To: Rosemarie Foster and Tom Borak

From: Robert Yaffee

Date: 21 July 2010

Re: Preliminary linear models regarding perceived health risk of Chornobyl radiation on the part of Ukrainian residents of Kiev and Zhitomer

Files: do files= Jul16_2010.do

Output files: GeneralRadhlw3linearmodels.smcl

Data file: "C:\users\ray2\stats\stata11\research\chwk\wide\chwide15jul2010.dta"

Basic linear modeling strategy

We pursued three approaches to selecting candidate variables for model-building. The first approach was that of graphical review of functional for deviations from linearity of the relationship, the second was that of bivariate screening without graphical assistance, and the third approach was that of the general-to-specific multipath search of different routes to developing an broadly theoretically encompassing regression model advocated by Sir David F. Hendry and Hans-Martin Krolzig in their general-to-specific ("gets") modeling strategy. This approach was further developed by Dornik and Hendry into a computer program called Autometrics.

To begin, we examine the relationship between our endogenous variable and candidate explanatory variables to detect nonlinear patterns. If possible, we attempt transformations which will render these relationships linear and amenable to conventional statistical testing. If the relationships are not intrinsically linear, we may deal with them by means of nonlinear or nonparametric approaches later. For the time being, we are trying to model linear relationships. We developed a set of linear models for the whole sample and for gender-specific segments of the sample. The reason for doing so is that the biological differences might predispose one sex from experiencing different effects than the other would Therefore, we began with a full-general model, and trimmed out the nonsignificant effects to arrive at a pruned or trimmed model This was done for each of the three sets of data, leaving us with six basic models.

The trimming was performed on the basis of nonsignificance of variables. Nonsignificance was determined as anything with significance level higher than 0.10. We decided that this was the appropriate cut-off level in general because the residuals of our sample were frequently found to be nonnormal based on the Shapiro-Wilk and Kolmogorov-Smirnov tests. Therefore, we decided to be more liberal in our estimation of what may be of interest. We indicate levels of significance greater than 0.05 but less than 0.10 by a # sign. Conventional applications of asterisks are used otherwise to indicate statistical significance. As a matter of convention, when the data are presented in the tables or sentences below, we round upward for the last figure to the right of the decimal point.

Following Hendry and Krolzig (1999), we take these six models and assign a value for each time a variable is statistically significant. By summing these values, the variable is given a reliability score. We then sort the variables according to the reliability score to obtain a sense of robustness of the variables comprising the model. Because the general to specific methodology of Hendry and Richard (1982) proceeds along a multipath tree-search from the general unrestricted model down each possible route of adding variables to the model, until a specification assumption is violated, at which point the model terminates. The models are built with a view toward encompassing theory. The more encompassing the model the better, as long as assumptions of the model are met. Model specification proceeds until any competing models are tested against one another. Attempts to combine them are made and the best fitting model that encompasses the most theory is selected. In case of ties, the Schwartz Bayesian criterion is used as a tie-breaker.

George E. P. Box once was reported to have said that "all models are wrong, but some are useful." We will test each of our models for regression specification requirements of residual normality, homogeneity of variance, independence of observations and identical distributions, dearth of multicollinearity, lack of outlier distortion, and for lack of omitted variable bias. If there are too many outliers, we shall endeavor to use an outlier down weighting algorithm to fit the model. If there is heteroskedasticity of the residuals, we can employ robust sandwich variance estimators to find the correct standard errors. From this analysis, we hope to gain a sense of which models are reliable and robust, as well as which are more fragile than the others.

In the second phase of the analysis, we take the linear models and test for interactions among the variables following any transformation of them that may have been applied. We will examine the nonlinear portions of the model. We will sequentially test these interactions to determine which should be included in the model. Once all the possible interactions have been included, we will simultaneous test the interactions to be sure that these are worthy of retention with a simultaneous test by which all variables and interactions are tested for retention within the model at the same level of power. This is the test of sufficiency to determine which variables need to be retained in the model. Then we will discuss the interactions and graph them to illustrate the nature of their interactions.

The Interim sample

At this stage of the data collection, our sample consists of 281 cases, approximately 29.54% (83) of which consist of males and the remainder of females. Seventy-five and 44/100 percent of the sample lives in the Kiev Oblast. The remainder resides in Zhitomer. The sample consists of fairly well-educated people, 39.5% of whom have a specialists or master's degree. About 38.08% of them have a technical degree. Only one did not finish high school. Four had doctoral degrees of one kind or another.

What factors explain perceived health risk from the Chornobyl radiation?

The full model for both men and women has for its endogenous variable, the perceived health risk from the Chornobyl radiation. The question asked of respondents living in the Ukraine was "In terms of percent, how much of your health has been affected by the Chornobyl radiation?" The answers lead to the development of a simple model consisting of the variables displayed in Table one on the next page.

Males and Females together: Model 1

The first regression model is has a lot of explanatory power. The R^2 for the model is 0.7934 and when that is adjusted for the number of variables in the model, the adjusted R^2 is 0.769. Not all of these variables are statistically significant. We know that the biological systems are have age and gender differences. Therefore, whether age or gender is significant or not, we include these variables in the model to control for such differences. In this way, we hope to control for the basic differences between them. At this juncture we only include first order terms. But the model we develop does explain much of the systematic variation involved. We address these risk factors in terms of their beta weights. Perhaps the strongest association with this endogenous variable is the amount of family health that has been affected by the radiation. The relationship is positive so that the more people believe that their health has been affected, the more they believe that their family's health has been affected. This is not surprising. The second most powerful relationship seems to be that of drinking liquor during wave two is about the second most powerful influence. The more respondents believe that their health was affected, the more they drank hard liquor during between 1987 and 1996. Similarly, energy level has the same positive relationship with the belief in the amount of their health that they think was selected. Perhaps the immediate threat raised the adrenaline to deal with the jeopardy in their environment. Perhaps the third most powerful influence is that of the energy level. The next most powerful influence is that of the amount of pollution of the air and water by the Chornobyl radiation. To the extent that was polluted, people tend to think that their health was proportionally compromised. Next in importance is the natural log of the cumulative external dose of CS137 that they got from external sources. We use this transformation to render the variable amenable to linear statistical modeling. The greater the does, the more they think that their health has been affected. The next more important is the stresses and hassles to their health is directly related to the amount that they believe their health has been affected. Then the next most important fact seems to be the personal intrusion to their interests and hobbies. Females seem to believe that their health was affected somewhat more than the men did. Next in importance is the number of separations related to the amount of health affected by this radiation. This too was a positive relationship. Most of these relationships seem reasonable and not counterintuitive.

