A robust path analysis of anxiety and depression among Ukrainian residents of Kiev and Zhitomyr Oblasts after Chornobyl

Robert Alan Yaffee
Silver School of Social Work
New York University

robert.yaffee@nyu.edu

13 Aug 2012

Contents

1 Acknowledgements

This project has been funded by National Science Foundation HSD grant 08262983, and to them we remain deeply grateful. We are also grateful to the developers of Stata in College Station, Texas, Salford Systems, Inc. in San Diego, California, and AutoMetrics in Oxford, London for the software they have developed and which we are using. We are also grateful to Ben Jann of ETH in Switzerland for his development of the estout.ado program which allows us to format our output so neatly. We are grateful for invaluable data management

2 Introduction

In this analysis we examine some plausible causal etiological paths of Depression, Anxiety, and PTSD among residents of Zhitomyr and Kiev Oblasts in the years since Chornobyl. We will focus on omnibus measures of fit, as well as statistically significant paths, broken down into direct, indirect, and total effects. We employ path analysis to allow us to find out which variables are mediating ones and which have direct effects. The path analysis permits us to decompose total into direct, indirect, and spurious effects. After a short introduction to path analysis, we begin with an analysis of our depression models for men and women. We guard against selection bias by a random generation of phone numbers from a computer and the attachment of those phone numbers to the area codes provided by the telephone company.

In this report, we address hypotheses postulated in hypothesis 4, 5, and 8. Hypothesis 4 refer to direct effects of radiation on the radiation on measures of the Brief Symptom Inventory (BSI) measures of psychological health (e.g., anxiety and depression for men and Positive symptoms, anxiety, and depression for women). Hypothesis 5 pertains to direct effects of perceived exposure risk on BSI measures of psychological health, whereas hypothesis 8 refers to direct effects of perceived exposure on Nottingham measures of physical health (e.g., sleep for males and energy level, sleep, and physical ability for women).

These hypotheses were tested with our path models to facilitate distinction between direct and mediating effects on a representative sample of the population in the Kiev and Zhitomyr Oblasts. We discuss our findings in the passages that follow.

3 Structural path analysis

3.1 Nomenclature

Although we may refer to these models as causal, they are really only models of association. Causality requires an invariable space-time relationship between two phenomena that may be likened to a logical and probabilistic chain of events, where an effect temporally follows a cause, when the two these phenomena are spatially contiguous to one another, conditional upon specified conditions affecting these phenomena. For the time being, we exclude matters of quantum entanglement as being beyond the scope of this analysis.

To determine that the relationship between these two phenomena may be causal, we would have to be able to conduct a controlled experiment to demonstrate that the cause is proximate, facilitating, necessary and/or sufficient for the effect to occur, given specific circumstances. Without such circumstances, we cannot know whether models are causal[5, 56-78]. In a sense, we are statistically analyzing what David Hume in his Enquiry Concerning Human Understanding (1748) referred to as an association and the models which we develop are to be construed only as reflections of a possible causal path.

3.2 Path effect specification

In path analysis, we endeavor to model reflections of a possible causal paths among variables. The coefficients in such a system are called path coefficients. Although some practitioners standardize these coefficients, we do not, lest we lose the sense of scale and mean location of the metric being used when interpreting the effects of different equations.

When all effects are in a regression model, the regression coefficients are called direct path coefficients. When a variable y intervenes between w and z, the indirect effect is computed by the product of the regression coefficients in each of the component paths from w to y and from y to z. The sum of all of the indirect paths plus the direct effect is called the total effect.

The *spurious or unmeasured effect* is that difference between the total effect and the zero-order effect (correlation if standardization is employed or regression coefficient if variables are not standardized) between the exogenous and the endogenous variable, where the zero-order correlation is the bivariate correlation between the exogenous and endogenous variable with 0 controls for other variables to hold them constant to partial out other effects [1, 359-360].

We use a robust path model, by controlling for the serial correlation across the waves by applying a cluster control of id across the waves of the study.

3.3 Model structure

Because we make the working assumption that variables are fixed effects, we rely on the submodel structural equation formulation of Joreskog and Sorbom for observed variables, except that we adopt Sorbom's formulation of mean structures.

If and only there are no feedback loops, our models will be simplified to

$$y = \alpha + \gamma x + \zeta \tag{1}$$

with ϕ = covariance matrix among observed variables [3, 9,136-137], [6, 210].

However, in the event that our model is nonrecursive, we rely on their formulation of it as

$$y = \alpha + \beta y + \gamma x + \zeta \tag{2}$$

where α is a px1 vector of constants, β is an pxp matrix of parameter estimates for those endogenous observed variables, ξ is a nxq matrix of exogenous observed variables, and ζ= px1 vector of equation errors, with n= number of observations.

The mean of the vector is

$$y = (I - \beta)^{-1}(\alpha + \gamma\kappa) \tag{3}$$

The mean of vector ξ is denoted by vector, κ, which has an order of nx1.

3.4 Assumptions

Because the building blocks of path analysis consist of covariance structure analysis and regression analysis, the assumptions of linear structural equation modeling are are essential to assure statistical conclusion validity. The uncorrelated errors assumption ($E(\xi\zeta) = 0$) is an essential assumption. According to this principle, the errors of the equations are uncorrelated with the explanatory variables in the model. Otherwise, the equation errors could be driving both the explanatory and endogenous variable, rendering the explanatory variable endogenous rather than exogenous and rendering the model spurious.

What is not modeled is in the error term and if there are important omitted variables correlated with the explanatory variables, the errors will be correlated with the explanatory variables, allowing for omitted variable bias or specification error that can engender the same spurious result.

For these reasons, the optimal model building strategy of choice is one of a general-to-specific nature. There is no other way to minimize the probability of omitted variable bias assumption violations.

We make a working assumption of linearity of functional form. We have used basis functions to linearize nonlinear function forms and assume that these transformations will capture delayed effects or threshold effects sufficiently, even though this may never totally accomplished.

Any model that is to be estimated must be identified. Without adequate identification the model cannot be estimated with unique solutions for its variables. If the model is non-recursive, it contains feedback loops or cyclical effects. There must be enough variables from outside the loop to allow that loop to be estimated. The rank condition which is necessary and sufficient for this condition to hold should be tested for a model to be proposed.

Hidden in the assumption of the feedback loop is the assumption of a dynamic equilibrium is a condition that also must exist. The dynamic equilibrium is otherwise known as covariance stationarity is necessary if the model is to be estimated by non-Bayesian methods. Covariance stationarity requires stability of the mean, the variance, and the autocovariance. From the stability of the variance derives the requirement of residual homoskedasticity. For this condition of stability of the mean to obtain, level shifts in the middle of a dataset being estimated by a model of the equations are not to be tolerated without proper modeling of those effects. If feedback loops obtain within the model, we assume that the moduli (absolute value) of the eigenvalues are all within the unit circle so that the system is stable in the long run. Without such stability, variances could not be properly estimated. Also, without such just or over-identification, the variables in the system would not be estimable.

Although we construct our summary measures of Chornobyl related health threat from factor scores, in waves one though three, with alpha reliability coefficients in excess of 0.78, we make a simplifying working assumption in our exploratory mode that these variables are fixed effects without measurement error. This permits us to eschew use of the measurement equations of the structural equation modeling system and to rely on the submodel of Joreskog and Sorbom, plus Sorbom's formulation of mean structures [3, 9,136-137].

Regression models presume a causal direction from the exogenous to the endogenous variable variable and then from one to another endogenous variable. We furthermore assume that multicollinearity is not a problem in controlling for the effects of other variables. We assume that our cluster control of serial correlation is robust enough to attend to issues that otherwise may have derived from serial correlation of our residuals and deviations from homoskedasticity.

Finally, we assume that all models are stationary, lest we be unable to rely on the consistency of our statistical analysis.

In order for our models to accommodate a substantial number of variables simultaneously, we make a working assumption that our variables are fixed in that they are not subject to measurement error.

Linear structural equation models in general assume independence of observations and multivariate normality of the observed and latent variables. Sometimes joint normality is too restrictive and conditional normality or general symmetry may suffice. If too many of the variables appear to be ski jumps without clear modes or maxima, the models may not converge at all. However, there are estimation algorithms that such as asymptotic distribution free (ADF) or quasi-maximum likelihood (QML) which relax this assumption. When we request ADF, we obtain a kind of weighted least square which can correct for heteroskedasticity. WHen we request cluster robust estimates, the estimation method becomes QML, which relaxes the independence of observations by allowing clustering (correlation among id) across the waves, while requiring independence of the clustered observations [6, 57].

3.5 Advantages of path analysis

Structural equation modeling permits a full-information maximum likelihood analysis, which in a confirmatory mode, estimates linear models well, if the target endogenous variables, have a symmetrical mode, mean, or maximum value. They are excellent at handling linear, additive variables, whose models have Gaussian residuals. They are excellent at decomposing effects into direct, indirect, and total effects as long as those effects are linear and additive.

3.6 Disadvantages of path analysis

These algorithms generally cannot handle endogenous variables that are nonlinear and non-Gaussian, which often appear to be zero-inflated or appear to have a ski-jump distribution. Nor do they estimate interactions well, without some form of conditional estimation. Without special modifications found in M-Plus or Prelis 2, they they cannot handle dichotomous variables, ordinal variables, or categorical variables.

This form of model is not designed for variable selection and model-building where the models must be developed from data-mining. They fall prey to specification error and omitted variable bias under those circumstances.

4 Dose-Depression response path models

4.1 The male model

We begin examining the relationship between the initial dose of radiation to which a respondent was exposed and the links to self-reported depressive symptoms in waves one and two, and depression as defined by the Brief symptom inventory in wave three. In Figure 1, we display a path diagram of our findings then a list of the output to illustrate the presentation. In Table 2 we present the output of our analysis. For us to understand the either the table or the figure, we must be familiar with the variable names, which we present in Table 1.

Table 1

variable name			variable label
age	byte	%8.0g	* Respondent´s age
airw1	byte	%8.0g	consider hazardous (in percent) - air and water pollution in 1986
cumdose1	float	%9.0g	cumulative external dose in mGys in wave 1
cumdose2	float	%9.0g	cumulative external dose in mGys in wave 2
cumdose3	float	%9.0g	cumulative external dose in mGys in wave 3
radchw1	byte	%8.0g	believed % of polution related to chornobyl in 1986
radchw2	byte	%8.0g	believed % of polution related to chornobyl in 1996
radchw3	byte	%8.0g	believed % of polution related to chornobyl NOW
crhtw1	float	%9.0g	Chornobyl related health threat: wave 1 alpha = .835
crhtw2	float	%9.0g	Chornobyl related health threat in wave 2 alpha=.822
crhtw3	float	%9.0g	Chornobyl rleated health threat in wave 3 alpha=0.833
fdferw1	byte	%8.0g	* Level (in %) of fear of eating radioactively contaminated food in 1986
BSIanx	byte	%9.0g	Brief symptom inventory anxiety subscale score
BSIdep	byte	%9.0g	Brief symptom inventory depression subscale score
whppa	float	%9.0g	Nottingham physical ability subscale
whpsleep	float	%9.0g	Nottingham sleep subscale

What can we learn from these results. First, we see that the model, not using the cluster robust variance estimates fits the data nicely from the likelihood ratio test provided at the bottom of Table 2. Second, we note that all of the paths are statistically significant. The nonsignificant paths, with the exception of one constant, have been trimmed from the model to support parsimony.

In the path diagram in Figure 1, the reader will find numbers on the right hand side of the boxes that represent observed variables. The upper right hand number is the mean and the lower right hand number is the variance when the variables are exogenous. When the variables are endogenous, the numbers represent the constant in the regression model. The reader will also note that the errors are represented by circles and the number attached to the circle represents the error variance of the equation. The numbers along side the arrows represent the path coefficient of that path.

