(-1.05)	
		(0.294)	
WHPsleep		0.009#	
		(1.86)	
		(0.063)	

Table 17: Male model episodes 1, 2 & 3 for recurrent PTSD by spell- pt. 4

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
HP2work		0.419# (1.70) (0.090)	
HP2probsoc		1.064* (2.37) (0.018)	
HP2inthob		0.973* (2.38) (0.017)	
HP2vacatn		-1.556*** (-3.39) (0.001)	
fcrisis2008		-2.228*** (-3.47) (0.001)	
y2009		-1.631** (-3.15) (0.002)	
movew			1.133** (3.06) (0.002)
repair			-0.015* (-2.48) (0.013)
Nagelkerke-R2	0.572***	0.531***	0.418***
LL_0	-640.287	-333.086	-148.465
LL	-575.324	-295.997	-133.859
df	32.000	28.000	16.000
time_at_risk_half_yrs	3844.000	1906.000	824.000
n_subjects	153.000	98.000	54.000
n_w_ptsd	153.000	98.000	54.000

# p<.1, * p<.05, ** p<0.01, *** p<0.001

Table 18: Proportional Hazards tests for male episodes 1, 2, & 3 models

episode 1

	chi2	df	Prob>chi2
global test	23.34	32	0.8672

episode 2

	chi2	df	Prob>chi2
global test	12.91	28	0.9933

episode 3

	chi2	df	Prob>chi2
global test	12.23	16	0.7282

note: robust variance-covariance matrix used.

the deviance in the linear form. For this reason, we believe that these models fulfilled both the proportional hazards and the linearity assumptions.

Among the limitations of the model are that it covered such a long lapse of time that other factors not addressed in our study probably impacted the occurrence and recurrence of PTSD over time, potentially leading to some specification error. Notwithstanding this possibility, we obtained reasonable Nagelkerke pseudo-R^2 for our models from 0.57 down to 0.42, while fulfilling the principal assumptions. However, the proportional hazards assumption does not preclude inclusions of all interactions with a model and to date we have not tested all interactions among the variables. In future research, we could explore these frontiers of interest.

6.5 Hypothesis tests with the male model

Following the refinement of the male model, we tested several hypotheses with it to see whether the effects would emerge as statistically significant. Among the variables tested were that reconstructed external dose (hypothesis 3) and perceived Chornobyl health risk (hypothesis 6) directly explained PTSD. With the Cox regression we test those hypotheses by showing to what extent the relative hazard rate of PTSD is explained by these variables.

The test results are displayed in Table 20. Among these variables, the only variable that was partly statistically significant in explaining male PTSD after Chornobyl, with respect to its baseline reference group was that of mid-level perceived Chornobyl health risk.

We tested the variables relating to our hypothesis with the male model once it was developed and validated.

Table 19: Fractional polynomial linearity tests for male episode 1, 2, & 3 models

Fractional polynomial model comparisons: male episode 1

age	df	Deviance	Dev. dif.	P (*)	Powers
Not in model	0	1893.998	9.778	0.044	
Linear	1	1884.358	0.137	0.987	1
m = 1	2	1884.223	0.002	0.999	2
m = 2	4	1884.221	—	—	1 3

(*) P-value from deviance difference comparing reported model with m = 2 model

Fractional polynomial model comparisons: male episode 2

age	df	Deviance	Dev. dif.	P (*)	Powers
Not in model	0	738.039	0.118	0.998	
Linear	1	737.987	0.066	0.996	1
m = 1	2	737.974	0.052	0.974	3
m = 2	4	737.922	—	—	3 3

(*) P-value from deviance difference comparing reported model with m = 2 model

Fractional polynomial model comparisons: male episode 3

inc4w	df	Deviance	Dev. dif.	P (*)	Powers
Not in model	0	281.421	4.539	0.338	
Linear	1	276.882	0.000	1.000	1
m = 1	2	276.882	0.000	1.000	0
m = 2	4	276.882	—	—	0 0