Some of the relationships were inverse rather than direct in their association. Age was one of these, the older the respondent was, and the less he or she thought that their health was affected. Visits to the homeopath were related also. The more the respondent thought that their health was affected, the less the person thought his health was related. The more children the respondent had, the less he or she thought that the relationship wax so. Next was the amount of stresses or hassles on the job, which is inversely related to the amount of health perceived to have been affected. The amount of depression linked to the Chornobyl radiation was next. It appears that the more the person thought his health was affected by the Chornobyl radiation, the less depressed him or she was. This may be a cause attributable to others from which misery found comforting that others were suffering from it too. Then came those who drank hard liquor around the time of the accident during the first wave, the less they thought their health was affected the more they drank hard liquor around the time of the accident and the more they drink hard liquor during the last wave. This latter relationship is perhaps one of the strongest inverse relationships we detected so far.

Table 1 Key variables in preliminary models

```
radhlw3     byte   %8.0g             how much believed personal health is affected by radiation now
age         byte   %8.0g             Age of respondent in years
sex         float  %9.0g    sx       gender of respndnt
childw3     byte   %8.0g             number of children now
radfmw3     byte   %8.0g             how much believed family health is affected by radiation now
airw1       byte   %8.0g             consider hazardous (in percent) - air and water pollution in 1986
airw3       byte   %8.0g             consider hazardous (in percent) - air and water pollution , NOW
ecprw1      byte   %8.0g             consider hazardous (in percent) - economic problems in 1986
injselfr    float  %9.0g    dum      were u injured because of chornobyl acc in 1986?
injothr     float  %9.0g    inj      was anyone u know injured by chornobyl accident?
enlev       double %9.0g             energy level (el)
liqw1       byte   %8.0g             number of spirits per week in 1976-1986
liqw2       byte   %8.0g             number of spirits per week in 1987-1996
liqw3       byte   %8.0g             number of spirits per week in 1997-now
hospw1      int    %8.0g           * number of days per year as a patient in a clinic for medical condition in 1976-
vishphw1    byte   %8.0g             number of visits per year to a homeopath for a physical condition in 1976-1986
depress     byte   %8.0g             depression
hp2inthob   float  %9.0g    hp2fmt   health causing prb with interests & hobbies
phychot     byte   %8.0g             psychoticism
sepaw3      byte   %8.0g             Total number of separations, experienced in time period 1996-NOW
movew2      byte   %8.0g             Total number of moves, experienced in time period 1987-1996
shjobw2     byte   %8.0g             Percentage of strains and hassles related to job, 1996
shhlw1      byte   %8.0g             Percentage of strains and hassles related to health, 1986
lcumdosew3  float  %9.0g             Ln(cumdosew3)

.  * coding check
. summarize  radhlw3 age sex childw3 radfmw3 airw1 airw3 ecprw1 injselfr injothr enlev liqw1 liqw2 liqw3 hospw1 ///
>    vishphw1 depress hp2inthob phychot ///
>   sepaw3 movew2 shjobw2 shhlw1 lcumdosew3
```

Variable	Obs	Mean	Std. Dev.	Min	Max
radhlw3	268	60.09701	34.20885	0	100
age	281	50.84342	11.95514	28	84
sex	281	.7046263	.4570245	0	1
childw3	281	1.427046	.82105	0	4
radfmw3	271	71.5941	32.44776	0	100
airw1	270	63.79259	32.35757	0	100
airw3	277	46.15523	38.49225	0	100
ecprw1	230	31.72174	32.01652	0	100
injselfr	281	.6797153	.4674184	0	1
injothr	281	.86121	.3463441	0	1
enlev	281	29.22135	34.29539	0	100
liqw1	281	1.081851	2.167221	0	10
liqw2	281	1.298932	2.1187	0	10
liqw3	281	1.096085	2.241178	0	25
hospw1	280	5.096429	16.60617	0	200
vishphw1	154	.1688312	.9954484	0	10
depress	281	3.537367	3.667355	0	21
hp2inthob	281	.1352313	.3425806	0	1
phychot	281	2.341637	2.76793	0	18
sepaw3	281	.0462633	.2104296	0	1
movew2	281	.1530249	.4071676	0	3
shjobw2	281	40.80427	38.31329	0	100
shhlw1	281	24.91459	29.58824	0	100
lcumdosew3	281	6.305894	.8780264	3.786925	10.18873

Table 2 Full model for males and females

Source	SS	df	MS
Model	118442.795	16	7402.67466
Residual	30838.042	136	226.750309
Total	149280.837	152	982.110767

Number of obs	=	153
F(16, 136)	=	32.65
Prob > F	=	0.0000
R-squared	=	0.7934
Adj R-squared	=	0.7691
Root MSE	=	15.058

radhlw3	Coef.	Std. Err.	t	P>|t|	Beta
age	-.0645008	.1435428	-0.45	0.654	-.0222962
sex	3.428334	3.368783	1.02	0.311	.0512094
childw3	-3.580692	1.81387	-1.97	0.050	-.0864127
radfmw3	.7334324	.0454715	16.13	0.000	.7685719
airw1	.1377916	.0369565	3.73	0.000	.1549096
enlev	.1466435	.0437756	3.35	0.001	.1558308
liqw1	-2.314402	.84321	-2.74	0.007	-.1665128
liqw2	2.676547	.8983654	2.98	0.003	.2027088
liqw3	-2.335569	.6457014	-3.62	0.000	-.1963929
vishphw1	-1.767211	1.280603	-1.38	0.170	-.0563131
depress	-.9206115	.3548281	-2.59	0.011	-.1206354
hp2inthob	13.80775	4.861413	2.84	0.005	.1188435
sepaw3	6.923541	6.457443	1.07	0.286	.0430244
shjobw2	-.0995534	.0421508	-2.36	0.020	-.112795
shhlw1	.141008	.0504808	2.79	0.006	.1367251
lcumdosew3	4.792278	1.577076	3.04	0.003	.1370676
_cons	-26.29338	11.87144	-2.21	0.028	.

This system of relationships is subject to question. Many would want to which of the assumptions of this model hold and which violated and to what extent. If they are violated, how should we alter our view of these relationships to accommodate such a specification test failure? Should we consider altering our model to handle these violations? First, let us examine the fulfillment of the model assumptions.

As a regression model, there are specific conditions which must be fulfilled for us to have complete confidence in these findings.