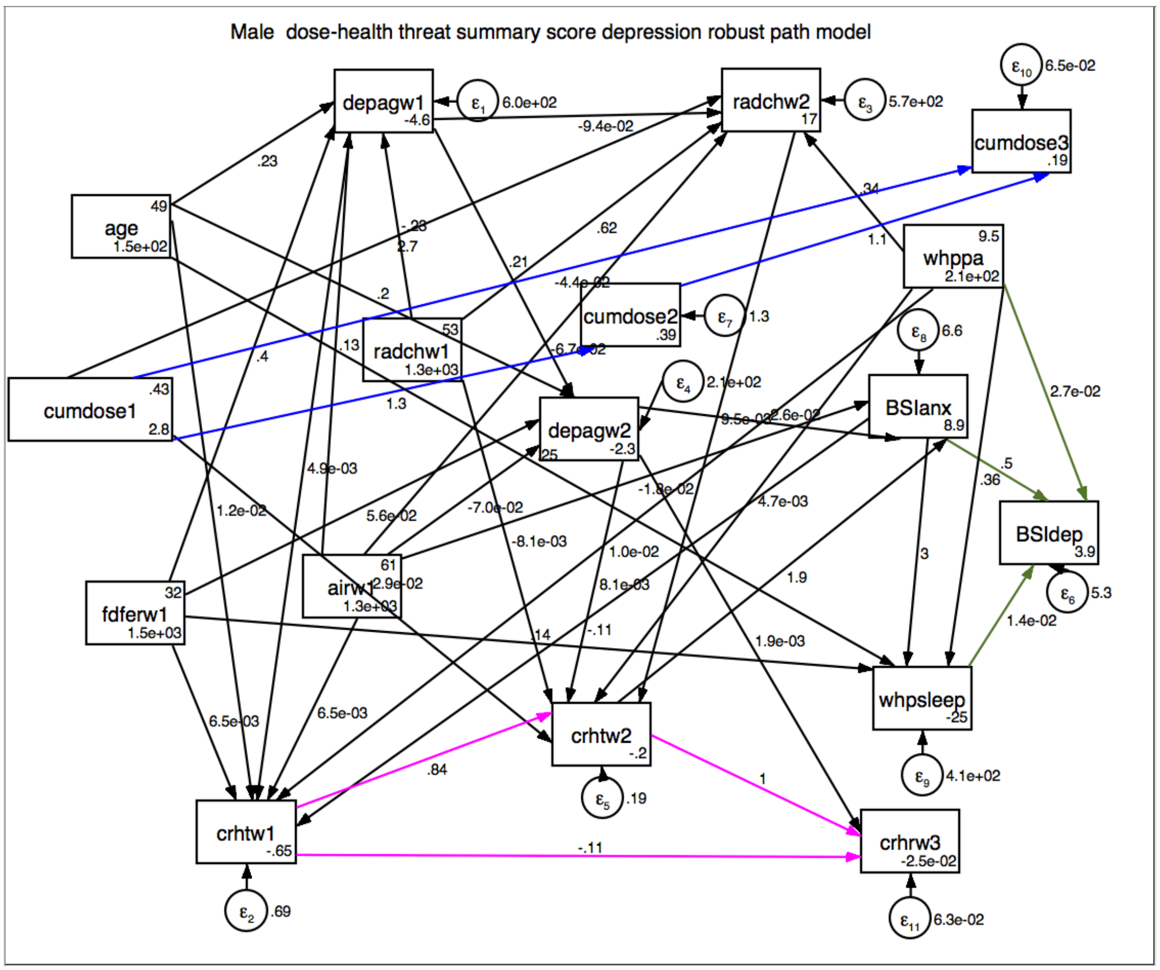

Figure 1: Dose-depression robust path diagram for males

On the right hand side of the diagram, he will find BSI variables relating to anxiety and depression as well as Nottingham physical health variable of sleep. The number suffixes indicate the respective wave of the variable, as in cumdose1 or or perceived Chornobyl health threat or risk as in crhtw1(or crhrw1).

Table 2 Endogenous variables

Observed: radchw2 crhtw2 cumdose2 cumdose3 depagw1 crhtw1 depagw2 crhrw3 BSIanx whpsleep BSIdep

Exogenous variables

Observed: cumdose1 radchw1 age whppa airw1 fdferw1

Structural equation model Number of obs = 339
Estimation method = ml
Log likelihood = -17106.081

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
radchw2 <-						
depagw1	-.093878	.0454092	-2.07	0.039	-.1828784	-.0048776
cumdose1	2.655714	.7798212	3.41	0.001	1.127292	4.184135
radchw1	.6243548	.0385784	16.18	0.000	.5487426	.699967
whppa	.3441295	.0900283	3.82	0.000	.1676772	.5205817
airw1	-.0670459	.0383486	-1.75	0.080	-.1422077	.008116
_cons	16.64974	3.188173	5.22	0.000	10.40103	22.89844
crhtw2 <-						
radchw2	.0094791	.0009893	9.58	0.000	.0075401	.0114182
crhtw1	.8351204	.0308141	27.10	0.000	.7747258	.895515
depagw2	.0081446	.0014478	5.63	0.000	.0053069	.0109823
cumdose1	-.0292823	.0145104	-2.02	0.044	-.0577221	-.0008424
radchw1	-.0080512	.0009309	-8.65	0.000	-.0098757	-.0062268
whppa	.0046527	.0017384	2.68	0.007	.0012455	.0080599
_cons	-.1997385	.0498335	-4.01	0.000	-.2974103	-.1020667
cumdose2 <-						
cumdose1	1.339597	.0366997	36.50	0.000	1.267667	1.411527
_cons	.3879549	.0632438	6.13	0.000	.2639992	.5119105
cumdose3 <-						
cumdose2	1.087217	.0123079	88.34	0.000	1.063094	1.11134
cumdose1	-.0439337	.0184663	-2.38	0.017	-.080127	-.0077403
_cons	.1920846	.0151063	12.72	0.000	.1624768	.2216924
depagw1 <-						
radchw1	-.2255648	.0376144	-6.00	0.000	-.2992877	-.151842
age	.2291889	.1151014	1.99	0.046	.0035943	.4547835
airw1	.1277529	.0406249	3.14	0.002	.0481295	.2073762
fdferw1	.4034211	.0364406	11.07	0.000	.3319988	.4748434
_cons	-4.638666	5.916464	-0.78	0.433	-16.23472	6.957391

Continued...

Table 2 continued:

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
crhtw1 <-						
depagw1	.0048837	.0017954	2.72	0.007	.0013648	.0084026
BSIanx	-.1148348	.0314752	-3.65	0.000	-.176525	-.0531446
age	.0121176	.0042331	2.86	0.004	.0038209	.0204142
whppa	.0104254	.0034569	3.02	0.003	.0036499	.0172009
airw1	.0065012	.0014229	4.57	0.000	.0037124	.0092901
fdferw1	.0065179	.0015234	4.28	0.000	.0035321	.0095036
_cons	-.646787	.2757334	-2.35	0.019	-1.187214	-.1063596
depagw2 <-						
depagw1	.2134912	.0307456	6.94	0.000	.1532309	.2737515
age	.2029756	.0689214	2.95	0.003	.0678921	.3380591
airw1	-.0703643	.024173	-2.91	0.004	-.1177426	-.0229861
fdferw1	.0562186	.0252903	2.22	0.026	.0066506	.1057867
_cons	-2.322406	3.333129	-0.70	0.486	-8.855218	4.210407
crhrw3 <-						
crhtw2	1.036497	.0271138	38.23	0.000	.9833552	1.089639
crhtw1	-.1077892	.0259464	-4.15	0.000	-.1586432	-.0569352
depagw2	.0018722	.0008637	2.17	0.030	.0001793	.0035651
_cons	-.0247038	.0161901	-1.53	0.127	-.0564358	.0070282
BSIanx <-						
crhtw2	1.868707	.2873568	6.50	0.000	1.305498	2.431916
depagw2	.0257663	.0093035	2.77	0.006	.0075318	.0440009
airw1	-.0184936	.0048134	-3.84	0.000	-.0279277	-.0090596
_cons	8.872709	.384909	23.05	0.000	8.118301	9.627117
whpsleep <-						
BSIanx	2.988487	.4189314	7.13	0.000	2.167396	3.809577
age	.2483807	.0967779	2.57	0.010	.0586996	.4380619
whppa	.3560758	.0814963	4.37	0.000	.196346	.5158056
fdferw1	.1378615	.0294973	4.67	0.000	.0800479	.1956752
_cons	-25.44547	5.244783	-4.85	0.000	-35.72505	-15.16588
BSIdep <-						
BSIanx	.4953912	.0508597	9.74	0.000	.395708	.5950744
whpsleep	.0140118	.0059299	2.36	0.018	.0023893	.0256342
whppa	.0265236	.0092044	2.88	0.004	.0084833	.0445638
_cons	3.853865	.3756437	10.26	0.000	3.117617	4.590113
Variance						
e.radchw2	565.2633	43.41761			486.262	657.0995
e.crhtw2	.1894244	.0147039			.1626905	.2205512
e.cumdose2	1.271465	.0976606			1.093765	1.478035
e.cumdose3	.0652934	.0050152			.056168	.0759014
e.depagw1	596.2898	45.80074			512.9523	693.1668
e.crhtw1	.6949654	.0787495			.5565573	.8677936
e.depagw2	211.3539	16.234			181.8151	245.6918
e.crhrw3	.0634885	.0048765			.0546154	.0738033
e.BSIanx	6.639715	.5969929			5.566931	7.919231
e.whpsleep	406.8025	31.24631			349.9477	472.8942
e.BSIdep	5.300662	.4071414			4.559841	6.161841

LR test of model vs. saturated: chi2(80) = 90.44, Prob > chi2 = 0.1993

Table 2 presents the coefficients found in the path diagram. It is presented in order to help the reader understand the diagram. The model is consistent with the data, as can be confirmed by examination of the Likelihood ratio chi-square test that accompanies the non-robust version of the output and the stability index = 0.5637951, indicating that the moduli reside within the unit circle, rendering the model stable.

4.1.1 Findings regarding direct effects

Table 3 contains the direct effects. The target variable has an arrow pointing to it. The origin variable or starting point of the path is listed below the arrow.

Hypothesis 4, 5 and 8 (part 1 and 2) refer to direct effects. Hypothesis 4 refers to the direct effects of radiation on the BSI measures, such as depression and anxiety. Hypothesis 5 refers to perceived risk of exposure on such measures. Hypothesis 8 refers to direct effects of perceived exposure on Nottingham measures of physical health–such as, sleep.

However, we find no direct cumulative external dose-response effect for males whether we use the self-reported depressive symptoms in waves 1 or 2, or whether we we use the Brief symptom inventory scale in wave 3. But this finding goes beyond a dose-depression effect. The cumulative external radiation dose (cumdose1 for wave 1, cumdose2 for wave 2, or cumdose3 for wave 3) exhibits no direct path from any of boxes designating the reconstructed external dose in mGrays at those points in time to the BSI or to the Nottingham measures of sleep (or physical ability, which is exogenous in this model) in Figure 1, even though there is a direct path between cumulative external dose in wave 1 to perceived exposure in wave 2.

Cumulative external dose in wave 3 projects directly to no other variable. For this reason, we cannot expect either a direct or an indirect effect from it. If there is an dose effect, it would have to emanate from either waves 1 or 2.

Moreover, we find no direct path emanating from cumulative external dose to either Nottingham physical health variable sleep in Figure 1. Therefore, Figure 1 provides no evidence in support of hypothesis 8 at this point.

Hypothesis 5 refers to the direct effects of perceived exposure on the psychological measures of the BSI. We find a direct effect from wave 2 perceived risk of exposure to BSI anxiety, as measured in wave 3. The direct effect is statistically significant ($stdized\ \beta = 0.156, p = 0.049$). Therefore, we have partial support for the hypothesis that there is a statistically significant relationship between perceived risk and anxiety, particularly during wave 2. If there are no indirect effects, we could obtain a partial R^2 for the exogenous variables in a regression equation to obtain a sense of how well the direct effect explains and predicts the target endogenous variable, such as that of BSI anxiety or BSI depression. Otherwise, we might have to resort to another form of analysis to obtain the answer to this question.

4.1.2 Findings regarding indirect effects

We turn to Table 4 to find the listing of the sum of the indirect effects, and immediately proceed to the BSI anxiety and BSI depression panels, where we will find out how much indirect effect originates with either cumulative external dose or perceived exposure risk.

The sum of the indirect effects from each source to the endogenous variable on the upper left. To examine the results with respect to indirect effects on anxiety we go directly the "BSI anxiety" panel to find indirect effects from perceived risk of exposure. After sorting these effects by the size of the sum of their indirect effect, we identify two major sources of indirect effects from perceived exposure risk. Pre-eminent among these sources of indirect effects was the perceived exposure risk in 1986, the standardized coefficient magnitude of which is approximately twice that of the second largest impact–namely, that of fear of consuming contaminated food in 1986. The third largest indirect effect was on BSI anxiety was the percent belief in the proportion of pollution due to Chornobyl, with the fourth largest indirect effect being that of self-reported symptoms of depression in 1986. Fifth in the descending ranks of magnitudes of sums of indirect effects was that of physical ability. Next down the list was the extent to which the air and water in 1986 were hazardous, after which was the age of the respondent. Self-expressed depressive symptoms in the decade after Chornobyl was next going down the list of indirect effect on BSI anxiety. The next effect, cumdose1, was not statistically significant.

Before examining the sum of the indirect effects on BSI depression, we should recall that the direct effects on BSI depression included neither a path from reconstructed external dose nor from perceived risk of exposure. The statistically significant direct effects on BSI depression stemmed from BSI anxiety and Nottingham physical ability, but not the direct effect of sleep was not quite statistically significant (Table 3).

By sorting the standardized sums of indirect effects, we discovered a very interesting result. Nevertheless, the two largest tallies of indirect effects on wave 3 BSI depression included perceived exposure risk in the decade after Chornobyl and in 1986, respectively. Fear of consuming contaminated food was third largest. Next down the list of declining indirect impact was self-reported symptoms of depression in the decade after Chornobyl. Fifth down the list was physical ability as measured by the Nottingham. Sixth was the percent belief in the proportion of pollution deriving from Chornobyl in the decade after 1986. Seventh was self-expressed feelings of depression in 1986. However, we found no evidence of statistically significant indirect effects of cumulative external dose of radiation in this male model (Table 4). The concern for long-run deleterious effect for most of the population may not be warranted.

When we examine the sum of the indirect effects on Nottingham sleep behavior, by the same sorting described immediately above, we find that these standardized effects on the Nottingham sleep variable, we discover that the two largest sums of indirect effects are those of perceived risk of exposure in wave two ($crhtw2\ stdized\ \beta = 0.177$) and wave one (crhtw1 stdized $\beta = 0.150$).

However, further down the ranks to the smaller sums of indirect paths, we find one from cumulative external dose to sleep that is not statistically significant ($cumdose1\ stdized\ \beta = -0.0001, p = 0.665$), leaving us with little basis for believing that indirect effects from cumulative dose affect sleep measure in this model.