(*) P-value from deviance difference comparing reported model with m = 2 model

Table 20: Male model hypothesis test results

Episode 1			
Variable	**ln(Haz ratio)**	**z**	**p-value**
cumdosewgp1	-0.338	-1.65	0.099#
percRiskgp med	-1.217	-5.21	0.000***
percRiskgp hi	-0.591	-1.81	0.070#
Episode 2			
Variable	**ln(Haz ratio)**	**z**	**p-value**
cumdosewgp1	-0.353	-1.42	0.157
percRiskgp med	-0.082	-0.26	0.793
percRiskgp hi	-0.017	-0.05	0.959
Episode 3			
Variable	**ln(Haz ratio)**	**z**	**p-value**
cumdosewgp1	-0.112	0.33	0.740
percRiskgp med	-0.121	-0.30	0.762
percRiskgp hi	-0.186	-0.50	0.614
Legend: $\# = p < .1$	$* = p < .05$	$** = p < .01$	$*** = p < 0.001$

7 The Female proportional hazards regression model

7.1 Omnibus measures

The Nagelkerke R^2 measures have a higher range from .185 to .598 among the females, with episodes one and three having values above 0.5.

7.2 The female model for episodes one through three

7.2.1 Episodes 1 2 and 3

The coefficients (not the hazard rates) of the female model presented in Tables 21 through 24, representing trimmed models, revealing only parameter estimates statistically or almost significant at the 0.05 level. In general, almost significant at the .05 level means that $p \leq 0.15$. With more than 2500 variables in the dataset, we present the trimmed model. As with the male models, the variables tested as covariates are found in Tables 11, 12, and 13.

Table 21: Female model episodes 1, 2, and 3 for recurrent PTSD by spell

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
1.agegp	0.522**	0.421#	0.926*
	(2.58)	(1.85)	(2.12)
	(0.010)	(0.065)	(0.034)
2.agegp	0.760**	0.402	0.697
	(3.14)	(1.40)	(1.44)
	(0.002)	(0.161)	(0.150)
3.educ	-0.087	-0.221	-1.178**
	(-0.31)	(-0.56)	(-2.82)
	(0.760)	(0.576)	(0.005)
4.educ	-1.364**	-0.850*	1.164*
	(-3.02)	(-2.01)	(2.16)
	(0.003)	(0.044)	(0.031)
5.educ	-0.303	-0.196	0.694
	(-0.95)	(-0.44)	(1.45)
	(0.341)	(0.663)	(0.146)
6.educ	-0.330	-0.480	-0.099
	(-1.15)	(-1.24)	(-0.22)
	(0.252)	(0.215)	(0.828)
7.educ	0.853*		
	(2.24)		
	(0.025)		
3.marrw	0.087	0.194	-1.570**
	(0.20)	(0.38)	(-2.90)
	(0.841)	(0.702)	(0.004)
4.marrw	-0.850	-0.613	-5.074***
	(-1.55)	(-1.13)	(-6.28)
	(0.121)	(0.257)	(0.000)
5.marrw	-0.703	-0.898	-0.541
	(-1.59)	(-1.29)	(-1.14)
	(0.112)	(0.198)	(0.252)
6.marrw	-0.998#	-0.444	-2.387***
	(-1.88)	(-0.83)	(-3.60)
	(0.060)	(0.407)	(0.000)

Continued in the next table ...

7.3 Parameter estimates

7.3.1 Covariates significantly impacting three episodes

In this section we address those parameter estimates which appear to impact three or almost three episodes. We consider them in order of their decreasing buffering impact and increasing risk factor impact.

For the females, the most buffering of the three episode effects, with respect to the first episode coefficient is having some college (4.educ), which has a 74.4% reduction in PTSD incidence. Familial stresses and hassles accounts only for a reduction of about 0.39% in PTSD. Belonging to the middle (1.agegp) or elderly (2.agegp) age groups by contrast aggravates the relative hazard of experiencing PTSD: The middle age group by 1.68 and the elderly group by 2.13.