Table 3 Specification tests for Both Male and Female Full Model				
Assumption	**Test**	**X^2, f, F, or t**	**p-value**	**violation**
Residual normality	*Shapiro-Wilk test* *Kolmogorov-Smirnov test*	3.816 25.16	0.000 0.000	yes
Residual homoskedasticity	*Breusch –Pagan /Cook Weisburg test*	1.67	0.2096	No
No outliers	*Standardized residuals > |3.5|*	1 negative outlier		yes
No omitted variables	*Ramsey reset test*	4.83	0.0032	Yes
No multicollinearity	*VIF < 10*	Mean VIF=14.56		yes

How can we manage these specification violations? We can loosen up our significance criteria to compensate for violation of the residual normality by noting when things are borderline or almost significant by designating them with a pound sign if they are 0.10 in probability. We do not have to use weighted least squares or sandwich variance estimators to handle heteroskedasticity for this model. We could use an outlier downweighting robust regression to deal with the single negative outlier, but our sample size is large enough to diminish the relative effect of this influence on the overall model. When we model our interactions we should attempt to model polynomial versions of the variables to handle the specification error suggested by the Ramsey Reset test. Probably the best solution is to obtain empirical standard errors by bootstrapping and using the bootstrapped model as empirical validation of the full and trimmed models.

We bootstrap the model 998 times and display those results in Table two. We cluster by id owing to the complex sample being applied. In the process, we apply bias correction and acceleration to correct for the asymmetry and skew. The bootstrap works best when there are no outliers in the distribution. With only one negative outlier, it is quite likely that our results will work out nicely. Indeed, we discover that this consistent method accurately replicates the results displayed in Table two. As the sample size (number of bootstrap replication increases) the statistic approximates the population parameter. It has as much power as indicated by the almost identical R^2 results. The parameter estimates are identical but the bootstrap standard errors vary a little from those generated by our regression model. Nevertheless, the results are proportional and supportive of the claim to validation of our model.

Table 4 Bootstrap Validation

Linear regression

Number of obs	=	153
Replications	=	998
Wald chi2(16)	=	678.51
Prob > chi2	=	0.0000
R-squared	=	0.7934
Adj R-squared	=	0.7691
Root MSE	=	15.0582

(Replications based on 153 clusters in id)

radhlw3	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
age	-.0645008	.1605658	-0.40	0.688	-.3792039	.2502024
sex	3.428334	3.038835	1.13	0.259	-2.527673	9.384341
childw3	-3.580692	1.7104	-2.09	0.036	-6.933014	-.22837
radfmw3	.7334324	.0432227	16.97	0.000	.6487175	.8181473
airw1	.1377916	.0380811	3.62	0.000	.0631539	.2124293
enlev	.1466435	.0499217	2.94	0.003	.0487988	.2444883
liqw1	-2.314402	1.222597	-1.89	0.058	-4.710648	.0818444
liqw2	2.676547	.8979844	2.98	0.003	.9165296	4.436564
liqw3	-2.335569	.7475209	-3.12	0.002	-3.800683	-.8704549
vishphw1	-1.767211	2.462538	-0.72	0.473	-6.593696	3.059274
depress	-.9206115	.3616268	-2.55	0.011	-1.629387	-.211836
hp2inthob	13.80775	5.112128	2.70	0.007	3.788161	23.82733
sepaw3	6.923541	11.90627	0.58	0.561	-16.41232	30.2594
shjobw2	-.0995534	.0425842	-2.34	0.019	-.1830169	-.0160899
shhlw1	.141008	.0481963	2.93	0.003	.0465449	.2354711
lcumdosew3	4.792278	1.657119	2.89	0.004	1.544384	8.040172
_cons	-26.29338	12.1052	-2.17	0.030	-50.01914	-2.567624

Trimmed Model for both males and females

Before proceeding to our gender-specific models, we will re-estimate the model by trimming out the nonsignificant effects but not those that are borderline and then we will re-evaluate the model. After trimming out those variables that are not statistically significant, we obtain a more parsimonious understanding of the risk factors related to perceived Chornobyl radiation health risk on the part of our interim sample. Nevertheless, the model remains powerful with an $R^2 = 0.71$ and when we adjust for the number of degrees of freedom consumed by the number of variables in our model, we still have about the same goodness of fit (adjusted R^2=.71). For a first pass, the model in Table four has plenty of explanatory appeal.

We will briefly describe the model in terms of decreasing beta weights. Notwithstanding their statistical significance, age and gender remain in the model to account for normal lifecycle effects. Both variables are nonsignificanty related to the Chornobyl perceived heath risk. Apart from age and gender, all other seven variables are highly statistically significant at 0.5 levels.

Table 4 Trimmed Model both males and females

Source	SS	df	MS
Model	212860.597	9	23651.1774
Residual	83885.2011	247	339.616199
Total	296745.798	256	1159.16327

Number of obs =	257
F(9, 247) =	69.64
Prob > F =	0.0000
R-squared =	0.7173
Adj R-squared =	0.7070
Root MSE =	18.429

radhlw3	Coef.	Std. Err.	t	P>|t|	Beta
age	-.0708767	.1177613	-0.60	0.548	-.0244775
sex	-.4350829	3.050774	-0.14	0.887	-.0058433
radfmw3	.8378355	.039044	21.46	0.000	.7984541
airw1	.1357923	.0365322	3.72	0.000	.1294581
liqw1	-2.730379	.679945	-4.02	0.000	-.1777916
hp2inthob	10.99926	3.730547	2.95	0.004	.1110236
shjobw2	-.1107804	.0352072	-3.15	0.002	-.1230737
shhlw1	.0930175	.0429941	2.16	0.031	.0808609
lcumdosew3	4.720468	1.453429	3.25	0.001	.1229101
_cons	-30.13108	10.51535	-2.87	0.005	.

In order of decreasing relative influence, the explanatory variables are amount of family health affected by the Chornobyl radiation, the amount of pollution of the air and water, the computed external effective dose of CS137 accumulated over the years, its interference with interests and hobbies, the stresses and hassles to ones heath, the gender effect, the age effect, the stresses and hassles associated with the job during wave two and the amount of hard liquor consumption. There were direct relationships between the amount of health affected and the amount of family health affected, the amount of air and water polluted, the actual cumulative external dose, the interference with hobbies and interests, and the amount of stresses and hassles with the job. The other relationships were inverse ones.

To evaluate this model, we can refer to Table five. We find that this model fails a number of the specification tests. Indeed, apart from there being no outlier s for this model, all other specifications are violated. One solution is to use robust variance estimators here, which we will do later. This will not change our parameter estimates, but will widen the standard errors somewhat. We need to loosen up on our significance criteria again, allowing borderline cases to be deemed as possibly significant. With no outlier problems, we need not run an outlier downweighting regression. Even if we loosen up on these criteria, we explain about 71% of the variance of the endogenous variable with these few explanatory variables before considering interaction terms.