Table 3 Decomposition of effects: Direct effects

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
radchw2 <-					
depagw1	-.093878	.0428477	-2.19	0.028	-.0886703
cumdose1	2.655714	.6143069	4.32	0.000	.1302358
radchw1	.6243548	.0464084	13.45	0.000	.6565207
age	0	(no path)			0
whppa	.3441295	.0885185	3.89	0.000	.1470539
airw1	-.0670459	.0388998	-1.72	0.085	-.0714449
fdferw1	0	(no path)			0
crhtw2 <-					
radchw2	.0094791	.001602	5.92	0.000	.3485933
crhtw2	0	(no path)			0
depagw1	0	(no path)			0
crhtw1	.8351204	.0318508	26.22	0.000	.8442537
depagw2	.0081446	.0013258	6.14	0.000	.1484385
BSIanx	0	(no path)			0
cumdose1	-.0292823	.0093715	-3.12	0.002	-.0528085
radchw1	-.0080512	.0015821	-5.09	0.000	-.3113358
age	0	(no path)			0
whppa	.0046527	.0019655	2.37	0.018	.0731155
airw1	0	(no path)			0
fdferw1	0	(no path)			0
cumdose2 <-					
cumdose1	1.339597	.2873117	4.66	0.000	.8928449
cumdose3 <-					
cumdose2	1.087217	.0775735	14.02	0.000	1.019854
cumdose1	-.0439337	.0846185	-0.52	0.604	-.0274676

Continued...

Table 3 Decomposition of effects: Direct effects continued...

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
depagw1 <-					
radchw1	-.2255648	.0385603	-5.85	0.000	-.2511159
age	.2291889	.1084503	2.11	0.035	.0871474
airw1	.1277529	.037617	3.40	0.001	.1441306
fdferw1	.4034211	.0454174	8.88	0.000	.4890452
crhtw1 <-					
radchw2	0	(no path)			0
crhtw2	0	(no path)			0
depagw1	.0048837	.0018256	2.68	0.007	.1677987
crhtw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	-.1148348	.0390817	-2.94	0.003	-.3415511
cumdose1	0	(no path)			0
radchw1	0	(no path)			0
age	.0121176	.0044302	2.74	0.006	.1583131
whppa	.0104254	.0038295	2.72	0.006	.1620592
airw1	.0065012	.001561	4.16	0.000	.2520121
fdferw1	.0065179	.001664	3.92	0.000	.2714782
depagw2 <-					
depagw1	.2134912	.0519535	4.11	0.000	.40688
radchw1	0	(no path)			0
age	.2029756	.0570147	3.56	0.000	.1470927
airw1	-.0703643	.0226263	-3.11	0.002	-.1512949
fdferw1	.0562186	.0343449	1.64	0.102	.1298844
crhrw3 <-					
radchw2	0	(no path)			0
crhtw2	1.036497	.0362494	28.59	0.000	1.039724
depagw1	0	(no path)			0
crhtw1	-.1077892	.0386713	-2.79	0.005	-.1093073
depagw2	.0018722	.0008049	2.33	0.020	.0342278
BSIanx	0	(no path)			0
cumdose1	0	(no path)			0
radchw1	0	(no path)			0
age	0	(no path)			0
whppa	0	(no path)			0
airw1	0	(no path)			0
fdferw1	0	(no path)			0

Continued...

Table 3 Decomposition of effects: Direct effects continued...

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
BSIanx <-					
radchw2	0	(no path)			0
crhtw2	1.868707	.3448081	5.42	0.000	.6214915
depagw1	0	(no path)			0
crhtw1	0	(no path)			0
depagw2	.0257663	.0130751	1.97	0.049	.1561794
BSIanx	0	(no path)			0
cumdose1	0	(no path)			0
radchw1	0	(no path)			0
age	0	(no path)			0
whppa	0	(no path)			0
airw1	-.0184936	.0052776	-3.50	0.000	-.2410266
fdferw1	0	(no path)			0
whpsleep <-					
radchw2	0	(no path)			0
crhtw2	0	(no path)			0
depagw1	0	(no path)			0
crhtw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	2.988487	.5801398	5.15	0.000	.3365734
cumdose1	0	(no path)			0
radchw1	0	(no path)			0
age	.2483807	.0951416	2.61	0.009	.1228754
whppa	.3560758	.1140478	3.12	0.002	.2095894
airw1	0	(no path)			0
fdferw1	.1378615	.0317204	4.35	0.000	.2174301
BSIdep <-					
radchw2	0	(no path)			0
crhtw2	0	(no path)			0
depagw1	0	(no path)			0
crhtw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	.4953912	.0933942	5.30	0.000	.4817067
whpsleep	.0140118	.007848	1.79	0.074	.1209759
cumdose1	0	(no path)			0
radchw1	0	(no path)			0
age	0	(no path)			0
whppa	.0265236	.0121607	2.18	0.029	.1347922
airw1	0	(no path)			0
fdferw1	0	(no path)			0

Table 4 Indirect effects

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
radchw2 <-					
depagw1	0	(no path)			0
cumdose1	0	(no path)			0
radchw1	.0211756	.0100389	2.11	0.035	.0222665
age	-.0215158	.0135135	-1.59	0.111	-.0077274
whppa	0	(no path)			0
airw1	-.0119932	.0071154	-1.69	0.092	-.0127801
fdferw1	-.0378724	.0184354	-2.05	0.040	-.0433638
crhtw2 <-					
radchw2	-.0014406	.0002435	-5.92	0.000	-.0529775
crhtw2	-.1519751	.028042	-5.42	0.000	-.1519751
depagw1	.0037312	.0012964	2.88	0.004	.1296016
crhtw1	-.1269175	.0048405	-26.22	0.000	-.1283056
depagw2	-.0033333	.0010923	-3.05	0.002	-.06075
BSIanx	-.0813263	.0276778	-2.94	0.003	-.2445329
cumdose1	.0257983	.0066303	3.89	0.000	.0465253
radchw1	.0054009	.0012393	4.36	0.000	.2088482
age	.0104134	.0031478	3.31	0.001	.1375367
whppa	.0094425	.0026259	3.60	0.000	.1483857
airw1	.0057074	.0012105	4.71	0.000	.223659
fdferw1	.0063917	.0009577	6.67	0.000	.2691347
cumdose2 <-					
cumdose1	0	(no path)			0
cumdose3 <-					
cumdose2	0	(no path)			0
cumdose1	1.456433	.2682484	5.43	0.000	.9105718
depagw1 <-					
radchw1	0	(no path)			0
age	0	(no path)			0
airw1	0	(no path)			0
fdferw1	0	(no path)			0

Continued...

Table 4 continued...

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
crhtw1 <-					
radchw2	-.001725	.0002915	-5.92	0.000	-.0627507
crhtw2	-.1819799	.0335784	-5.42	0.000	-.1800112
depagw1	-.0014324	.0003178	-4.51	0.000	-.049215
crhtw1	-.1519751	.0057962	-26.22	0.000	-.1519751
depagw2	-.0039913	.001308	-3.05	0.002	-.071957
BSIanx	.017452	.0059395	2.94	0.003	.0519073
cumdose1	.0007476	.0017885	0.42	0.676	.0013337
radchw1	-.0003904	.0004538	-0.86	0.390	-.0149315
age	-.0018607	.001412	-1.32	0.188	-.0243097
whppa	-.0030247	.0015971	-1.89	0.058	-.0470183
airw1	.0016504	.0007119	2.32	0.020	.0639738
fdferw1	.0001774	.0009893	0.18	0.858	.0073888
depagw2 <-					
depagw1	0	(no path)			0
radchw1	-.0481561	.0145475	-3.31	0.001	-.102174
age	.0489298	.0272882	1.79	0.073	.0354585
airw1	.0272741	.0095268	2.86	0.004	.0586438
fdferw1	.0861269	.0216348	3.98	0.000	.1989827
crhrw3 <-					
radchw2	.0085179	.0014395	5.92	0.000	.3142179
crhtw2	-.1379063	.0254461	-5.42	0.000	-.1383356
depagw1	.003895	.0012013	3.24	0.001	.1357144
crhtw1	.7504316	.0286208	26.22	0.000	.7610005
depagw2	.0054172	.0014945	3.62	0.000	.0990373
BSIanx	-.0737977	.0251156	-2.94	0.003	-.2225866
cumdose1	-.0036917	.0083375	-0.44	0.658	-.0066785
radchw1	-.0027952	.0007928	-3.53	0.000	-.1084239
age	.0101595	.0028935	3.51	0.000	.134601
whppa	.0138119	.0025362	5.45	0.000	.2177253
airw1	.0049564	.0011361	4.36	0.000	.1948328
fdferw1	.0061698	.0009048	6.82	0.000	.2606
BSIanx <-					
radchw2	.0150217	.0025387	5.92	0.000	.1837227
crhtw2	-.283997	.0524023	-5.42	0.000	-.0944512
depagw1	.0124734	.002767	4.51	0.000	.1440926
crhtw1	1.323424	.0504743	26.22	0.000	.4449557
depagw2	.008991	.0028175	3.19	0.001	.0544977
BSIanx	-.1519751	.0517217	-2.94	0.003	-.1519751
cumdose1	-.0065106	.0149365	-0.44	0.663	-.0039049
radchw1	-.0061936	.0016437	-3.77	0.000	-.0796527
age	.0259503	.0070156	3.70	0.000	.1139887
whppa	.0263398	.0068459	3.85	0.000	.1376611
airw1	.0095552	.0036132	2.64	0.008	.124532
fdferw1	.0156119	.0026898	5.80	0.000	.2186272

Continued on the next page...

Table 4 continued...

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whpsleep <-					
radchw2	.0448922	.0075868	5.92	0.000	.0618362
crhtw2	4.735885	.873851	5.42	0.000	.1773877
depagw1	.0372765	.0082692	4.51	0.000	.0484977
crhtw1	3.955035	.1508417	26.22	0.000	.1497602
depagw2	.1038717	.0340385	3.05	0.002	.0709083
BSIanx	-.4541756	.1545696	-2.94	0.003	-.0511508
cumdose1	-.0194567	.0449783	-0.43	0.665	-.0013143
radchw1	-.0185093	.0062616	-2.96	0.003	-.026809
age	.0775522	.0257124	3.02	0.003	.0383655
whppa	.0787162	.0236244	3.33	0.001	.0463331
airw1	-.0267125	.0139968	-1.91	0.056	-.039209
fdferw1	.046656	.011922	3.91	0.000	.0735841
BSIdep <-					
radchw2	.0080706	.0013639	5.92	0.000	.0959811
crhtw2	.8514096	.1570995	5.42	0.000	.2753385
depagw1	.0067015	.0014866	4.51	0.000	.0752774
crhtw1	.7110295	.0271181	26.22	0.000	.2324555
depagw2	.0186739	.0061194	3.05	0.002	.1100628
BSIanx	-.039777	.0307042	-1.30	0.195	-.0386782
whpsleep	0	(no path)			0
cumdose1	-.0034979	.0080106	-0.44	0.662	-.00204
radchw1	-.0033276	.0010108	-3.29	0.001	-.0416125
age	.0174225	.0049794	3.50	0.000	.0744154
whppa	.0191407	.0051791	3.70	0.000	.0972727
airw1	-.0048023	.0023764	-2.02	0.043	-.0608596
fdferw1	.0103194	.0020034	5.15	0.000	.1405199

4.1.3 Findings concerning total effects

To be able to add direct and indirect effects to obtain total effects, we warn that we have to be able to assume linearity and additivity of effects. Moreover, this may be difficult to do when the sum may be greater than the component parts, particularly when there is a class between a positive direct and a negative tally of added indirect effects. The perspectival paradigms may generate cognitive dissonances that may not be easily and happily resolved, leaving the negatives to outweigh the positives among the pessimists and the positives to outweigh the negatives among the optimists, and leaving others to ponder if not brood over how to proceed with their lives. Others may not worry about such things.

Until the psychologists come up with an alternative calculus for total effects, we will make the working assumption of additivity and linearity of effects on the part of male respondents so this problem will not bog us down. To appreciate the total effects of radiation and risk of exposure on anxiety, depression, and sleep, we turn to Table 5 and direct our attention to those panels.

Table 5 Total effects

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
radchw2 <-					
depagw1	-.093878	.0428477	-2.19	0.028	-.0886703
cumdose1	2.655714	.6143069	4.32	0.000	.1302358
radchw1	.6455304	.0416932	15.48	0.000	.6787872
age	-.0215158	.0135135	-1.59	0.111	-.0077274
whppa	.3441295	.0885185	3.89	0.000	.1470539
airw1	-.079039	.0372871	-2.12	0.034	-.0842251
fdferw1	-.0378724	.0184354	-2.05	0.040	-.0433638
crhtw2 <-					
radchw2	.0080386	.0013585	5.92	0.000	.2956158
crhtw2	-.1519751	.028042	-5.42	0.000	-.1519751
depagw1	.0037312	.0012964	2.88	0.004	.1296016
crhtw1	.7082029	.0270103	26.22	0.000	.7159482
depagw2	.0048113	.0015077	3.19	0.001	.0876885
BSIanx	-.0813263	.0276778	-2.94	0.003	-.2445329
cumdose1	-.003484	.0078851	-0.44	0.659	-.0062831
radchw1	-.0026504	.0007693	-3.45	0.001	-.1024876
age	.0104134	.0031478	3.31	0.001	.1375367
whppa	.0140952	.0026125	5.40	0.000	.2215012
airw1	.0057074	.0012105	4.71	0.000	.223659
fdferw1	.0063917	.0009577	6.67	0.000	.2691347
cumdose2 <-					
cumdose1	1.339597	.2873117	4.66	0.000	.8928449
cumdose3 <-					
cumdose2	1.087217	.0775735	14.02	0.000	1.019854
cumdose1	1.412499	.3182587	4.44	0.000	.8831041
depagw1 <-					
radchw1	-.2255648	.0385603	-5.85	0.000	-.2511159
age	.2291889	.1084503	2.11	0.035	.0871474
airw1	.1277529	.037617	3.40	0.001	.1441306
fdferw1	.4034211	.0454174	8.88	0.000	.4890452
crhtw1 <-					
radchw2	-.001725	.0002915	-5.92	0.000	-.0627507
crhtw2	-.1819799	.0335784	-5.42	0.000	-.1800112
depagw1	.0034513	.0016185	2.13	0.033	.1185837
crhtw1	-.1519751	.0057962	-26.22	0.000	-.1519751
depagw2	-.0039913	.001308	-3.05	0.002	-.071957
BSIanx	-.0973828	.0331423	-2.94	0.003	-.2896438
cumdose1	.0007476	.0017885	0.42	0.676	.0013337
radchw1	-.0003904	.0004538	-0.86	0.390	-.0149315
age	.0102569	.0037359	2.75	0.006	.1340033
whppa	.0074007	.0031722	2.33	0.020	.1150409
airw1	.0081516	.001294	6.30	0.000	.3159859
fdferw1	.0066953	.0010796	6.20	0.000	.278867

Continued on the next page...