7.3.2 Covariates significantly impacting two episodes

The major risk factor for having PTSD that extends over two episodes is that of becoming widowed (6.marrw) with a 2.7 increase in the relative hazard.

7.3.3 Covariates significantly impacting one episode

Some covariates that have major increases in the relative hazard of PTSD on the third episode of PTSD are the number of deaths in the period, insufficient income (inc1w) , health problems impacting homecare (HP2hmcare), moving (movew), and separations (sepaw).The number of deaths increases the relative hazard of PTSD for women by 1.3, insufficient income the relative hazard of PTSD by about 1.7 times, health problems impacting home care increases the relative hazard of PTSD by 2.74 times. Moving increases the relative hazard by 4.99 times and separations increases it by 5.16 time.

7.3.4 Hypothesis related parameter estimates

The parameter estimates related to the hypotheses are those of cumulative external dose (Hypothesis 3) and that of perceived Chornobyl health risk (Hypothesis 6). In Table 27, we list these results in some detail. But we can easily summarize them here.

7.4 Assessment of the female model

All of female PTSD models fulfill the proportional hazards assumption, shown in Table 25. The fractional polynomial test in Table 26 shows that the model fulfills the linearity assumption for continuous variables as well. The only polynomial transformation suggested was that for age and what was suggested did not significantly improve upon the deviance of the linear model.

Table 22: Female model episodes 1, 2, & 3 for recurrent PTSD by spell- pt. 2

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
inc2w	-0.528**	0.066	
	(-3.12)	(0.36)	
	(0.002)	(0.719)	
inc3w	-0.639***	-0.076	
	(-3.33)	(-0.35)	
	(0.001)	(0.724)	
shjobw	0.008***	0.011***	
	(3.96)	(4.30)	
	(0.000)	(0.000)	
shfamw	-0.004#	-0.007**	-0.015***
	(-1.90)	(-3.01)	(-3.60)
	(0.057)	(0.003)	(0.000)
suprtw	-0.010***	-0.007*	
	(-5.92)	(-2.07)	
	(0.000)	(0.039)	
phlthw	0.011**		
	(3.10)		
	(0.002)		
healthef	-0.000	-0.003	
	(-0.03)	(-0.85)	
	(0.975)	(0.397)	
icdxcnt	0.016		
	(0.58)		
	(0.562)		
CSavoid	0.015	-0.026	
	(0.86)	(-1.27)	
	(0.391)	(0.204)	
WHPer	-0.012**	0.009*	
	(-2.67)	(2.20)	
	(0.008)	(0.028)	
WHPpa	0.009*		
	(2.22)		
	(0.026)		
HP2hmcare	-0.319#		1.011***
	(-1.88)		(4.28)
	(0.060)		(0.000)
BSIanx	0.043*		
	(1.96)		
	(0.050)		

Continued in the next table ...

Table 23: Female model episodes 1, 2, & 3 for recurrent PTSD by spell - pt. 3

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
1.cumdosewgp	-0.615***	-0.334#	0.347
	(-4.37)	(-1.79)	(1.35)
	(0.000)	(0.073)	(0.176)
1.percRiskgp	-0.344*	0.158	-0.304
	(-2.02)	(0.69)	(-0.83)
	(0.043)	(0.487)	(0.407)
2.percRiskgp	-0.282	0.075	-0.162
	(-1.45)	(0.27)	(-0.37)
	(0.148)	(0.787)	(0.710)
fcrisis2008	-3.522***		
	(-3.87)		
	(0.000)		
illw		0.019	
		(0.31)	
		(0.760)	
saferad		0.003	
		(1.27)	
		(0.205)	
goodrad		0.002	
		(0.85)	
		(0.396)	
HP2sxlife		0.204	
		(0.84)	
		(0.402)	
HP2inthob		-0.217	
		(-0.80)	
		(0.425)	
inc1w			0.564**
			(2.73)
			(0.006)
deaw			0.270**
			(3.04)
			(0.002)
sepaw			1.642***
			(3.83)
			(0.000)
mhlthw			0.021***
			(4.50)
			(0.000)
movew			1.608*
			(2.36)
			(0.018)
toxic			-0.007*
			(-2.38)
			(0.017)

Continued in the next table ...