Bootstrap validation of Trimmed model for both males and females

Table5 Specification tests for Both Male and Female Trimmed Model				
Assumption	**Test**	**X^2, f, F, or t**	**p-value**	**violation**
Residual normality	*Shapiro-Wilk test* *Kolmogorov-Smirnov test*	W=.845 Z=6.60 64.92	0.0000 0.0000	yes
Residual homoskedasticity	*Breusch –Pagan /Cook Weisburg test*	0.62	0.4317	no
No outliers	*Standardized residuals > |3.5|*	Not applicable	none	no
No omitted variables	*Ramsey reset test*	F(3, 244) = 5.40	0.000	yes
No multicollinearity	*VIF < 10*	Mean VIF |	23.04	yes

We are able to replicate the results of the previous model by reproducing the empirical standard errors from a bootstrap in Table 5 below. The parameter estimates again are identical. Although the standard errors are not identical, they are close enough so that this serves as validation of the parameter estimates of the model.

Table 6: Bootstrap validation of the trimmed model for males and females

```
Linear regression                               Number of obs      =       257
                                                Replications       =      1000
                                                Wald chi2(9)       =    962.80
                                                Prob > chi2        =    0.0000
                                                R-squared          =    0.7173
                                                Adj R-squared      =    0.7070
                                                Root MSE           =   18.4287

                                   (Replications based on 257 clusters in id)
```

radhlw3	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
age	-.0708767	.1222838	-0.58	0.562	-.3105486	.1687952
sex	-.4350829	2.770746	-0.16	0.875	-5.865645	4.995479
radfmw3	.8378355	.0354566	23.63	0.000	.7683417	.9073293
airw1	.1357923	.0365666	3.71	0.000	.0641231	.2074614
liqw1	-2.730379	.8722664	-3.13	0.002	-4.43999	-1.020768
hp2inthob	10.99926	3.75268	2.93	0.003	3.644143	18.35438
shjobw2	-.1107804	.0391823	-2.83	0.005	-.1875763	-.0339845
shhlw1	.0930175	.0405443	2.29	0.022	.013552	.1724829
lcumdosew3	4.720468	1.525557	3.09	0.002	1.730431	7.710506
_cons	-30.13108	10.59084	-2.85	0.004	-50.88874	-9.373411

Although we find that the standard errors vary a little from the original output, the parameter estimates are replicated as well as the omnibus goodness of fit statistics. We find this validation of the results and accept this output as support for faith in our findings. That we were able to support our full and trimmed model with bootstrap validation with empirical standard errors lends support to our approach.

Gender-specific Regression Models

By splitting the sample into two segments, we provide an opportunity for additional reliability testing. We save a degree of freedom by not having to include gender in the model, but until our sample size increases, we still have low power to assess the male subpopulation. The question arises whether we can obtain as powerful explanatory models as we did with the general population.

We begin our examination of the full male model. The answer to that question appears to be in the affirmative. The explanatory power of this model reaches and R^2 =0 .872 with an adjusted R^2=0.814. This model is bereft of a lot of nuisance variables. However, this model includes most of the variables we have seen in the earlier models.

However, there is one change that it noteworthy and we will tender some plausible explanations for it. The natural log of the computed cumulative external dose has lost its statistical significance. This loss is suspicious and may be due to the artifact of a temporary loss of power of this model to effects of a medium to small size. It is possible that the listwise deletion, used before we begin the multiple imputations, has engendered this loss. The model has 15 variables in it and a lot of data has dropped out due to the listwise deletion being used until we commence with multiple imputation to replace missing values. The corresponding loss of power to this model might result in a lack of statistical significance. We should be able to test this model with a bootstrap validation as well.

Table 7 Full Male Model

variable name	storage type	display format	value label	variable label
radhlw3	byte	%8.0g		how much believed personal health is affected by
age	byte	%8.0g		Age of respondent in years
childw3	byte	%8.0g		number of children now
radfmw3	byte	%8.0g		how much believed family health is affected by r
airw1	byte	%8.0g		consider hazardous (in percent) - air and water
injselfr	byte	%9.0g	dum	Were u injured because of Chornobyl acc in 1986?
enlev	double	%9.0g		energy level (el)
ecprw1	byte	%8.0g		consider hazardous (in percent) - economic probl
injothr	byte	%9.0g	inj	Was anyone u know injured by Chornobyl accident?
liqw1	byte	%8.0g		number of spirits per week in 1976-1986
liqw2	byte	%8.0g		number of spirits per week in 1987-1996
liqw3	byte	%8.0g		number of spirits per week in 1997-now
vishphw1	byte	%8.0g		number of visits per year to a homeopath for a p 1976-1986
sepaw3	byte	%8.0g		Total number of separations, experienced in time
movew2	byte	%8.0g		Total number of moves, experienced in time perio
lcumdosew3	float	%9.0g		Ln(cumdosew3)

```
. regress radhlw3 age childw3 radfmw3 airw1 injselfr enlev ecprw1 injothr liqw1 liqw2 liqw3 vi
>     sepaw3 movew2 lcumdosew3 if sex == 0, beta
```

Source	SS	df	MS
Model	42390.8425	15	2826.05617
Residual	6235.68812	33	188.960246
Total	48626.5306	48	1013.05272

Number of obs =	49
F(15, 33) =	14.96
Prob > F =	0.0000
R-squared =	0.8718
Adj R-squared =	0.8135
Root MSE =	13.746

radhlw3	Coef.	Std. Err.	t	P>|t|	Beta
age	.1310031	.2452847	0.53	0.597	.0477863
childw3	-6.791034	3.078787	-2.21	0.034	-.1716361
radfmw3	.7955687	.0785506	10.13	0.000	.8405813
airw1	.1877148	.0695692	2.70	0.011	.2039689
injselfr	17.05465	5.415575	3.15	0.003	.2706348
enlev	.2652716	.0757442	3.50	0.001	.2579531
ecprw1	-.2113004	.0763644	-2.77	0.009	-.2130265
injothr	-11.88774	6.537681	-1.82	0.078	-.1520888
liqw1	-3.247168	1.038611	-3.13	0.004	-.3286789
liqw2	1.564941	.944816	1.66	0.107	.1573163
liqw3	-2.025951	.6810037	-2.97	0.005	-.2596001
vishphw1	-14.78002	4.996491	-2.96	0.006	-.1990134
sepaw3	-26.3187	11.36104	-2.32	0.027	-.1653079
movew2	-9.262259	4.631316	-2.00	0.054	-.145255
lcumdosew3	1.133064	3.284673	0.34	0.732	.0305176
_cons	-2.294297	25.317	-0.09	0.928	.