Table 5 Total effects - continued:

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
depagw2 <-					
depagw1	.2134912	.0519535	4.11	0.000	.40688
radchw1	-.0481561	.0145475	-3.31	0.001	-.102174
age	.2519054	.0640369	3.93	0.000	.1825512
airw1	-.0430902	.0226668	-1.90	0.057	-.0926511
fdferw1	.1423455	.0243998	5.83	0.000	.3288671
crhrw3 <-					
radchw2	.0085179	.0014395	5.92	0.000	.3142179
crhtw2	.8985909	.0429053	20.94	0.000	.9013884
depagw1	.003895	.0012013	3.24	0.001	.1357144
crhtw1	.6426425	.0449893	14.28	0.000	.6516932
depagw2	.0072894	.0015972	4.56	0.000	.1332651
BSIanx	-.0737977	.0251156	-2.94	0.003	-.2225866
cumdose1	-.0036917	.0083375	-0.44	0.658	-.0066785
radchw1	-.0027952	.0007928	-3.53	0.000	-.1084239
age	.0101595	.0028935	3.51	0.000	.134601
whppa	.0138119	.0025362	5.45	0.000	.2177253
airw1	.0049564	.0011361	4.36	0.000	.1948328
fdferw1	.0061698	.0009048	6.82	0.000	.2606
BSIanx <-					
radchw2	.0150217	.0025387	5.92	0.000	.1837227
crhtw2	1.58471	.2924058	5.42	0.000	.5270402
depagw1	.0124734	.002767	4.51	0.000	.1440926
crhtw1	1.323424	.0504743	26.22	0.000	.4449557
depagw2	.0347573	.0113899	3.05	0.002	.2106771
BSIanx	-.1519751	.0517217	-2.94	0.003	-.1519751
cumdose1	-.0065106	.0149365	-0.44	0.663	-.0039049
radchw1	-.0061936	.0016437	-3.77	0.000	-.0796527
age	.0259503	.0070156	3.70	0.000	.1139887
whppa	.0263398	.0068459	3.85	0.000	.1376611
airw1	-.0089385	.0042483	-2.10	0.035	-.1164946
fdferw1	.0156119	.0026898	5.80	0.000	.2186272
whpsleep <-					
radchw2	.0448922	.0075868	5.92	0.000	.0618362
crhtw2	4.735885	.873851	5.42	0.000	.1773877
depagw1	.0372765	.0082692	4.51	0.000	.0484977
crhtw1	3.955035	.1508417	26.22	0.000	.1497602
depagw2	.1038717	.0340385	3.05	0.002	.0709083
BSIanx	2.534311	.6339816	4.00	0.000	.2854226
cumdose1	-.0194567	.0449783	-0.43	0.665	-.0013143
radchw1	-.0185093	.0062616	-2.96	0.003	-.026809
age	.325933	.0959862	3.40	0.001	.161241
whppa	.434792	.1159941	3.75	0.000	.2559224
airw1	-.0267125	.0139968	-1.91	0.056	-.039209
fdferw1	.1845175	.0311076	5.93	0.000	.2910142

Continued...

Table 5 Total effects - continued:

(Std. Err. adjusted for 339 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
BSIdep <-					
radchw2	.0080706	.0013639	5.92	0.000	.0959811
crhtw2	.8514096	.1570995	5.42	0.000	.2753385
depagw1	.0067015	.0014866	4.51	0.000	.0752774
crhtw1	.7110295	.0271181	26.22	0.000	.2324555
depagw2	.0186739	.0061194	3.05	0.002	.1100628
BSIanx	.4556142	.1044693	4.36	0.000	.4430286
whpsleep	.0140118	.007848	1.79	0.074	.1209759
cumdose1	-.0034979	.0080106	-0.44	0.662	-.00204
radchw1	-.0033276	.0010108	-3.29	0.001	-.0416125
age	.0174225	.0049794	3.50	0.000	.0744154
whppa	.0456643	.012677	3.60	0.000	.232065
airw1	-.0048023	.0023764	-2.02	0.043	-.0608596
fdferw1	.0103194	.0020034	5.15	0.000	.1405199

Let's consider BSI anxiety first. The only total effect that we find is that of reconstructed radiation dose in 1986 ($cumdose1\ stdized\ \beta = -0.004, p = 0.663$). There was no total effect of cumulative dose for waves 2 or 3 on anxiety. As we indicated, this representative sample was drawn from randomly generated telephone numbers numbers by a computer, so that each person presumably had approximately the same chance of his number having been selected and the average person resided some 77 miles from the accident site, which was safely beyond the exclusion zone, notwithstanding meteorological vagaries or a risk of contamination of the food and/or fluid supply.

If we put these total effects on wave 3 anxiety into perspective, we find that the sources of anxiety were in decreasing order of magnitude were: 1) Perceived risk of exposure to radiation in the decade after Chornobyl 2) Perceived risk of exposure to radiation in 1986, 3) fear of consuming contaminated food in 1986, 4) self-reported depressive symptoms in decade after 1986, 5) Percent belief in proportion of pollution due to Chornobyl, 6) self-reported depressive symptoms in 1986, 7 Nottingham measured physical ability, 8) age of respondent, and 8) the statistically nonsignificant cumulative external dose in 1986 (see Table 5 std coefficients).

In terms of total effects upon BSI depression in Table 5, we find that the sources of depression measured by wave 3 BSI, were in order of decreasing magnitude: 1) BSI anxiety, 2) perceived risk of radiation exposure in the decade after Chornobyl, 3) perceived risk of radiation exposure in 1986, 3) Nottingham measured physical ability, 4) fear of consuming contaminated food, 5) Nottingham measured sleep or lack thereof, 6) self-reported depressive symptoms in 1987-1996, 6) the proportion of pollution due to Chornobyl, and self-reported depressive symptoms in 1986, 7) the respondent's age, and 8) statistically nonsignificant cumulative external dose in milliGrays. In short, we find that male anxiety and depression in wave three, although not at all irrational in light of the official record of candor and forthrightness about the nature of the radiological danger, is not based on statistical evidence of actual exposure. Perhaps this will lighten the load of historical baggage on the part of the male population and free them from this burden so they can live more normal lives.

As for the total effects on sleep, the largest was that of fear of eating contaminated food, second largest was that of anxiety (BSI), third was that of physical ability, fourth was perceived risk of exposure in the decade after Chornobyl, fifth was age, and sixth largest was that of perceived risk of exposure in 1986. Self-reported depressive symptoms in 1987-1996, belief in the proportion of pollution due to Chornobyl, self-expressed depressive symptoms in 1986. The next largest was cumulative external dose in 1986, which was not statistically significant (Table 5).

4.2 The female model

The female dose-psychological and physical response model is a little more complex than that of the males insofar as it contains more endogenous measures. We not only include cumulative external dose but also measures of perceived risk of exposure in all three waves. Among the several BSI measures in this model, there are measures of the positive symptoms, anxiety, and depression. The Nottingham measures of physical health and health behavior in this model include sleep, energy level, and physical ability measures. We color the direct effects among the perceived Chornobyl health risk magenta and the direct affects emanating from cumulative external dose in red to guide the reader. This provides an initial focal point as a guide to departing upon our journey toward extracting order from this apparent chaos.

Figure 2 depicts the paths which we will explain in terms of the hypotheses tested. To help explain these interrelationships, we provide the list of variable names and labels for the female model in Table 6 and we present the listing of these paths in Table 7. It should be noted that this model fits the data well. The likelihood $\chi^2 = 174.48$, $df = 185$, $p = 0.6994$.. The stability index = .962, suggesting that all eigenvalues reside within the unit circle and that the model satisfies the conditions of stability. Table 8 presents the clustered robust output with autocorrelated and heteroskedasticly corrected asymptotic standard errors. We turn to Table 9, 10, and 11 to examine the direct, indirect, and total effects in connection with the related hypotheses.

4.2.1 Findings concerning the direct effects

To help us analyze the direct effects, we examine Table 8. We first focus on the cumulative external dose as a source of effects and find that in wave one, there are several statistically significant direct effects emanating it. First, there is a statistically significant direct effect from dose to depression for female respondents (b = 1.00 z=2.74, p=.006). However, the sum of the indirect effects on depression, measured by the BSI depression score, is also statistically significant (b= 0.415 z=2.72 p=0.007). The total effect (b=1.415 z=3.37 p=.001) is also statistically significant.

If we accept the self-reported depression in waves one and two as measures, we find no direct effect in either waves one or two, but the sum of the seven indirect paths are (b=13.933 z=2.97 p=0.007) in wave one and in wave two (b=5.024 z=3.04 p=0.002) are substantial. They are a much larger impacts than that measured by the Brief symptom inventory. They comprise evidence that the mediating or indirect effects are significant and in some cases more substantial than conventionally measured direct effects in cases of cumulative external dose on depression for Ukrainian female residents of Zhitomyr and Kiev Oblasts.

Table 6 Variable names and labels for Figure 2 and Tables relating to female model

fdferw1	byte	%8.0g	* Level (in %) of fear of eating radioactively contaminated food in 1986
cumdose1	float	%9.0g	cumulative external dose in mGys in wave 1
cumdose2	float	%9.0g	cumulative external dose in mGys in wave 2
cumdose3	float	%9.0g	cumulative external dose in mGys in wave 3
crhrw1	float	%9.0g	Chornobyl related health risk: wave 1 alpha = .796
crhrw2	float	%9.0g	Chornobyl related health risk: wave 2 alpha = .822
crhrw3	float	%9.0g	Chornobyl related health risk: wave 3 alpha = .834
medcow1	byte	%8.0g	number of medical visits for a medical condition per year 1976-1986
medcow2	byte	%8.0g	number of medical visits for a medical condition per year 1987-1996
medcow3	byte	%8.0g	number of medical visits for a medical condition per year 1997-now
age	byte	%8.0g	* Respondent´s age
injselfr	byte	%9.0g	Were u injured because of Chornobyl acc in 1986?
depagw1	byte	%9.0g	Depression aggregated to wave 1 in 1986
depagw2	double	%9.0g	Depression aggregated to wave 2: 1987 thru 1996
BSIdep	byte	%9.0g	Brief symptom inventory depression subscale score
anxagw1	byte	%9.0g	Average Anxiety level for wave 1
anxagw2	double	%9.0g	Average Anxiety level for wave 2
BSIanx	byte	%9.0g	Brief symptom inventory anxiety subscale score
BSIposymp	int	%9.0g	Brief Symptom inventory positive symptom total subscale
illw1	byte	%8.0g	Total number of illnesses experienced in time period
illw2	byte	%8.0g	Total number of illnesses experienced

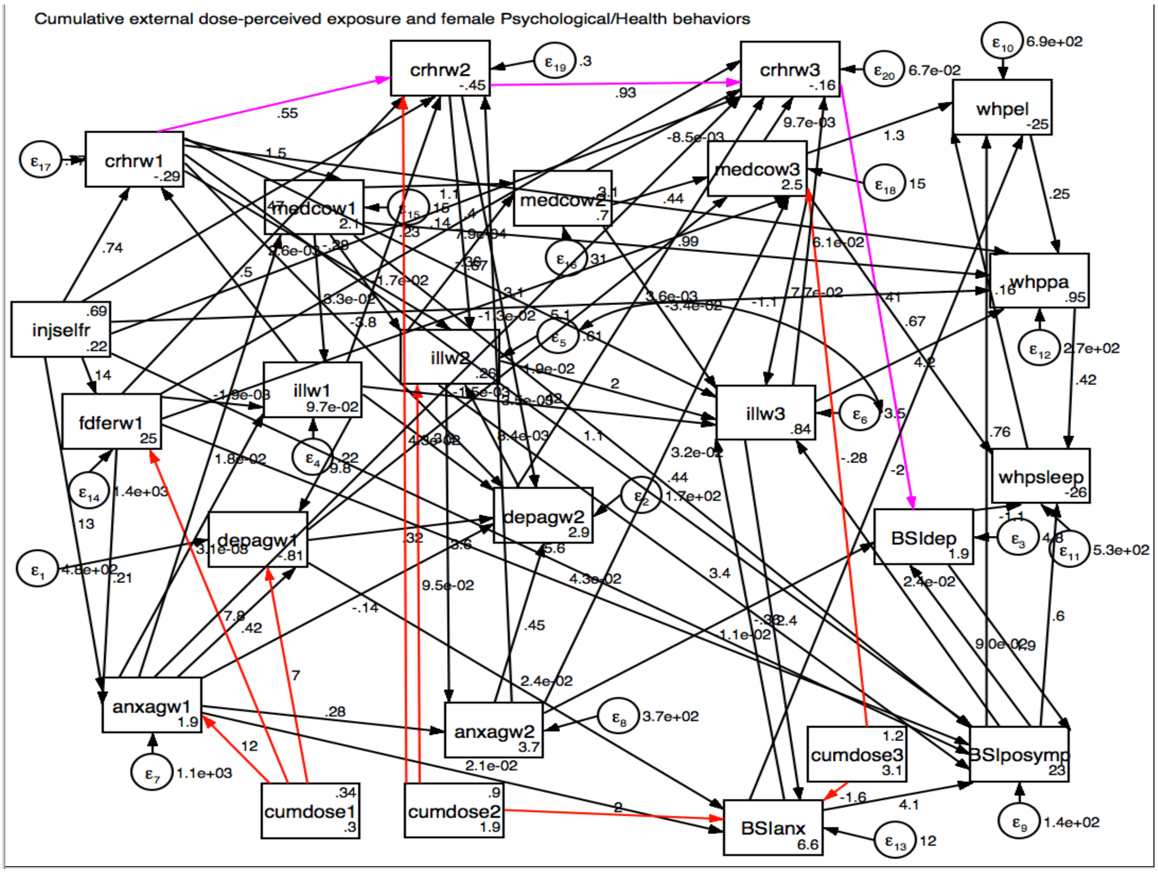

Figure 2: Dose-depression robust path diagram for females

```
                                                           in time period
                                                             1987-1996
illw3           byte    %8.0g                            Total number of illnesses
                                                           experienced in time period
                                                           1996-NOW
whpsleep        float   %9.0g                            Nottingham sleep subscale
whpel           float   %9.0g                            Nottingham energy level subscale
whppa           float   %9.0g                            Nottingham physical ability
                                                           subscale

        end of variable names and labels for female model
```