Table 24: Female model episodes 1, 2, & 3 for recurrent PTSD by spell- pt. 4

	spell1 b/t/p	spell2 b/t/p	spell3 b/t/p
repair			0.010***
			(3.46)
			(0.001)
CSsocspt			0.085***
			(4.19)
			(0.000)
BSIdep			0.160***
			(8.00)
			(0.000)
radtlw			-0.016***
			(-4.55)
			(0.000)
Nagelkerke-R2	0.598***	0.185***	0.512***
LL_0	-863.309	-473.719	-231.698
LL	-774.049	-460.192	-203.680
df	28.000	26.000	25.000
time_at_risk_half_yrs	5292.000	2250.000	1004.000
n_subjects	196.000	132.000	78.000
n_w_ptsd	196.000	132.000	78.000

# p<.1, * p<.05, ** p<0.01, *** p<0.001

Table 25: Proportional Hazards tests for female models for episodes 1, 2, & 3

episode 1

	chi2	df	Prob>chi2
global test	27.85	28	0.4724

episode 2

	chi2	df	Prob>chi2
global test	17.58	26	0.8905

episode 3

	chi2	df	Prob>chi2
global test	7.41	25	0.9997

note: robust variance-covariance matrix used.

Table 26: Female model Fractional polynomial model comparisons:

Episode 1

Fractional polynomial model comparisons:

age	df	Deviance	Dev. dif.	P (*)	Powers
Not in model	0	2074.085	13.357	0.010	
Linear	1	2060.800	0.073	0.995	1
m = 1	2	2060.800	0.073	0.964	1
m = 2	4	2060.727	—	—	-2 3

(*) P-value from deviance difference comparing reported model with m = 2 model

Episode 2

Fractional polynomial model comparisons:

age	df	Deviance	Dev. dif.	P (*)	Powers
Not in model	0	1008.205	4.277	0.370	
Linear	1	1005.177	1.249	0.741	1
m = 1	2	1004.278	0.350	0.840	-2
m = 2	4	1003.928	—	—	-2 -2

(*) P-value from deviance difference comparing reported model with m = 2 model

Episode 3

Deviance: 524.91. Best powers of age among 44 models fit: -2 -2.

Fractional polynomial model comparisons:

age	df	Deviance	Dev. dif.	P (*)	Powers
Not in model	0	525.734	0.824	0.935	
Linear	1	525.415	0.505	0.918	1
m = 1	2	525.153	0.243	0.886	-2
m = 2	4	524.910	—	—	-2 -2

(*) P-value from deviance difference comparing reported model with m = 2 model

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7.5 Hypothesis tests with the female model

As part of the female PTSD proportional hazards regression model was developed, we tested the variables listed in Table 27, to ascertain whether any of these variables could significantly explain the female hazard rate for PTSD. Hypothesis 3 postulates that radiation exposure is directly related to PTSD. In the first spell of PTSD, we found a significant inverse relationship between external dose and PTSD (a reduction in 45% of the PTSD incidence is associated with high external dose relative to the low external dose). If external dose were actually related to PTSD incidence, we would expect a direct rather than an indirect relationship. We only observed this effect in the first spell. It did not appear in all spells, although there was a quasi-significant relationship of the same kind in the second spell. The sample size of course decreased from spell 1 to spell 2. It went from 196 women in the first spell to 132 in the second and this might account for the reduced significance. Nonetheless, we suspect that this relationship is a false positive probably due to the impact variables not included in this analysis. Because the level of external dose assessed is below that of the biological level of reactivity, this false positive appears to be without actual impact even though it appears to be statistically significant.