However, let us examine the extent to which the model assumptions are fulfilled. From Table eight, we see that the homoskedasticity assumption is fulfilled here, but the normality assumption is not, even though there is no excess kurtosis or skewness. Most of the assumptions are fulfilled. Because there are no distorting outliers in the residual distribution, we can either relax our hypothesis testing criteria a little or be more assured with a bias corrected and accelerated bootstrap. We decide to select the latter option.

Table 8 Specification tests for Full Male Model				
Assumption	**Test**	**X^2, f, F, or t**	**p-value**	**violation**
Residual normality	*Shapiro-Wilk test* *Kolmogorov-Smirnov test*	V=18.325 Z=6.6 64.92	0.0000 0.0000	yes
Residual homoskedasticity	*Breusch –Pagan /Cook Weisburg test*	$X^2(1)$ = 0.62	0.4328	no
No outliers	*Standardized residuals > |3.5|*	Not applicable	none	no
No omitted variables	*Ramsey reset test*	F(3, 30) = 1.57	0.2166	no
No multicollinearity	*VIF < 10*	Mean VIF |	20.34	yes

Although the Ramsey reset test indicates a lack of specification error owing to polynomial transformations, there may be other variables inversely related to the natural log of cumulative dose that are inadvertently excluded from the model. This may not be likely given the adjusted R^2 of the model. However, it is still possible. Owing to listwise deletion, the sample size has been reduced to 49. The fact that this natural log of cumulative external effective dose of CS137 is negatively correlated with 10 of the 15 other parameter estimates in the model could potentially suppress its significance if these correlations were sufficiently large. Yet the largest in negative magnitude is only -0.262. Such specification error could suppress the significance of the natural log of cumulative external dose of CS137. We might want to run a simulation to test whether this could be the case. For the moment, this phenomenon may be an example of something we should investigate but that we do not yet know. If we discover it to be so, then that would explain this loss of statistical significance.

Bootstrap replication brings the consistency of the estimator to bear on the problem, for which reason we can accept the bootstrap as a validation of the former model in Table Six. We compare our clustered bootstrapped results in Table ten to those we obtained in Table seven. Of course, the bootstrap standard errors vary somewhat due to the random resampling with replacement but not enough to say that validation has not occurred. The variation is sufficiently small so that our results appear to be validated.

Perhaps one way to begin the testing is to trim the model. If it is the plethora of small negative correlations that are reducing the significance of this parameter, we should see what happens when we are able to trim some of these from the model. If the significance of this parameter re-emerges, then we have further evidence of the omitted variable bias that could engender a spurious nonsignificance. Therefore, we now turn our attention to the trimmed male model in Table 11.

Table 10 Bootstrap validation of the full male model

```
Linear regression                               Number of obs      =        49
                                                Replications       =      1035
                                                Wald chi2(15)      =    395.33
                                                Prob > chi2        =    0.0000
                                                R-squared          =    0.8718
                                                Adj R-squared      =    0.8135
                                                Root MSE           =   13.7463

                                     (Replications based on 49 clusters in id)
```

radhlw3	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
age	.1310031	.2414022	0.54	0.587	-.3421366	.6041428
childw3	-6.791034	3.598476	-1.89	0.059	-13.84392	.2618486
radfmw3	.7955687	.0927857	8.57	0.000	.6137121	.9774252
airw1	.1877148	.0773054	2.43	0.015	.0361989	.3392306
injselfr	17.05465	6.219577	2.74	0.006	4.864501	29.24479
enlev	.2652716	.0993308	2.67	0.008	.0705868	.4599563
ecprw1	-.2113004	.0892625	-2.37	0.018	-.3862517	-.0363491
injothr	-11.88774	8.235777	-1.44	0.149	-28.02957	4.254082
liqw1	-3.247168	1.286178	-2.52	0.012	-5.76803	-.7263066
liqw2	1.564941	1.166375	1.34	0.180	-.7211114	3.850994
liqw3	-2.025951	.8515801	-2.38	0.017	-3.695018	-.3568849
vishphw1	-14.78002	2.231581	-6.62	0.000	-19.15384	-10.4062
sepaw3	-26.3187	16.20863	-1.62	0.104	-58.08704	5.449637
movew2	-9.262259	6.089893	-1.52	0.128	-21.19823	2.673713
lcumdosew3	1.133064	3.241864	0.35	0.727	-5.220873	7.487001
_cons	-2.294297	26.28609	-0.09	0.930	-53.81409	49.2255

The Trimmed Male Model

The trimmed male model details are presented in Table 11. The number of parameters in the model is reduced from 15 in Table 10 to nine in Table 11. With only 49 observations that leaves only 37 degrees of freedom for testing. This is not a very large file and although the reduction of the number of explanatory variables leaves more power with which to test, it is not a great improvement in power. If we examine the square of the natural log of the cumulative external dose of CS137 sustained, we observe that the significance level tends toward more significance, but at p=0.221, we cannot say that it statistically significant. However, the reduction of the p-value to 0.221 may reflect the improved power of a still weak model. By the time we obtain our full sample, we hope to have enough male observations such that our assessments will be more definitive. At this juncture, we can only proffer these as interim results awaiting additional power to be obtained from a larger sample size of males.

However, we need to examine the differences between the full and trimmed model to observe what robustly remains and what does not.

Table 11 Trimmed male model

Source	SS	df	MS
Model	39913.1689	11	3628.4699
Residual	8713.36175	37	235.496264
Total	48626.5306	48	1013.05272

Number of obs	= 49
F(11, 37)	= 15.41
Prob > F	= 0.0000
R-squared	= 0.8208
Adj R-squared	= 0.7675
Root MSE	= 15.346

radhlw3	Coef.	Std. Err.	t	P>|t|	Beta
age	.2128123	.2704167	0.79	0.436	.0776281
childw3	-7.987085	3.290603	-2.43	0.020	-.201865
radfmw3	.852851	.0833552	10.23	0.000	.9011046
enlev	.2073325	.0813314	2.55	0.015	.2016125
injselfr	12.50024	5.083299	2.46	0.019	.1983624
liqw1	-2.853126	1.061364	-2.69	0.011	-.2887939
liqw3	-1.249931	.6386906	-1.96	0.058	-.1601628
vishphw1	-15.88501	5.403158	-2.94	0.006	-.213892
sepaw3	-28.57907	12.25482	-2.33	0.025	-.1795053
movew2	-10.09214	4.95614	-2.04	0.049	-.1582696
lcumdosew3sq	.363855	.2921443	1.25	0.221	.1162601
_cons	-16.0379	17.50836	-0.92	0.366	.