Table 7 Female cumulative external dose, perceived exposure risk, psychological and physical response model

Endogenous variables

Observed: depagw1 depagw2 BSIanx medcow3 illw2 crhrw3 BSIdep BSIposymp whpsleep illw1 illw3 crhrw1 crhrw2 anxagw2 medcow2 whppa anxagw1 medcow1 whpel fdferw1

Exogenous variables

Observed: injselfr cumdose1 cumdose2 cumdose3

Structural equation model Number of obs = 360
Estimation method = ml
Log likelihood = -22255.815

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
depagw1 <-						
illw1	9.792269	2.383065	4.11	0.000	5.121548	14.46299
anxagw1	.4163872	.0343997	12.10	0.000	.3489651	.4838094
cumdose1	6.970709	2.156049	3.23	0.001	2.74493	11.19649
_cons	-.8094252	1.494901	-0.54	0.588	-3.739377	2.120526
depagw2 <-						
depagw1	.3230697	.0312513	10.34	0.000	.2618182	.3843211
illw1	3.315657	1.509467	2.20	0.028	.3571546	6.274158
crhrw1	-3.826883	1.060841	-3.61	0.000	-5.906094	-1.747673
crhrw2	3.136258	1.159577	2.70	0.007	.8635282	5.408988
anxagw2	.4528473	.0357539	12.67	0.000	.382771	.5229235
anxagw1	-.1367064	.0270073	-5.06	0.000	-.1896398	-.0837729
_cons	2.94718	.8589524	3.43	0.001	1.263665	4.630696
BSIanx <-						
depagw1	.0235434	.008415	2.80	0.005	.0070504	.0400364
illw3	2.449876	.2918139	8.40	0.000	1.877932	3.021821
anxagw1	.0209484	.0066252	3.16	0.002	.0079632	.0339336
cumdose2	2.039526	.8317915	2.45	0.014	.4092452	3.669808
cumdose3	-1.647574	.6617384	-2.49	0.013	-2.944558	-.3505909
_cons	6.613891	.2879772	22.97	0.000	6.049466	7.178316
medcow3 <-						
depagw1	.0186108	.0077709	2.39	0.017	.00338	.0338416
anxagw2	.0316561	.0095703	3.31	0.001	.0128987	.0504134
medcow2	.4384699	.0295481	14.84	0.000	.3805568	.4963831
fdferw1	-.0127401	.0056223	-2.27	0.023	-.0237595	-.0017207
cumdose3	-.2802811	.1198321	-2.34	0.019	-.5151476	-.0454146
_cons	2.529274	.3269219	7.74	0.000	1.888519	3.170029

Continued...

Table 7 continued:

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
illw2 <-						
depagw2	.0083969	.0018012	4.66	0.000	.0048667	.0119272
crhrw1	-.2825861	.0562134	-5.03	0.000	-.3927624	-.1724099
crhrw2	.3970329	.055161	7.20	0.000	.2889193	.5051465
medcow1	-.0170443	.0078919	-2.16	0.031	-.0325121	-.0015765
cumdose2	.0948242	.0212138	4.47	0.000	.0532459	.1364025
_cons	.2583383	.0534123	4.84	0.000	.1536521	.3630245
crhrw3 <-						
depagw2	.0036474	.0007761	4.70	0.000	.0021263	.0051685
medcow3	.0096525	.0034799	2.77	0.006	.002832	.0164729
illw3	.0611431	.0124677	4.90	0.000	.0367069	.0855794
crhrw2	.925388	.0187656	49.31	0.000	.888608	.962168
medcow2	-.0084943	.0025082	-3.39	0.001	-.0134102	-.0035784
anxagw1	-.0015415	.00043	-3.58	0.000	-.0023844	-.0006986
fdferw1	.0007906	.0003864	2.05	0.041	.0000332	.001548
injselfr	.1376517	.0346674	3.97	0.000	.0697049	.2055985
_cons	-.1621874	.0300203	-5.40	0.000	-.2210261	-.1033488
BSIdep <-						
crhrw3	.4067761	.1453172	2.80	0.005	.1219595	.6915926
BSIposymp	.0903483	.0063868	14.15	0.000	.0778304	.1028662
anxagw2	-.0113743	.0055454	-2.05	0.040	-.022243	-.0005056
_cons	1.888787	.5393435	3.50	0.000	.8316928	2.945881
BSIpos~p <-						
BSIanx	4.105985	.2998383	13.69	0.000	3.518313	4.693657
illw2	3.397684	.8133658	4.18	0.000	1.803517	4.991852
BSIdep	1.917203	.325494	5.89	0.000	1.279246	2.555159
crhrw1	1.077694	.7714241	1.40	0.162	-.4342689	2.589658
medcow1	.4385798	.161399	2.72	0.007	.1222435	.754916
fdferw1	.043344	.0174328	2.49	0.013	.0091763	.0775117
injselfr	5.607952	1.563045	3.59	0.000	2.54444	8.671465
_cons	22.99451	2.474651	9.29	0.000	18.14429	27.84474
whpsleep <-						
medcow3	.6678517	.2438921	2.74	0.006	.1898319	1.145872
BSIdep	-1.117785	.5608258	-1.99	0.046	-2.216983	-.0185865
BSIposymp	.6036404	.0782958	7.71	0.000	.4501836	.7570973
whppa	.4152616	.067414	6.16	0.000	.2831326	.5473906
_cons	-25.55277	3.998744	-6.39	0.000	-33.39017	-17.71538
illw1 <-						
anxagw1	.0030794	.0007473	4.12	0.000	.0016148	.0045441
medcow1	.0325509	.0068287	4.77	0.000	.0191669	.0459348
fdferw1	-.0019308	.0006889	-2.80	0.005	-.0032811	-.0005806
_cons	.0972021	.0385294	2.52	0.012	.0216859	.1727182

Continued....

Table 7 continued:

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
illw3 <-						
BSIanx	-.3602456	.0597563	-6.03	0.000	-.4773659	-.2431253
medcow3	.0773526	.0171196	4.52	0.000	.0437988	.1109064
illw2	2.013229	.3077053	6.54	0.000	1.410137	2.61632
BSIposymp	.0239693	.0054364	4.41	0.000	.0133141	.0346245
illw1	.4223779	.1491495	2.83	0.005	.1300502	.7147056
crhrw1	-.3646996	.1094545	-3.33	0.001	-.5792265	-.1501726
medcow2	-.0342891	.0129091	-2.66	0.008	-.0595905	-.0089878
_cons	.8432319	.3150589	2.68	0.007	.2257279	1.460736
crhrw1 <-						
illw1	-.497547	.1044483	-4.76	0.000	-.702262	-.292832
injselfr	.7351058	.100856	7.29	0.000	.5374317	.9327799
_cons	-.2876322	.0829841	-3.47	0.001	-.4502781	-.1249863
crhrw2 <-						
illw1	.2284674	.0601546	3.80	0.000	.1105666	.3463682
crhrw1	.5476816	.0332719	16.46	0.000	.4824698	.6128934
anxagw2	.0034734	.0013772	2.52	0.012	.000774	.0061727
fdferw1	.0025973	.0007995	3.25	0.001	.0010302	.0041644
injselfr	.4733239	.0683817	6.92	0.000	.3392982	.6073495
cumdose2	.0432457	.0211564	2.04	0.041	.0017799	.0847114
_cons	-.4450734	.0587807	-7.57	0.000	-.5602814	-.3298654
anxagw2 <-						
illw2	3.592459	1.299615	2.76	0.006	1.04526	6.139658
anxagw1	.2831393	.0291825	9.70	0.000	.2259426	.3403361
_cons	3.723282	1.281806	2.90	0.004	1.210987	6.235576
medcow2 <-						
illw2	.6694346	.3301301	2.03	0.043	.0223914	1.316478
medcow1	1.058045	.0703431	15.04	0.000	.9201749	1.195915
_cons	.695324	.3763194	1.85	0.065	-.0422485	1.432896
whppa <-						
illw3	4.244149	.8344537	5.09	0.000	2.60865	5.879649
crhrw1	3.086825	1.078381	2.86	0.004	.9732366	5.200412
medcow1	.9892521	.2225502	4.45	0.000	.5530618	1.425442
whpel	.2485385	.0277822	8.95	0.000	.1940863	.3029906
injselfr	5.147011	2.086334	2.47	0.014	1.057871	9.23615
_cons	.9483559	1.712053	0.55	0.580	-2.407207	4.303919
anxagw1 <-						
fdferw1	.2089858	.0466116	4.48	0.000	.1176287	.3003428
injselfr	12.65965	3.797455	3.33	0.001	5.216776	20.10252
cumdose1	11.77704	3.174534	3.71	0.000	5.555072	17.99902
_cons	1.941381	3.389721	0.57	0.567	-4.702351	8.585113
medcow1 <-						
crhrw1	1.516698	.2410805	6.29	0.000	1.044189	1.989207
anxagw1	.0176617	.0058987	2.99	0.003	.0061004	.029223
_cons	2.072729	.2455291	8.44	0.000	1.591501	2.553957

Continued on the next page...

Table 7 continued:

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
whpel <-						
BSIanx	-1.96893	.6525338	-3.02	0.003	-3.247872	-.6899869
medcow3	1.30711	.2811047	4.65	0.000	.7561551	1.858065
BSIposymp	.7550155	.0922893	8.18	0.000	.5741318	.9358993
whpsleep	.161302	.0613171	2.63	0.009	.0411227	.2814813
_cons	-25.31982	4.883089	-5.19	0.000	-34.8905	-15.74915
fdferw1 <-						
injselfr	13.84293	4.231418	3.27	0.001	5.549507	22.13636
cumdose1	7.764987	3.566101	2.18	0.029	.775558	14.75442
_cons	25.33306	3.592751	7.05	0.000	18.2914	32.37472
Variance						
e.depagw1	480.1144	35.78561			414.8584	555.6349
e.depagw2	172.4914	12.86218			149.0376	199.6361
e.BSIanx	12.40073	1.435438			9.88364	15.55885
e.medcow3	15.23561	1.135595			13.16482	17.63213
e.illw2	.6123116	.0459151			.5286203	.7092529
e.crhrw3	.0666203	.0049656			.0575653	.0770996
e.BSIdep	4.794159	.3944471			4.080172	5.633087
e.BSIposymp	143.8491	14.92101			117.3856	176.2786
e.whpsleep	526.1998	39.32713			454.4997	609.2111
e.illw1	.2245922	.0168919			.1938094	.2602644
e.illw3	3.473916	.803432			2.207787	5.466149
e.crhrw1	.7703395	.0579389			.6647546	.8926946
e.crhrw2	.3001869	.0224113			.2593241	.3474886
e.anxagw2	374.0492	28.36548			322.3881	433.9886
e.medcow2	30.77471	2.293812			26.59189	35.61548
e.whppa	271.6195	20.27141			234.6575	314.4036
e.anxagw1	1072.493	79.93892			926.7225	1241.193
e.medcow1	15.42933	1.156031			13.32206	17.86992
e.whpel	694.5317	52.53352			598.8365	805.5192
e.fdferw1	1371.211	102.204			1184.839	1586.898
Covariance						
e.illw2						
e.illw3	-1.109058	.2083522	-5.32	0.000	-1.517421	-.700695

LR test of model vs. saturated: chi2(185) = 174.48, Prob > chi2 = 0.6994

Stability analysis of simultaneous equation systems

stability index = .9616202

Table 8 Cluster robust version of the female model

Endogenous variables

Observed: depagw1 depagw2 BSIanx medcow3 illw2 crhrw3 BSIdep BSIposymp whpsleep illw1 illw3 crhrw1 crhrw2 anxagw2 medcow2 whppa anxagw1 medcow1 whpel fdferw1

Exogenous variables

Observed: injselfr cumdose1 cumdose2 cumdose3

Structural equation model   Number of obs = 360
Estimation method = ml
Log pseudolikelihood= -22255.815