Hypothesis 6 postulates that perceived Chornobyl health risk is directly related to PTSD. In general, we do not find evidence in support of this claim. There does appear to be an inverse relationship between mid-level perceived Chornobyl health risk and PTSD only in the first female episode, but this is an inverse rather than a direct relationship. Because there is no evidence in the other spells, we also infer that this may be a false positive finding. Therefore, we do not find evidence consistent with our Hypothesis 3 and Hypothesis 6 in this PTSD analysis. of self-reported illnesses nor the number of medically diagnosed illnesses was

7.6 Discussion

Because of the reduced sample size for episodes four and higher, we chose not to attempt to model them. The power to properly estimate such recurrent events would be questionable at best with only 24 males and 30 females reporting such a recurrence. The average hazard ratio for episode 3 for women was about 1.02. The average standard error was about 0.156 and with a sample size of 30, the Cox regression model would have paltry power with an alpha of 0.05. To attain a power of .80, we would have to have an average coefficient of -3.2788 with under these conditions. For this reason, we refrain from estimating more episodes for the women. The men have an even smaller sample size, so the same reasoning holds for the analysis of the male subsample.

In future studies, we would hope to have more observations so that we would have a better notion of the nature of PTSD recurrence.

Table 27: Female model hypothesis test results

Episode 1			
Variable	**ln(Haz ratio)**	**z**	**p-value**
cumdosewgp1	-0.615	-4.37	0.000***
percRiskgp med	-0.344	-2.02	0.043*
percRiskgp hi	-0.282	-1.45	0.148
Episode 2			
Variable	**ln(Haz ratio)**	**z**	**p-value**
cumdosewgp1	-0.334	-1.79	0.073#
percRiskgp med	0.158	0.69	0.487
percRiskgp hi	0.075	0.27	0.787
Episode 3			
Variable	**ln(Haz ratio)**	**z**	**p-value**
cumdosewgp1	0.347	1.35	0.176
percRiskgp med	-0.304	-0.83	0.407
percRiskgp hi	-0.162	-0.37	0.710
Legend: $\# = p < .1$	$* = p < .05$	$** = p < .01$	$*** = p < 0.001$

8 PTSD cure models

8.1 Population average generalized estimating equations

We endeavor to ascertain what factors contribute to the length of the time a respondent has been cured. To be deemed cured, we maintain that a person must exhibit no signs of PTSD for a period of two years. Provided that the respondent has already experienced and reported PTSD and has reported no relapse for the duration of this two year period, he or she is considered cured and the time duration between his last period of reported PTSD in half-years and his interview time is computed the time he or she has been cured. Using this cured time as a dependent variable in a generalized estimating equation for a panel dataset, we set the working correlation matrix as exchangeable and employed clustered-robust variances to estimate the parameters of a model. The link was an identity link with a Gaussian family.

8.2 Model-building

Model building entailed a general-to-specific strategy. We employed clustered-robust variance estimators and an exchangeable working correlation matrix to control for autocorrelation across the waves of observations. A general unrestricted model was built and statistically non-significant covariates were trimmed from the model. In the final trim, a p-value of 0.15 was used as a cut-off and variables whose statistical significance was less than this threshold were removed. The results below reveal what remained after that pruning process was complete.

8.3 Covariates related to being cured among men

In the section below we present the findings of the male and female PTSD models as evidence of the factors that may contribute to the resiliency and recovery of the respondents after the Chornobyl experience. In Table 28, we observe the parameter estimates for the main effects explaining the number of years cured.

Although age level does not appear to be statistically significant in determining cure time, it defines part of the life cycle and is included nonetheless.

Factors contributing to the explanation of the length of the cure time in men include several aspects of marital and familial status. Apparently, having partnership obligations detracts from the cure time. But the number of children a respondent reports (childw) appears to be positively associated with the length of cure time.