The more robust risk factors are those phenomena that retain their significance and sign in both models. The amount of family health affected remains directly associated with the amount of personal health affected by the radiation. Energy level remains positively significant in both models. Risk may raise energy level for some time. Self-injury as a result of Chornobyl is positively significant in both models. It appears that people were rushed around and in a hurry, which may have results in various kinds of injury in the commotion. Visits to the homeopaths are inversely significant in both male models. Under times of crisis and commotion, homeopathic visits seem to be inversely related to the perceived health risk here. Inverse significant relationships between consumption of hard liquor and the perceived heath risk remains in wave one.

The changes from the full to the trimmed model are several. A number of significances emerged. One of them was the number of children the respondent has is a variable that was not statistically significant in the full model but is statistically significant in the trimmed model among the men in the sample. The total number of moves from one place to another was not significant in the full model but emerged as significant in the trimmed model. The number of marital separations became significant in the trimmed model. In wave three, hard liquor consumption became almost significant from significant. Injury to others dropped from significance in the trimmed model. The economy went from negative significance to nonsignificance in the trimmed model. The basis for these differences may follow from a difference in statistical power or from a transformation of the situation.

In this model, we employed the square of the natural log of the cumulative external effective dose of CS 137 because it was more significantly related to the perceived risk perception of Chornobyl radiation. In this model that transformation provided a better link between the endogenous and exogenous variable under consideration. To appreciate the validity of this model, we need to review the specification requirements. That may give us an indication of where the model weakness may reside. Then, we may still wish to resort to bootstrap validation for more data. Therefore, we resort to this now in hopes of providing more information about what is reliable and what is fragile in these models.

From a review of the model assumptions in Table twelve it is clear that there are more violations than there are fulfillments. Homoskedasticity is not violated so the confidence intervals may be estimated but the residual distribution is nonnormal. This may be due to the presence of outliers that could distort the distribution. We will examine this situation in greater detail because the presence of bad influence from outliers can undermine the coverage of a percentile or a t bootstrap with small sample sizes, even though we use bias correction and acceleration to compensate for the bias that could follow from such bootstraps(Efron and Tibshirani, 1993). In this case we examine the Cook's D as a measure of the adversity of the influence of these outlying observations.

Table 12 Specification tests for the trimmed male model

Assumption	**Test**	**X^2, f, F, t, or z**	**p-value**	**violation**
Residual normality	*Shapiro-Wilk test* *Kolmogorov-Smirnov test*	Z=6.963 Adj X^2 = 66.74	0.0000 0.0000	yes
Residual homoskedasticity	*Breusch –Pagan /Cook Weisburg test*	$X^2(1)$ = 1.97	0.1601	no
No outliers	*Standardized residuals > |3.5|*	7 outliers 5 negative 2 positive	0.000	yes
No omitted variables	*Ramsey reset test*	F(3, 34) = 1.67	0.1923	no
No multicollinearity	*VIF < 10*	Mean VIF |	13.21	yes

Ken Bollen and Robert Jackman (1990) have noted that when Cook's D exceeds 4/n, the observation in question exhibits problematic influence, where n designates the sample size. If our effective sample size is 49, that means Cook's D values in excess of 0.082 would be problematic. The residual distribution is riven with 28 of these observations, nine of which exceed unity while five of which exceed 4.0. Under these circumstances, perhaps a nonparametric bootstrap would be the best approach to arriving at empirical standard errors. According to Bollen and Jackman, Belsey in 1980 suggested that the lower size cut-off for a dfBeta coefficient is 2/√n whereas the upper is unity. With this effective sample size, this amounts to 2/7=0.286. I performed a sensitivity test on the parameter estimate of the natural log of the cumulative external dose of CS137, by listing all of the dfBetas for the natural log of the cumulative external dose for any observation with a Cook's D greater than unity. No dfBeta was indicated. From this I suspect that the changes in significance result either from correlations with omitted variables or from multiple low-level negative correlations with included variables or from the improvement in power by reducing the sample size of the correlation matrix and thus in turn attenuating the power of the model to detect medium to small effects. I suspect that this problem will be alleviated by the input of more male respondents as our data collection continues. With the plethora of outliers, a parametric bootstrap would probably not bear fruit. With that caveat issued, we undertake the bootstrap validation nevertheless.

Table 13 Bootstrap validation of trimmed male model

```
Linear regression                               Number of obs      =        49
                                                Replications       =      1012
                                                Wald chi2(11)      =    386.24
                                                Prob > chi2        =    0.0000
                                                R-squared          =    0.8208
                                                Adj R-squared      =    0.7675
                                                Root MSE           =   15.3459

                                  (Replications based on 49 clusters in id)
```

radhlw3	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
age	.2128123	.2542247	0.84	0.403	-.2854588	.7110835
childw3	-7.987085	3.242337	-2.46	0.014	-14.34195	-1.632222
radfmw3	.852851	.0997553	8.55	0.000	.6573342	1.048368
enlev	.2073325	.0935577	2.22	0.027	.0239627	.3907023
injselfr	12.50024	5.208347	2.40	0.016	2.292067	22.70841
liqw1	-2.853126	1.168345	-2.44	0.015	-5.14304	-.5632128
liqw3	-1.249931	.6963277	-1.80	0.073	-2.614708	.1148468
vishphw1	-15.88501	1.67703	-9.47	0.000	-19.17192	-12.59809
sepaw3	-28.57907	16.03039	-1.78	0.075	-59.99806	2.839913
movew2	-10.09214	7.518164	-1.34	0.179	-24.82747	4.643186
lcumdosew3sq	.363855	.2761775	1.32	0.188	-.1774429	.9051529
_cons	-16.0379	19.53673	-0.82	0.412	-54.3292	22.2534

For the square of the natural log of cumulative external dose of CS137 we observe that the significance level is closer to significance than with our first estimation of this model, but it remains nonsignificant. The number of moves is no longer significant. The number of separations is no longer significant. Otherwise, the model remains very much the same, as far as the parameter estimates and the goodness of fit indices are concerned. At this juncture, we will turn to the female full and trimmed models as well as their validations. At the end of this presentation, we will sort the variable in order of their reliability, which will be computed from the proportion of models in which they were found to be statistically significant.