(Std. Err. adjusted for 360 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
depagw1 <-						
illw1	9.792269	2.810517	3.48	0.000	4.283757	15.30078
anxagw1	.4163872	.0536479	7.76	0.000	.3112393	.5215352
cumdose1	6.970709	3.433148	2.03	0.042	.2418619	13.69956
_cons	-.8094252	1.318778	-0.61	0.539	-3.394182	1.775331
depagw2 <-						
depagw1	.3230697	.0593149	5.45	0.000	.2068146	.4393247
illw1	3.315657	2.327519	1.42	0.154	-1.246196	7.877509
crhrw1	-3.826883	1.24072	-3.08	0.002	-6.258651	-1.395116
crhrw2	3.136258	1.166022	2.69	0.007	.8508967	5.421619
anxagw2	.4528473	.0673497	6.72	0.000	.3208443	.5848502
anxagw1	-.1367064	.0390617	-3.50	0.000	-.2132658	-.0601469
_cons	2.94718	.6234849	4.73	0.000	1.725172	4.169188
BSIanx <-						
depagw1	.0235434	.0080816	2.91	0.004	.0077037	.039383
illw3	2.449876	.3909311	6.27	0.000	1.683666	3.216087
anxagw1	.0209484	.0072627	2.88	0.004	.0067137	.0351831
cumdose2	2.039526	1.293794	1.58	0.115	-.4962627	4.575316
cumdose3	-1.647574	1.062973	-1.55	0.121	-3.730962	.4358135
_cons	6.613891	.2539099	26.05	0.000	6.116237	7.111545
medcow3 <-						
depagw1	.0186108	.0109562	1.70	0.089	-.0028629	.0400845
anxagw2	.0316561	.0115299	2.75	0.006	.0090579	.0542542
medcow2	.4384699	.0757898	5.79	0.000	.2899246	.5870152
fdferw1	-.0127401	.0064191	-1.98	0.047	-.0253212	-.000159
cumdose3	-.2802811	.1188318	-2.36	0.018	-.5131872	-.047375
_cons	2.529274	.294567	8.59	0.000	1.951933	3.106615
illw2 <-						
depagw2	.0083969	.0030066	2.79	0.005	.002504	.0142898
crhrw1	-.2825861	.0704198	-4.01	0.000	-.4206064	-.1445658
crhrw2	.3970329	.0719886	5.52	0.000	.2559378	.538128
medcow1	-.0170443	.0097031	-1.76	0.079	-.036062	.0019734
cumdose2	.0948242	.0297829	3.18	0.001	.0364508	.1531976
_cons	.2583383	.0499686	5.17	0.000	.1604016	.356275

Continued...

Table 8 continued:

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
crhrw3 <-						
depagw2	.0036474	.0009793	3.72	0.000	.0017279	.0055669
medcow3	.0096525	.0048475	1.99	0.046	.0001515	.0191534
illw3	.0611431	.0161024	3.80	0.000	.0295829	.0927034
crhrw2	.925388	.0162683	56.88	0.000	.8935027	.9572732
medcow2	-.0084943	.0036046	-2.36	0.018	-.0155592	-.0014294
anxagw1	-.0015415	.0004625	-3.33	0.001	-.0024481	-.000635
fdferw1	.0007906	.0003774	2.09	0.036	.0000509	.0015303
injselfr	.1376517	.037219	3.70	0.000	.0647038	.2105996
_cons	-.1621874	.0303271	-5.35	0.000	-.2216275	-.1027474
BSIdep <-						
crhrw3	.4067761	.150314	2.71	0.007	.1121662	.701386
BSIposymp	.0903483	.0079942	11.30	0.000	.07468	.1060166
anxagw2	-.0113743	.0047141	-2.41	0.016	-.0206138	-.0021347
_cons	1.888787	.6192929	3.05	0.002	.6749949	3.102579
BSIpos~p <-						
BSIanx	4.105985	.3805595	10.79	0.000	3.360102	4.851868
illw2	3.397684	1.019818	3.33	0.001	1.398877	5.396491
BSIdep	1.917203	.369867	5.18	0.000	1.192277	2.642129
crhrw1	1.077694	.7939411	1.36	0.175	-.4784016	2.633791
medcow1	.4385798	.1915041	2.29	0.022	.0632386	.8139209
fdferw1	.043344	.0187452	2.31	0.021	.0066042	.0800839
injselfr	5.607952	1.321709	4.24	0.000	3.01745	8.198454
_cons	22.99451	2.730157	8.42	0.000	17.6435	28.34552
whpsleep <-						
medcow3	.6678517	.2268386	2.94	0.003	.2232563	1.112447
BSIdep	-1.117785	.6217303	-1.80	0.072	-2.336354	.1007842
BSIposymp	.6036404	.0859285	7.02	0.000	.4352236	.7720573
whppa	.4152616	.0788069	5.27	0.000	.2608029	.5697202
_cons	-25.55277	3.61909	-7.06	0.000	-32.64606	-18.45949
illw1 <-						
anxagw1	.0030794	.0011302	2.72	0.006	.0008642	.0052947
medcow1	.0325509	.0111559	2.92	0.004	.0106857	.054416
fdferw1	-.0019308	.000791	-2.44	0.015	-.0034812	-.0003805
_cons	.0972021	.0317444	3.06	0.002	.0349841	.15942
illw3 <-						
BSIanx	-.3602456	.086608	-4.16	0.000	-.5299941	-.1904971
medcow3	.0773526	.0222972	3.47	0.001	.0336509	.1210543
illw2	2.013229	.4849667	4.15	0.000	1.062712	2.963746
BSIposymp	.0239693	.0070887	3.38	0.001	.0100757	.0378629
illw1	.4223779	.178631	2.36	0.018	.0722675	.7724883
crhrw1	-.3646996	.12953	-2.82	0.005	-.6185736	-.1108255
medcow2	-.0342891	.0168576	-2.03	0.042	-.0673294	-.0012489
_cons	.8432319	.3307397	2.55	0.011	.194994	1.49147

Continued....

Table 8 continued:

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
crhrw1 <-						
illw1	-.497547	.1123862	-4.43	0.000	-.7178199	-.277274
injselfr	.7351058	.099048	7.42	0.000	.5409753	.9292363
_cons	-.2876322	.0753083	-3.82	0.000	-.4352338	-.1400305
crhrw2 <-						
illw1	.2284674	.0632985	3.61	0.000	.1044046	.3525303
crhrw1	.5476816	.0408433	13.41	0.000	.4676303	.6277329
anxagw2	.0034734	.0012076	2.88	0.004	.0011064	.0058403
fdferw1	.0025973	.000828	3.14	0.002	.0009744	.0042203
injselfr	.4733239	.0779942	6.07	0.000	.320458	.6261897
cumdose2	.0432457	.0170781	2.53	0.011	.0097732	.0767181
_cons	-.4450734	.0587899	-7.57	0.000	-.5602994	-.3298474
anxagw2 <-						
illw2	3.592459	1.852712	1.94	0.052	-.0387905	7.223709
anxagw1	.2831393	.048295	5.86	0.000	.1884829	.3777958
_cons	3.723282	.9074527	4.10	0.000	1.944707	5.501857
medcow2 <-						
illw2	.6694346	.2569322	2.61	0.009	.1658567	1.173012
medcow1	1.058045	.2299723	4.60	0.000	.6073074	1.508782
_cons	.695324	.3800501	1.83	0.067	-.0495606	1.440209
whppa <-						
illw3	4.244149	.8278314	5.13	0.000	2.62163	5.866669
crhrw1	3.086825	1.030954	2.99	0.003	1.066192	5.107457
medcow1	.9892521	.2823759	3.50	0.000	.4358056	1.542699
whpel	.2485385	.0318121	7.81	0.000	.1861879	.3108891
injselfr	5.147011	1.826874	2.82	0.005	1.566403	8.727619
_cons	.9483559	1.548867	0.61	0.540	-2.087369	3.98408
anxagw1 <-						
fdferw1	.2089858	.0508552	4.11	0.000	.1093114	.3086601
injselfr	12.65965	3.322472	3.81	0.000	6.147726	19.17157
cumdose1	11.77704	4.40861	2.67	0.008	3.136326	20.41776
_cons	1.941381	2.555255	0.76	0.447	-3.066827	6.94959
medcow1 <-						
crhrw1	1.516698	.3100721	4.89	0.000	.9089675	2.124428
anxagw1	.0176617	.0069531	2.54	0.011	.0040339	.0312896
_cons	2.072729	.2154314	9.62	0.000	1.650491	2.494967
whpel <-						
BSIanx	-1.96893	.7066047	-2.79	0.005	-3.353849	-.5840099
medcow3	1.30711	.2930117	4.46	0.000	.7328179	1.881403
BSIposymp	.7550155	.1048866	7.20	0.000	.5494416	.9605895
whpsleep	.161302	.0704702	2.29	0.022	.023183	.299421
_cons	-25.31982	4.726868	-5.36	0.000	-34.58432	-16.05533

Continued...

Table 8 continued:

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
fdferw1 <-						
injselfr	13.84293	4.125713	3.36	0.001	5.756685	21.92918
cumdose1	7.764987	3.359776	2.31	0.021	1.179947	14.35003
_cons	25.33306	3.399732	7.45	0.000	18.66971	31.99641
Variance						
e.depagw1	480.1144	64.55595			368.8863	624.8803
e.depagw2	172.4914	24.948			129.9138	229.0232
e.BSIanx	12.40073	1.958504			9.099405	16.89979
e.medcow3	15.23561	3.039725			10.30464	22.52615
e.illw2	.6123116	.1660254			.3598929	1.04177
e.crhrw3	.0666203	.0094016			.0505223	.0878477
e.BSIdep	4.794159	.484971			3.931932	5.845463
e.BSIposymp	143.8491	14.03835			118.8059	174.1713
e.whpsleep	526.1998	49.80617			437.1015	633.4599
e.illw1	.2245922	.0406083			.157576	.3201102
e.illw3	3.473916	1.199104			1.766067	6.833316
e.crhrw1	.7703395	.0418144			.6925937	.8568124
e.crhrw2	.3001869	.02931			.2479026	.3634984
e.anxagw2	374.0492	52.44262			284.1765	492.3447
e.medcow2	30.77471	17.62176			10.01824	94.53583
e.whppa	271.6195	25.73944			225.579	327.0569
e.anxagw1	1072.493	83.93363			919.9818	1250.287
e.medcow1	15.42933	2.562364			11.14261	21.3652
e.whpel	694.5317	50.71076			601.9247	801.3864
e.fdferw1	1371.211	67.30163			1245.448	1509.673
Covariance						
e.illw2						
e.illw3	-1.109058	.3635896	-3.05	0.002	-1.82168	-.3964353

Hypotheses 4 postulates that radiation directly predicts psychological health as measured by the BSI. Hypothesis 5 stipulates that perceived exposure risk directly predict psychological health as measured by the BSI. Hypothesis 8 maintains that perceived risk of exposure directly predict Nottingham measures of physical health.

These measures are operationalized in our study as reconstructed external dose measuring radiation, and perceived exposure risk as measured by our factor scores, crhrw1, crhrw2, and crhrw3. In this model we have BSI measures of psychological health including positive symptoms, anxiety, and depression. Also, we have Nottingham health profile measures of sleep, energy level, and physical ability. We examine Table 8 to ascertain what direct relationships are found to be statistically significant.

We begin with a consideration of hypothesis 4. We no find evidence in Table 8 of statistically significant direct relationship between cumulative external dose in any wave and BSI positive symptoms, BSI anxiety, or BSI depression. Hypothesis 4 appears to be inconsistent with our female model, which nicely fits the data.

Hypothesis 5 posits that the perceived risk of exposure to radiation directly predicts psychological health as measured by the subscales of the BSI. For evidence, we again turn to the relevant panels in Table 8. We find no evidence of a statistically significant relationship between our measures of perceived risk of exposure (crhrw1, crhrw2, or crhrw3) and BSI positive symptoms. Nor do we find any evidence of statistically significant direct relationships between these three measures of perceived risk and anxiety as measured by the BSI. But we do find a statistically significant direct effect on BSI depression originating with perceived risk of exposure in wave 3 ($crhrw3\ stdized\ \beta = 0.097, z = 2.71,\ p = 0.007$). Therefore, we have some evidence, partial support, for hypothesis 5 among the female subsample and we will discuss this finding after we consider other effects.

To test hypothesis 8, we examine the Nottingham panels of Table 8. First we consider the whpsleep direct effects. There are no direct paths emanating from perceived risk of exposure to sleep as an endogenous variable. When we examine the energy level panel, we again find no direct paths from perceived risk of exposure from any wave. However, we do find a statistically significant path from perceived risk of exposure to radiation in 1986 to physical ability. But for later waves, there is no evidence of such a relationship. Nonetheless, we have to admit of some evidence of a relationship between perceived risk and physical ability in 1986. The evidence we have found of direct effects is from perceived risk of exposure, rather than actual exposure, and depression or physical ability.

Table 9 Standardized direct effect path coefficients with clustered robust standard errors

Direct effects

(Std. Err. adjusted for 360 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
depagw1 <-					
illw1	9.792269	2.810517	3.48	0.000	.1729902
crhrw1	0	(no path)			0
anxagw1	.4163872	.0536479	7.76	0.000	.5222761
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	6.970709	3.433148	2.03	0.042	.1361388
depagw2 <-					
depagw1	.3230697	.0593149	5.45	0.000	.468539
depagw2	0	(no path)			0
illw2	0	(no path)			0
illw1	3.315657	2.327519	1.42	0.154	.0849488
crhrw1	-3.826883	1.24072	-3.08	0.002	-.1867739
crhrw2	3.136258	1.166022	2.69	0.007	.139376
anxagw2	.4528473	.0673497	6.72	0.000	.5249387
anxagw1	-.1367064	.0390617	-3.50	0.000	-.2486801
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
BSIanx <-					
depagw1	.0235434	.0080816	2.91	0.004	.1806947
depagw2	0	(no path)			0
BSIanx	0	(no path)			0
medcow3	0	(no path)			0
illw2	0	(no path)			0
crhrw3	0	(no path)			0
BSIdep	0	(no path)			0
BSIposymp	0	(no path)			0
illw1	0	(no path)			0
illw3	2.449876	.3909311	6.27	0.000	.7739233
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
medcow2	0	(no path)			0
anxagw1	.0209484	.0072627	2.88	0.004	.2016648
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	2.039526	1.293794	1.58	0.115	.768359
cumdose3	-1.647574	1.062973	-1.55	0.121	-.789521

Continued on the next page...