Major factors contributing to the being cured include educational status– particular whether or not college was completed and the time of the great global financial recession (fcrisis2008) and the year of 2009, which was begun with a Russian gas cut-off that led to a temporary closure of many Ukrainian factories. More minor but positive factors include the wellness (phlthw) or illness of the individual (icdxcnt and illw), partner support (suprt), the number of children reported (childw), and the year of 2009 (y2009).

Discord or difficulties with family life appear to be strongly negatively related to the cure time– especially being separated (separated) from one's spouse. Even cohabiting (cohabiting) or being married (married) appear related to a shorter cure time. Being divorced or widowed was not significantly related.

Catastrophes also may be negatively related to the length of time cured among men, but perception of Chornobyl related health risk and reconstructed cumulative external dose were not significantly related to the length of cure time among men.

Why the great global financial crisis of 2008 and the year of 2009 were significantly and positively related to the length of cure time in men, with the former of these two factors having more than four and one half times the impact of the latter is somewhat of a conundrum.

The more deaths a person has experienced, the more accidents experienced, and the more concerned the respondent is with Chornobyl survival benefits, the more the health related pain the person suffers, and the self-assessment of physical health appears to be related to the shorter the time cured.

8.4 Cure time among women

In Table 29, we observe those factors that explain the number of half-years cured for the female subsample. We note that some of the same factors appear to have different impacts for the woman than they appear to have for the men. Notwithstanding the non-significant aspect of age level, it is included for women as it was for men.

Table 28: Male cure model general estimating equation

```
GEE population-averaged model                   Number of obs      =     15483
Group variable:                         id      Number of groups   =       305
Link:                             identity      Obs per group: min =        14
Family:                           Gaussian                     avg =      50.8
Correlation:                  exchangeable                     max =        62
                                                Wald chi2(29)      =    204.01
Scale parameter:                  83.43861      Prob > chi2        =    0.0000
                                                  (Std. Err. adjusted for clustering on id)
```

hyrsptsdcrd	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
agegp						
43 thru 55	.7146734	1.297988	0.55	0.582	-1.829337	3.258684
56 thru 84	-1.567909	1.394281	-1.12	0.261	-4.30065	1.164832
marrw						
2. cohabitating	-4.623841	2.073304	-2.23	0.026	-8.687443	-.5602391
3. married	-5.288437	2.623844	-2.02	0.044	-10.43108	-.1457965
4. separated	-14.33764	6.709184	-2.14	0.033	-27.4874	-1.187879
5. divorced	2.429053	3.64584	0.67	0.505	-4.716663	9.574768
6. widowed	-1.089174	3.16066	-0.34	0.730	-7.283953	5.105606
childw	1.806332	.7825962	2.31	0.021	.2724722	3.340193
educ						
3. technical degree	2.333438	1.251795	1.86	0.062	-.1200343	4.786911
4. did not finish coll..	9.778575	3.600043	2.72	0.007	2.72262	16.834530
5. graduated college/b..	8.718716	1.84907	4.72	0.000	5.094606	12.342830
6. finished specialist..	1.028543	1.171516	0.88	0.380	-1.267586	3.324673
7. doctor of science/phd	3.943676	4.650299	0.85	0.396	-5.170743	13.058100
8. doctor of medicine/md	2.100478	2.336626	0.90	0.369	-2.479226	6.680182
icdxcnt	.6629837	.30699	2.16	0.031	.0612944	1.264673
inc1w	1.737647	1.360457	1.28	0.202	-.9287996	4.404094
deaw	-.8656608	.4211708	-2.06	0.040	-1.69114	-.0401812
accdw	-2.285209	.996829	-2.29	0.022	-4.238958	-.3314603
cataw	-2.309909	1.315464	-1.76	0.079	-4.888171	.2683543
shrelaw	-.0150022	.0117826	-1.27	0.203	-.0380957	.0080913
suprtw	.037558	.0164927	2.28	0.023	.005233	.0698830
sufamw	.0280517	.0172921	1.62	0.105	-.0058402	.0619436
suchrw	-.0411275	.0117532	-3.50	0.000	-.0641634	-.0180916
phlthw	-.0458789	.0239886	-1.91	0.056	-.0928958	.001138
WHPpain	-.0633094	.0253706	-2.50	0.013	-.1130349	-.013584
percRiskgp						
medium	.5554434	.9319054	0.60	0.551	-1.271058	2.381945
high	-1.507168	1.15141	-1.31	0.191	-3.76389	.749554
fcrisis2008	5.088548	.3981661	12.78	0.000	4.308156	5.868939
y2009	1.37558	.1696431	8.11	0.000	1.043085	1.708074
_cons	4.915827	3.390165	1.45	0.147	-1.728774	11.56043