The Full female model

The female portion of the sample at this juncture is almost 70% of the total interviewed. The Therefore, we are about to review a portion of the sample that may be similar to the total sample for males and females than the male analysis by itself. As with the previous segments of the sample, we begin our analysis with a standard OLS regression, from which we can glean beta weights, following our combined variable selection technique of the Hendry-Richard approach and our hybrid bivariate screening (with matrix scatterplots overlaid with loess fitting lines). Then we attempt to trim the model of nuisance parameters before deciding whether a robust version is in order. We validate our analysis with a cluster-controlled bootstrap.

The full female model is the largest model developed at this interim juncture. It contains 28 parameter estimates, some of which Stata drops to avert multicollinearity . PcGive does not drop them for any such reason. Table 14 on the next page lists the variables in this model, beginning with the endogenous variable. Regardless of the discarding of three of the variables both statistical packages report a very respectable goodness of fit.

Both statistical packages report the R^2 of the model as 0.933 and the adjusted R^2 of the model as 0.889 Because these figures were high by social science standards, we decided to graphically display them so they could be reviewed. To visually examine the residuals of the model, we examined not only the goodness of fit but also the behavior of the residuals. In the top panel of the three panels in Figure 1, we observe what appears to be a remarkably good estimation from the PcGive version of the model.

To have confidence in a model, we also had to examine the theoretical meaning of the parameter estimates. We present the Stata output on Table 15. We address these explanatory variables in increasing order of their beta weights. Most negatively related among these variables with perceived health risk to Chornobyl radiation. Some comment may be in order about those variables that appear to be statistically significantly related to the perception of health risk from the radiation. The more the respondent believes he or she was at risk, the less the phobic anxiety. It was reasonable to believe in the risk of exposure, given the circumstances and lack of information and amount of uncertainty that these people endured.