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
medcow3 <-					
depagw1	.0186108	.0109562	1.70	0.089	.1022367
depagw2	0	(no path)			0
illw2	0	(no path)			0
illw1	0	(no path)			0
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	.0316561	.0115299	2.75	0.006	.1389972
medcow2	.4384699	.0757898	5.79	0.000	.6047104
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
fdferw1	-.0127401	.0064191	-1.98	0.047	-.0940906
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	-.2802811	.1188318	-2.36	0.018	-.0961342
illw2 <-					
depagw1	0	(no path)			0
depagw2	.0083969	.0030066	2.79	0.005	.1840039
illw2	0	(no path)			0
illw1	0	(no path)			0
crhrw1	-.2825861	.0704198	-4.01	0.000	-.3022236
crhrw2	.3970329	.0719886	5.52	0.000	.3866421
anxagw2	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	-.0170443	.0097031	-1.76	0.079	-.0796616
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	.0948242	.0297829	3.18	0.001	.1479224
crhrw3 <-					
depagw1	0	(no path)			0
depagw2	.0036474	.0009793	3.72	0.000	.0796496
BSIanx	0	(no path)			0
medcow3	.0096525	.0048475	1.99	0.046	.0556479
illw2	0	(no path)			0
crhrw3	0	(no path)			0
BSIdep	0	(no path)			0
BSIposymp	0	(no path)			0
illw1	0	(no path)			0
illw3	.0611431	.0161024	3.80	0.000	.0797035
crhrw1	0	(no path)			0
crhrw2	.925388	.0162683	56.88	0.000	.8980548
anxagw2	0	(no path)			0
medcow2	-.0084943	.0036046	-2.36	0.018	-.0675376
anxagw1	-.0015415	.0004625	-3.33	0.001	-.0612355
medcow1	0	(no path)			0
fdferw1	.0007906	.0003774	2.09	0.036	.0336615
injselfr	.1376517	.037219	3.70	0.000	.0717541
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
BSIdep <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	0	(no path)			0
medcow3	0	(no path)			0
illw2	0	(no path)			0
crhrw3	.4067761	.150314	2.71	0.007	.0973153
BSIdep	0	(no path)			0
BSIposymp	.0903483	.0079942	11.30	0.000	.6719452
illw1	0	(no path)			0
illw3	0	(no path)			0
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	-.0113743	.0047141	-2.41	0.016	-.0688826
medcow2	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0
BSIpos~p <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	4.105985	.3805595	10.79	0.000	.5450107
medcow3	0	(no path)			0
illw2	3.397684	1.019818	3.33	0.001	.1089158
crhrw3	0	(no path)			0
BSIdep	1.917203	.369867	5.18	0.000	.257783
BSIposymp	0	(no path)			0
illw1	0	(no path)			0
illw3	0	(no path)			0
crhrw1	1.077694	.7939411	1.36	0.175	.0369472
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
medcow2	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	.4385798	.1915041	2.29	0.022	.0657092
fdferw1	.043344	.0187452	2.31	0.021	.0593642
injselfr	5.607952	1.321709	4.24	0.000	.0940331
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0

Continued ...

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whpsleep <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	0	(no path)			0
medcow3	.6678517	.2268386	2.94	0.003	.1122762
illw2	0	(no path)			0
crhrw3	0	(no path)			0
BSIdep	-1.117785	.6217303	-1.80	0.072	-.1362479
BSIposymp	.6036404	.0859285	7.02	0.000	.5472223
whpsleep	0	(no path)			0
illw1	0	(no path)			0
illw3	0	(no path)			0
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
medcow2	0	(no path)			0
whppa	.4152616	.0788069	5.27	0.000	.2905318
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
whpel	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0
illw1 <-					
illw1	0	(no path)			0
crhrw1	0	(no path)			0
anxagw1	.0030794	.0011302	2.72	0.006	.2186433
medcow1	.0325509	.0111559	2.92	0.004	.2709803
fdferw1	-.0019308	.000791	-2.44	0.015	-.1469388
injselfr	0	(no path)			0
cumdose1	0	(no path)			0

Continued on the next page...

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
illw3 <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	-.3602456	.086608	-4.16	0.000	-1.140368
medcow3	.0773526	.0222972	3.47	0.001	.342102
illw2	2.013229	.4849667	4.15	0.000	1.539075
crhrw3	0	(no path)			0
BSIdep	0	(no path)			0
BSIposymp	.0239693	.0070887	3.38	0.001	.5716285
illw1	.4223779	.178631	2.36	0.018	.1812851
illw3	0	(no path)			0
crhrw1	-.3646996	.12953	-2.82	0.005	-.2981806
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
medcow2	-.0342891	.0168576	-2.03	0.042	-.2091437
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0
crhrw1 <-					
illw1	-.497547	.1123862	-4.43	0.000	-.2611866
crhrw1	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	.7351058	.099048	7.42	0.000	.3595348
cumdose1	0	(no path)			0
crhrw2 <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
illw2	0	(no path)			0
illw1	.2284674	.0632985	3.61	0.000	.1317152
crhrw1	.5476816	.0408433	13.41	0.000	.6014826
crhrw2	0	(no path)			0
anxagw2	.0034734	.0012076	2.88	0.004	.0906006
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
fdferw1	.0025973	.000828	3.14	0.002	.113954
injselfr	.4733239	.0779942	6.07	0.000	.2542403
cumdose1	0	(no path)			0
cumdose2	.0432457	.0170781	2.53	0.011	.0692747

Continued on the next page...

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
anxagw2 <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
illw2	3.592459	1.852712	1.94	0.052	.1414257
illw1	0	(no path)			0
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
anxagw1	.2831393	.048295	5.86	0.000	.4443197
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
medcow2 <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
illw2	.6694346	.2569322	2.61	0.009	.0839047
illw1	0	(no path)			0
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	1.058045	.2299723	4.60	0.000	.6198001
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whppa <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	0	(no path)			0
medcow3	0	(no path)			0
illw2	0	(no path)			0
crhrw3	0	(no path)			0
BSIdep	0	(no path)			0
BSIposymp	0	(no path)			0
whpsleep	0	(no path)			0
illw1	0	(no path)			0
illw3	4.244149	.8278314	5.13	0.000	.2305928
crhrw1	3.086825	1.030954	2.99	0.003	.1371232
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
medcow2	0	(no path)			0
whppa	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	.9892521	.2823759	3.50	0.000	.1920427
whpel	.2485385	.0318121	7.81	0.000	.3965518
fdferw1	0	(no path)			0
injselfr	5.147011	1.826874	2.82	0.005	.1118266
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0
anxagw1 <-					
fdferw1	.2089858	.0508552	4.11	0.000	.2239984
injselfr	12.65965	3.322472	3.81	0.000	.1661237
cumdose1	11.77704	4.40861	2.67	0.008	.1833743
medcow1 <-					
illw1	0	(no path)			0
crhrw1	1.516698	.3100721	4.89	0.000	.3470622
anxagw1	.0176617	.0069531	2.54	0.011	.1506339
medcow1	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0

Continued on the next page...

Table 9 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whpel <-					
depagw1	0	(no path)			0
depagw2	0	(no path)			0
BSIanx	-1.96893	.7066047	-2.79	0.005	-.212239
medcow3	1.30711	.2930117	4.46	0.000	.1968529
illw2	0	(no path)			0
crhrw3	0	(no path)			0
BSIdep	0	(no path)			0
BSIposymp	.7550155	.1048866	7.20	0.000	.6131451
whpsleep	.161302	.0704702	2.29	0.022	.144498
illw1	0	(no path)			0
illw3	0	(no path)			0
crhrw1	0	(no path)			0
crhrw2	0	(no path)			0
anxagw2	0	(no path)			0
medcow2	0	(no path)			0
whppa	0	(no path)			0
anxagw1	0	(no path)			0
medcow1	0	(no path)			0
whpel	0	(no path)			0
fdferw1	0	(no path)			0
injselfr	0	(no path)			0
cumdose1	0	(no path)			0
cumdose2	0	(no path)			0
cumdose3	0	(no path)			0
fdferw1 <-					
injselfr	13.84293	4.125713	3.36	0.001	.1694766
cumdose1	7.764987	3.359776	2.31	0.021	.1128014

4.2.2 Findings regarding indirect effects on females

We obtain a more comprehensive perspective on the nature of the evidentiary support for hypotheses 4, 5, and 8 by examining indirect effects in Table 10. We begin an examination of Table 10 in search of indirect support for hypothesis 4. We first turn to the BSI positive symptom panel to look for significant indirect effects from reconstructed external dose in any wave of the study.

From the BSI positive symptom panel, we find that there are two statistically significant indirect effects from cumulative external dose in waves 1 (($stdized\ \beta = 0.073 p = .002$) and 2 ($stdized\ \beta = 0.0437, p = 0.023$) . The third wave sum of indirect effects is not statistically significant ($cumdose3\ \ stdized\ \beta = -.337, p = 0.072$).

From the BSI anxiety panel in Table 10, we find evidence of a statistically significant indirect effect only from cumulative dose in 1986 ($stdized\ \beta = .092,\ p = 0.003$).

From the BSI depression panel, we find evidence of statistically significant indirect effects in waves 1 ($stdized\ \beta = 0.044 p = 0.004$) and 2 ($stdized\ \beta =$

0.297, $p = 0.025$). External cumulative dose at wave 3 was not significant (p=.077).

Table 10 Indirect effects

(Std. Err. adjusted for 360 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
depagw1 <-					
illw1	-.2347686	.0530297	-4.43	0.000	-.0041474
crhrw1	.4718522	.096465	4.89	0.000	.0158792
anxagw1	.0349264	.0112813	3.10	0.002	.0438083
medcow1	.311105	.1066226	2.92	0.004	.0457531
fdferw1	.0758642	.0242826	3.12	0.002	.1019924
injselfr	7.110518	1.717552	4.14	0.000	.1170345
cumdose1	5.904225	2.078757	2.84	0.005	.1153102
depagw2 <-					
depagw1	.0046067	.0008458	5.45	0.000	.006681
depagw2	.0142591	.0051057	2.79	0.005	.0142591
illw2	1.698137	.8757679	1.94	0.052	.0774937
illw1	5.072001	.9846036	5.15	0.000	.1299472
crhrw1	1.94718	.194115	10.03	0.000	.0950336
crhrw2	.7189368	.1247058	5.77	0.000	.0319497
anxagw2	.0198477	.0049357	4.02	0.000	.0230074
anxagw1	.2984697	.0290223	10.28	0.000	.5429408
medcow1	.244082	.0961235	2.54	0.011	.0520593
fdferw1	.0276243	.011109	2.49	0.013	.0538606
injselfr	2.873242	.9847772	2.92	0.004	.0685858
cumdose1	4.403732	1.649219	2.67	0.008	.1247313
cumdose2	.327745	.1324471	2.47	0.013	.0233316
BSIanx <-					
depagw1	.0025416	.0037958	0.67	0.503	.0195068
depagw2	.0280717	.0100038	2.81	0.005	.1485577
BSIanx	-.3717607	.1421078	-2.62	0.009	-.3717607
medcow3	.1195552	.034302	3.49	0.000	.1670333
illw2	3.327951	.7473125	4.45	0.000	.803706
crhrw3	.0348463	.0128766	2.71	0.007	.0084446
BSIdep	.0856646	.0165264	5.18	0.000	.086776
BSIposymp	.0446821	.0108408	4.12	0.000	.3366244
illw1	1.699923	.2857214	5.95	0.000	.2304856
illw3	-.9086372	.1454084	-6.25	0.000	-.2870412
crhrw1	-.745805	.230565	-3.23	0.001	-.1926297
crhrw2	1.441592	.244382	5.90	0.000	.3390357
anxagw2	.0205296	.0034764	5.91	0.000	.1259403
medcow2	-.0007224	.020995	-0.03	0.973	-.0013919
anxagw1	.010538	.0037355	2.82	0.005	.1014467
medcow1	.0174437	.037602	0.46	0.643	.0196892
fdferw1	.0074833	.0025778	2.90	0.004	.0772151
injselfr	.8916643	.2213276	4.03	0.000	.1126394
cumdose1	.6107559	.204334	2.99	0.003	.091548
cumdose2	-.3803029	.5602915	-0.68	0.497	-.143273
cumdose3	.5789944	.4949112	1.17	0.242	.2774553

Continued ...