Where being separated was the only marital status factor that was positively related to the time of cure among men, it is the only aspect of marital status that is even quasi-significantly related at all among the women.

Whereas failure to complete college was significant among men, only the success in completing college is statistically significant for women. In fact, it was one of the more important factors contributing to the length of time cured for women.

For both men and women, major negative life events and stresses and hassles appear to be negatively related to the time cured. The number of deaths experienced, the number of accidents, and especially the number of catastrophes are significantly negatively related to the time cured for women. In fact, among women the number of catastrophes was a significant and major factor in reducing the time cured. The impact of health related matters on home care is a significant risk factor among women, whereas this was not a risk factor among men. For women, the stresses and hassles relating to health matters (shhlw) contributes significantly to a shorter time cured. But stresses and hassles stemming from the job is only quasi-related to a shorter time cured (shjobw $p=0.082$).

For both men and women, the great global financial crisis of 2008 appears to be strongly related to the length of time cured, and the year of 2009 does to a lesser extent. Why this is the case remains an open question for future research.

9 Discussion

PTSD is much more rare among the respondents in this sample than either depression or somatization. There is still a need to analyze males and females separately insofar as they have different biological processes at work and these are sufficiently multidimensional that they cannot be properly analyzed with an oversimplified dummy variable to distinguish them.

Although these PTSD processes are recurrent events, we had only enough of a sample size to model episode three, for all of those who reported the previous episode also reported the third episode. The definition of the hazard as a condition probability of an event, conditional upon its not having been experienced before meant that the first episode for which there was sufficient sample size for this analysis was that of episode three. We had no way of knowing how many of the respondents would report these events and therefore how much of a sample size we would have, and we analyze what we had in our sample. This is a limitation of this analysis.

Another limitation was the proportional reduction of deviance. When the pseudo-R^2 is low, the possibility of specification error emerges. The father one proceeds in time the more other factors impinge upon one's concerns and the less closed the system appears to be with respect to influences affecting PTSD. With a time span of 31 years, it is likely that other crises contribute to increases in anxiety and/or depression and/or PTSD over time. One, some, or many of the risk factors involved may not have been specified in the model, in spite of

Table 29: Female cure model of generalized estimating equation

```
GEE population-averaged model                   Number of obs      =     18047
Group variable:                         id      Number of groups   =       345
Link:                             identity      Obs per group: min =        14
Family:                           Gaussian                     avg =      52.3
Correlation:                  exchangeable                     max =        62
                                                Wald chi2(22)      =    217.65
Scale parameter:                  65.93896      Prob > chi2        =    0.0000
```