Figure 1 Model fit and residual graphics from the full female model

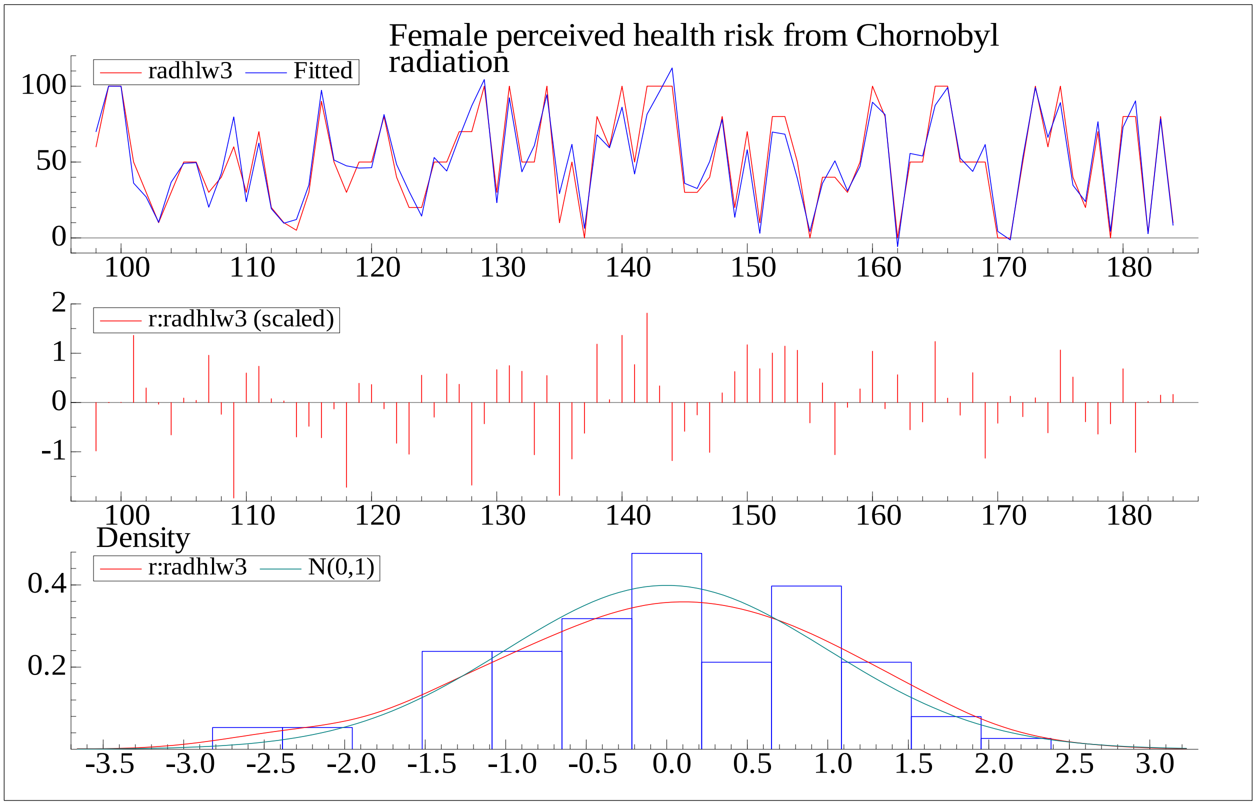

Table 14 Table of variables in the full female model

variable name	type	format	label	variable label
radhlw3	byte	%8.0g		how much believed personal health is affected by radiation now
age	byte	%8.0g		Age of respondent in years
childw2	byte	%8.0g		number of children in 1996
jsw3	byte	%8.0g		Job satisfaction on a scale of 0-100%, NOW
dvcew1	byte	%8.0g		Total number of divorces, experienced in time period 1976-1986
sepaw1	byte	%8.0g		Total number of separations, experienced in time period 1976-1986
shjobw2	byte	%8.0g		Percentage of strains and hassles related to job, 1996
shjobw3	byte	%8.0g		* Percentage of strains and hassles related to job, NOW
shhlw1	byte	%8.0g		Percentage of strains and hassles related to health, 1986
shfincw3	byte	%8.0g		Percentage of strains and hassles related to finances, NOW
shjobw2	byte	%8.0g		Percentage of strains and hassles related to job, 1996
shjobw3	byte	%8.0g		* Percentage of strains and hassles related to job, NOW
shhlw1	byte	%8.0g		Percentage of strains and hassles related to health, 1986
shhousw1	byte	%8.0g		Percentage of strains and hassles related to housing, 1986
beerw2	byte	%8.0g		nuber of beers per week in 1987-1996
vishphw1	byte	%8.0g		number of visits per year to a homeopath for a physical condition in 1976-1986
mhoutw1	byte	%8.0g		number of medical visits for a mental health condition per year 1976-1986
mhinw2	byte	%8.0g		* number of days per year as a patient in a clinic for a mental health in 1987-19
fdferw1	byte	%8.0g		* level of fear in percent from consuming foods contaminated with radiation in 197
injothr	byte	%9.0g	inj	Was anyone u know injured by Chornobyl accident?
evacselfr	byte	%9.0g	dum	Were u evacuated because of Chornobyl accident in 1986?
defnw2	byte	%8.0g		* consider hazardous (in percent) - deficiencies in essential nutrition, 1996
airw1	byte	%8.0g		consider hazardous (in percent) - air and water pollution in 1986
airw2	byte	%8.0g		consider hazardous (in percent) - air and water pollution in 1996
radw1	byte	%8.0g		believed % of the radioactively contaminated area in 1986
radtlw1	byte	%8.0g		believed % of cumulative radiation exposed to in a lifetime now
radtlw2	byte	%8.0g		believed % of cumulative radiation exposed to in a lifetime now
medw1	byte	%8.0g		level of danger by general media (in percent) in 1986
medw2	byte	%8.0g		level of danger by general media (in percent) in 1996
neiw1	byte	%8.0g		level of danger by neighbors (in percent) in 1986
neiw3	byte	%8.0g		level of danger by neighbors (in percent) now
carcin	byte	%8.0g		* if a person is exposed to a carcinogen then he/she is likely to get cancer (% of
paran	byte	%8.0g		paranoid ideation
hp2probsoc	byte	%9.0g	hp2fmt	health causing prb with social life
lcumdosew3	float	%9.0g		Ln(cumdosew3)
skin	byte	%8.0g		a suntan is caused by radiating damage to the skin (% of agreement)
phobanx	byte	%8.0g		phobic anxiety

transparency as the *nourvelle vague.* It would have been unusual if this were otherwise at the time.

Table 15: The full female model

Source	SS	df	MS
Model	77645.951	34	2283.70444
Residual	5536.27886	52	106.466901
Total	83182.2299	86	967.235231

F(34, 52) =	21.45
Prob > F =	0.0000
R-squared =	0.9334
Adj R-squared =	0.8899
Root MSE =	10.318

radhlw3	Coef.	Std. Err.	t	P>|t|	Beta
age	-.8099116	.1885641	-4.30	0.000	-.2595055
childw2	-6.076811	2.004463	-3.03	0.004	-.1568283
jsw3	.0405977	.047702	0.85	0.399	.0489797
dvcew1	19.34957	12.97149	1.49	0.142	.0937823
sepaw1	1.435227	24.398	0.06	0.953	.0049476
shjobw2	-.1396609	.0643423	-2.17	0.035	-.1587725
shjobw3	.0523426	.0575879	0.91	0.368	.0535273
shhlw1	.3906134	.0630193	6.20	0.000	.3869666
shfincw3	-.181303	.0505088	-3.59	0.001	-.2072783
shjobw2	(omitted)				
shjobw3	(omitted)				
shhlw1	(omitted)				
shhousw1	.0270548	.0510981	0.53	0.599	.0298696
beerw2	-3.616702	1.046327	-3.46	0.001	-.1485943
hospw1	.1543934	.2593117	0.60	0.554	.0460996
vishphw1	-.1221559	1.555324	-0.08	0.938	-.0050193
mhoutw1	-63.56694	11.20759	-5.67	0.000	-.3751083
mhinw2	5.412944	.850217	6.37	0.000	.3918566
fdferw1	.0898282	.0361347	2.49	0.016	.1077615
injothr	14.50102	4.10065	3.54	0.001	.1816824
evacselfr	-14.26622	6.110857	-2.33	0.023	-.1169101
defnw2	.3756419	.0480749	7.81	0.000	.4180842
airw1	.0289101	.0437431	0.66	0.512	.031219
airw2	.1466122	.0543268	2.70	0.009	.1140013
radw1	-.0939847	.0453465	-2.07	0.043	-.115307
radtlw1	-.1818966	.0608485	-2.99	0.004	-.2179561
radtlw2	.2032039	.0658901	3.08	0.003	.2304378
medw1	-.3578396	.0582068	-6.15	0.000	-.4167942
medw2	.3216693	.0644562	4.99	0.000	.2784995
neiw1	.1874692	.0464971	4.03	0.000	.2122646
neiw3	.2057604	.0492574	4.18	0.000	.2382699
carcin	.216806	.0469808	4.61	0.000	.2234897
paran	2.754042	.5258628	5.24	0.000	.3434905
hp2probsoc	27.51967	5.097608	5.40	0.000	.2957818
lcumdosew3	13.55739	2.236715	6.06	0.000	.3657654
skin	.0747895	.0359887	2.08	0.043	.1019782
phobanx	-3.650299	.5927038	-6.16	0.000	-.4187053
_cons	-76.95886	16.5505	-4.65	0.000	.

The belief in the danger posed by the media was also inversely related to the perceived health risk of the fallout. Perhaps the media was a major source of information about the problem; the media served as an early warning mechanism many may have believed. Glasnost had begun, so people believed in freedom of the press, openness, and transparency more than before. Also very strongly negatively related to perceived health risk from the accident was the number of mental health visits. The more the mental health visits the more oblivious people were to the potential threat. There was a significant negative relationship between the belief that the amount of radiation to which they were exposed in 1986 was equivalent a lifetime exposure. Yet the polarity of this belief was significantly reversed by the time of the second wave of our study. Moreover, there was a significant negative relationship between stresses and hassles due to financial matters with the belief in the amount of perceived health risk. Those without means may have found it more difficult to travel on the spur of the moment for example. Ukraine was not a highly mobile society at the time and most people did move around much. Also inversely related were the stresses and hassles on the job. The more the respondent had to contend with sh

If these models warrant robust analysis that downweights the outliers or implements Halbert White's sandwich variance estimators, we can apply those also. The decision to resort to that analysis will depend on sufficient violation either of the taboo on outlier distortion or the homoskedasticity assumption of ordinary least squares regression estimators.

From our collection of full and trimmed models, we score each variable that attained statistical significance. The sample splitting entailed provides us with a reliability index of the variables that found their ways into our models. We can also tally the percentage of cases in which the signs were identical and weight the significance by this amount. Moreover, we can list the parameter estimates of the variables and compute the variance of them. By normalizing this, we can form another weight. The original score can be multiplied by these weights to comprise an overall reliability index of the variables. We can sort them accordingly and obtain a reliability or stability index of the variables in accounting for perception of health risk of nuclear radiation---- specifically from Chornobyl. We would then suggest that this same procedure be pursued for residents who were potentially exposed to similar nuclear disasters to ascertain what the psycho-social impact of these disasters tends to be.

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