(Std. Err. adjusted for clustering on id)

hyrsptsdcrd	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
agegp						
43 thru 55	-1.57431	1.088078	-1.45	0.148	-3.706904	.5582844
56 thru 84	-.9455052	1.042855	-0.91	0.365	-2.989463	1.098453
marrw						
2. cohabitating	-4.630731	3.988521	-1.16	0.246	-12.44809	3.186626
3. married	1.644033	1.523854	1.08	0.281	-1.342667	4.630733
4. separated	4.999886	2.84763	1.76	0.079	-.5813671	10.58114
5. divorced	2.671097	1.918217	1.39	0.164	-1.088539	6.430733
6. widowed	2.880694	1.847247	1.56	0.119	-.7398426	6.501232
educ						
3. technical degree	1.747289	1.211325	1.44	0.149	-.6268632	4.121442
4. did not finish coll..	2.238072	1.971822	1.14	0.256	-1.626627	6.102772
5. graduated college/b..	5.126716	1.775332	2.89	0.004	1.647129	8.606302
6. finished specialist..	.0776046	1.170549	0.07	0.947	-2.21663	2.371839
7. doctor of science/phd	4.079876	3.941972	1.03	0.301	-3.646246	11.80600
deaw	-1.169389	.2553663	-4.58	0.000	-1.669897	-.6688799
accdw	-1.949335	.5327775	-3.66	0.000	-2.99356	-.9051104
cataw	-5.093087	1.772638	-2.87	0.004	-8.567394	-1.61878
shjobw	-.0139186	.0080047	-1.74	0.082	-.0296076	.0017704
shhlw	-.0345303	.0100973	-3.42	0.001	-.0543206	-.0147400
suprtw	.01545	.0069933	2.21	0.027	.0017434	.0291566
phlthw	-.0880307	.0181436	-4.85	0.000	-.1235916	-.0524698
HP2hmcare	-1.85236	.6571643	-2.82	0.005	-3.140379	-.5643421
fcrisis2008	5.200649	.3818968	13.62	0.000	4.452145	5.9491530
y2009	1.447799	.2172046	6.67	0.000	1.022086	1.8735139
_cons	9.904251	2.756598	3.59	0.000	4.501418	15.307080

the fact that we tested all of our major negative life events, stresses and hassles. In the models that we used interactions did not figure significantly. With larger sample sizes, it could be easier to test more main effects and their first and higher order interactions. Perhaps some of the risk factors may be nonlinear combinations of effects that are not included in our linear models. If effects are not in the model, they are in the error term, where they can confound the process of analysis with simultaneity and specification error. Omitted variables may have a confounding effect on the appearance of relationships. Counter-intuitive results such as the positive association of the great global financial recession and the year 2009 with longer cure times can result from the impact of omitted variables.

Further investigation into the effects on mass public opinion of the impact of the financial crises and threats to the power supply or critical infrastructure are clearly of an immediate nature, whereas those of Chornobyl are those of a residual and uncertain nature. Nevertheless they are important and worthy of future inquiry. Their high level of threat and their immediacy of a clear and present danger may solidly overwhelm those more uncertain and residual threats haunting the mass public from times past. It is important to understand how such later immediate threats to financial security may overwhelm erstwhile residual threats from Chornobyl, especially if the latter threats have been attenuated over time.

The risk factors explaining Chornobyl related PTSD stem from combinations of factors that generate these symptoms from diminished lagged, latent or hidden threshold effects, the magnitude of which mask their presence below a threshold of detection for an extended period of time. By the time they emerge if triggered by some associated event, the statistical power may not be sufficient at that time for detection. In future research, more attention will have to be focused on delayed, latent, and threshold effects and the pathways by which they impact people.

In directions for future research, we would have to be sure that we have a large enough sample to analyze recurring processes to be able to analyze them as such. We would also have to consider the possibility of two-way transitions with feedback or feedforward effects that could easily confound attempts to forecast with them, insofar as strong exogeneity will be violated. Our sample size was too small to try to forecast from, by segmenting our sample, but if we had a sufficiently larger sample we could have tried to predictively validate the estimation as well. We might investigate the use of threshold models to avoid the reliance on the proportional hazards assumption.

Notwithstanding these limitations, more work needs to be done with respect to cure models and their many variations in connection with PTSD and we would hope that models with interactions, which require larger sample sizes, as well as those structural equation models which would allow us to distinguish moderating from mediating effects would help us in the future to further understand the processes at work here.

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