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
medcow3 <-					
depagw1	.0011261	.0002068	5.45	0.000	.0061862
depagw2	.0034857	.0012481	2.79	0.005	.0132032
illw2	.4151136	.1106524	3.75	0.000	.0717551
illw1	-.0806767	.091075	-0.89	0.376	-.0078294
crhrw1	.6545217	.1415061	4.63	0.000	.1210006
crhrw2	.1757458	.0304846	5.77	0.000	.0295838
anxagw2	.0021889	.0003461	6.32	0.000	.0096112
medcow2	0	(no path)			0
anxagw1	.0250984	.0036489	6.88	0.000	.172938
medcow1	.4542195	.100517	4.52	0.000	.3669618
fdferw1	.0058574	.0012808	4.57	0.000	.0432595
injselfr	.7867879	.2553072	3.08	0.002	.0711397
cumdose1	.3797213	.209794	1.81	0.070	.0407391
cumdose2	.0469631	.0149013	3.15	0.002	.0126636
cumdose3	0	(no path)			0
illw2 <-					
depagw1	.0027652	.0005077	5.45	0.000	.0878777
depagw2	.0001621	.0000581	2.79	0.005	.0035529
illw2	.0193089	.0099581	1.94	0.052	.0193089
illw1	.2041626	.0377825	5.40	0.000	.1146226
crhrw1	.1818662	.0187737	9.69	0.000	.1945045
crhrw2	.0345097	.0101878	3.39	0.001	.0336066
anxagw2	.0053749	.0008499	6.32	0.000	.1365306
anxagw1	.0019424	.0004228	4.59	0.000	.0774268
medcow1	.0063166	.0022981	2.75	0.006	.0295223
fdferw1	.0011326	.0004067	2.78	0.005	.04839
injselfr	.1704876	.0598795	2.85	0.004	.0891788
cumdose1	.0509451	.0234416	2.17	0.030	.0316201
cumdose2	.0204933	.008017	2.56	0.011	.0319688
crhrw3 <-					
depagw1	.0014653	.0003004	4.88	0.000	.0464067
depagw2	.0008364	.0002983	2.80	0.005	.0182653
BSIanx	-.0092783	.0035467	-2.62	0.009	-.0382863
medcow3	.0029838	.0008561	3.49	0.000	.0172021
illw2	.0992321	.0225821	4.39	0.000	.0988891
crhrw3	.0008697	.0003214	2.71	0.007	.0008697
BSIdep	.002138	.0004125	5.18	0.000	.0089367
BSIposymp	.0011152	.0002706	4.12	0.000	.0346677
illw1	.0346725	.0790531	0.44	0.661	.0193988
illw3	-.0226774	.0036291	-6.25	0.000	-.0295613
crhrw1	.4715311	.0390555	12.07	0.000	.5025557
crhrw2	.0542655	.0091884	5.91	0.000	.0526627
anxagw2	.0058089	.0013163	4.41	0.000	.1470453
medcow2	.0042143	.0007154	5.89	0.000	.0335075
anxagw1	.0014717	.000305	4.83	0.000	.0584611
medcow1	-.0046021	.0015967	-2.88	0.004	-.0214348
fdferw1	.002351	.0008173	2.88	0.004	.100099
injselfr	.8592962	.0791523	10.86	0.000	.4479277
cumdose1	.0337858	.0155241	2.18	0.030	.0208974
cumdose2	.0328521	.0209675	1.57	0.117	.0510709
cumdose3	.0117449	.0116273	1.01	0.312	.0232244

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
BSIdep <-					
depagw1	.013315	.0023616	5.64	0.000	.1008832
depagw2	.0175563	.0056124	3.13	0.002	.0917196
BSIanx	.2773191	.0950055	2.92	0.004	.2737671
medcow3	.0598601	.0150865	3.97	0.000	.0825607
illw2	1.870117	.3491535	5.36	0.000	.4458519
crhrw3	.101285	.0374273	2.71	0.007	.024231
BSIdep	.2489944	.048036	5.18	0.000	.2489944
BSIposymp	.0395255	.0051216	7.72	0.000	.293962
illw1	.7530186	.1358734	5.54	0.000	.100791
illw3	.7104619	.1076316	6.60	0.000	.2215624
crhrw1	.0508306	.1645581	0.31	0.757	.0129606
crhrw2	1.267713	.1374132	9.23	0.000	.2943238
anxagw2	.0114164	.0028186	4.05	0.000	.0691374
medcow2	-.0024299	.0088104	-0.28	0.783	-.004622
anxagw1	.0113317	.0024767	4.58	0.000	.1076899
medcow1	.0470256	.0288178	1.63	0.103	.0523993
fdferw1	.0094752	.0027442	3.45	0.001	.0965151
injselfr	1.710285	.2640893	6.48	0.000	.2132844
cumdose1	.2998431	.1032866	2.90	0.004	.0443687
cumdose2	.7977551	.3556485	2.24	0.025	.2966921
cumdose3	-.4736815	.2683013	-1.77	0.077	-.2240818
BSIpos~p <-					
depagw1	.1420274	.026094	5.44	0.000	.1446892
depagw2	.1780019	.0622155	2.86	0.004	.1250372
BSIanx	-.9947669	.7559938	-1.32	0.188	-.1320411
medcow3	.6056558	.1695076	3.57	0.000	.1123177
illw2	17.31552	3.71853	4.66	0.000	.5550645
crhrw3	1.117135	.4128092	2.71	0.007	.035935
BSIdep	.8291104	.159952	5.18	0.000	.1114804
BSIposymp	.4324583	.0555372	7.79	0.000	.4324583
illw1	8.270848	1.408748	5.87	0.000	.1488512
illw3	7.690405	1.214013	6.33	0.000	.322471
crhrw1	-2.683619	1.38419	-1.94	0.053	-.0920039
crhrw2	9.815865	1.520817	6.45	0.000	.3064215
anxagw2	.1026371	.026598	3.86	0.000	.0835749
medcow2	-.0076247	.1028152	-0.07	0.941	-.0019501
anxagw1	.1622606	.0267511	6.07	0.000	.2073384
medcow1	.0977812	.2246768	0.44	0.663	.0146498
fdferw1	.0553471	.0155311	3.56	0.000	.0758035
injselfr	9.464876	1.567694	6.04	0.000	.1587053
cumdose1	3.667316	1.162241	3.16	0.002	.0729655
cumdose2	8.734018	3.834837	2.28	0.023	.4367537
cumdose3	-5.295717	2.948658	-1.80	0.072	-.3368458

Continued ...

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whpsleep <-					
depagw1	.0958854	.0176928	5.42	0.000	.0885527
depagw2	.1209983	.043031	2.81	0.005	.0770511
BSIanx	1.439367	.6830468	2.11	0.035	.1731987
medcow3	.5629911	.1268503	4.44	0.000	.0946475
illw2	14.31641	2.658751	5.38	0.000	.4160327
crhrw3	.2150638	.0794715	2.71	0.007	.0062714
BSIdep	1.646488	.3198483	5.15	0.000	.200692
BSIposymp	.2650269	.0390391	6.79	0.000	.2402566
whpsleep	.0169296	.0073962	2.29	0.022	.0169296
illw1	4.59773	.9528987	4.82	0.000	.0750121
illw3	5.33169	.658711	8.09	0.000	.2026711
crhrw1	.8545502	1.244992	0.69	0.492	.0265588
crhrw2	6.262583	1.051278	5.96	0.000	.1772269
anxagw2	.109496	.0210921	5.19	0.000	.0808267
medcow2	.3550418	.0749528	4.74	0.000	.082318
whppa	.0070302	.0013342	5.27	0.000	.0049186
anxagw1	.1174414	.0159233	7.38	0.000	.1360421
medcow1	1.08003	.2579377	4.19	0.000	.1466893
whpel	.1049558	.013434	7.81	0.000	.1171614
fdferw1	.0540726	.0192215	2.81	0.005	.0671363
injselfr	12.90229	1.752449	7.36	0.000	.1961232
cumdose1	2.471374	.8331131	2.97	0.003	.0445752
cumdose2	4.563998	1.850375	2.47	0.014	.2068966
cumdose3	-2.716446	1.366119	-1.99	0.047	-.1566365
illw1 <-					
illw1	-.0239749	.0054155	-4.43	0.000	-.0239749
crhrw1	.0481862	.0098511	4.89	0.000	.0917922
anxagw1	.0004873	.0002191	2.22	0.026	.0345982
medcow1	-.0007804	.0002675	-2.92	0.004	-.0064967
fdferw1	.0007917	.0001821	4.35	0.000	.0602485
injselfr	.0648065	.0272287	2.38	0.017	.06038
cumdose1	.0331601	.0208943	1.59	0.113	.0366592

Continued ...

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
illw3 <-					
depagw1	.0010374	.0015494	0.67	0.503	.0252051
depagw2	.0114584	.0040834	2.81	0.005	.191954
BSIanx	.2084989	.0295795	7.05	0.000	.6600091
medcow3	-.0285521	.0082961	-3.44	0.001	-.1262754
illw2	-.6548129	.1834505	-3.57	0.000	-.5005918
crhrw3	.0142237	.005256	2.71	0.007	.0109115
BSIdep	.0349669	.0067458	5.18	0.000	.1121249
BSIposymp	-.0057308	.0026865	-2.13	0.033	-.1366701
illw1	.1796552	.0996972	1.80	0.072	.0771082
illw3	-.370891	.0593534	-6.25	0.000	-.370891
crhrw1	.0557395	.1274767	0.44	0.662	.0455729
crhrw2	.5884347	.0997528	5.90	0.000	.438074
anxagw2	.0083799	.001419	5.91	0.000	.1627297
medcow2	.0339943	.0091794	3.70	0.000	.2073452
anxagw1	-.0000357	.0013838	-0.03	0.979	-.0010876
medcow1	.0041305	.0148474	0.28	0.781	.0147583
fdferw1	.0005385	.000793	0.68	0.497	.0175897
injselfr	.1626433	.0724028	2.25	0.025	.0650386
cumdose1	.010993	.0204584	0.54	0.591	.0052161
cumdose2	-.1552335	.2159441	-0.72	0.472	-.1851256
cumdose3	.2363362	.1812398	1.30	0.192	.3585049
crhrw1 <-					
illw1	.0119286	.0026944	4.43	0.000	.0062619
crhrw1	-.0239749	.0049014	-4.89	0.000	-.0239749
anxagw1	-.0017746	.0005732	-3.10	0.002	-.0661433
medcow1	-.0158073	.0054175	-2.92	0.004	-.0690795
fdferw1	.0005668	.000396	1.43	0.152	.0226423
injselfr	-.0322443	.016952	-1.90	0.057	-.0157704
cumdose1	-.0164987	.0107197	-1.54	0.124	-.0095749
crhrw2 <-					
depagw1	.0000345	6.33e-06	5.45	0.000	.001126
depagw2	.0001068	.0000382	2.79	0.005	.0024032
illw2	.0127189	.0065594	1.94	0.052	.0130607
illw1	-.2688942	.0611421	-4.40	0.000	-.1550219
crhrw1	-.0033784	.0010561	-3.20	0.001	-.0037103
crhrw2	.0053848	.000934	5.77	0.000	.0053848
anxagw2	.0000671	.0000106	6.32	0.000	.0017494
anxagw1	.0008506	.0001788	4.76	0.000	.0348195
medcow1	-.0015327	.0004593	-3.34	0.001	-.0073561
fdferw1	.0002698	.0000534	5.06	0.000	.0118378
injselfr	.4531276	.0658511	6.88	0.000	.2433921
cumdose1	.0325218	.0129323	2.51	0.012	.0207278
cumdose2	.0014389	.0007633	1.89	0.059	.002305

Continued ...

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
anxagw2 <-					
depagw1	.0099338	.0018238	5.45	0.000	.0124282
depagw2	.0307481	.0110098	2.79	0.005	.0265254
illw2	.0693666	.0357739	1.94	0.052	.0027308
illw1	.7334457	.1357321	5.40	0.000	.0162106
crhrw1	-.3618322	.2617533	-1.38	0.167	-.0152343
crhrw2	1.550299	.2689128	5.77	0.000	.059434
anxagw2	.0193089	.0030533	6.32	0.000	.0193089
anxagw1	.0069779	.0015191	4.59	0.000	.0109501
medcow1	-.038539	.0370064	-1.04	0.298	-.007091
fdferw1	.0632408	.014795	4.27	0.000	.1063705
injselfr	5.01603	1.264771	3.97	0.000	.1032917
cumdose1	3.977033	1.446319	2.75	0.006	.0971755
cumdose2	.4142735	.2214121	1.87	0.061	.0254412
medcow2 <-					
depagw1	.0018511	.0003399	5.45	0.000	.0073734
depagw2	.0057297	.0020516	2.79	0.005	.0157369
illw2	.0129261	.0066663	1.94	0.052	.0016201
illw1	-.6426149	.1684051	-3.82	0.000	-.0452192
crhrw1	1.498835	.3176902	4.72	0.000	.2009138
crhrw2	.2888895	.0501104	5.77	0.000	.0352608
anxagw2	.0035981	.000569	6.32	0.000	.0114556
anxagw1	.0171394	.007088	2.42	0.016	.0856314
medcow1	-.032548	.0094175	-3.46	0.001	-.0190666
fdferw1	.005573	.0010205	5.46	0.000	.0298439
injselfr	1.532667	.4336291	3.53	0.000	.1004835
cumdose1	.2580294	.1374226	1.88	0.060	.0200728
cumdose2	.0771975	.0324122	2.38	0.017	.0150937

Continued ...

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whppa <-					
depagw1	.0285456	.0082435	3.46	0.001	.0376806
depagw2	.0742795	.0262397	2.83	0.005	.0676078
BSIanx	-.3099424	.4296613	-0.72	0.471	-.0533068
medcow3	.6364747	.1153407	5.52	0.000	.1529385
illw2	8.73241	1.741805	5.01	0.000	.3627068
crhrw3	.2615679	.0966559	2.71	0.007	.0109021
BSIdep	.6430268	.1313719	4.89	0.000	.1120286
BSIposymp	.3591676	.0364348	9.86	0.000	.4653832
whpsleep	.0407685	.0178111	2.29	0.022	.058271
illw1	1.205755	.7173914	1.68	0.093	.0281174
illw3	-.6714759	.1226063	-5.48	0.000	-.0364826
crhrw1	.3896476	.7015083	0.56	0.579	.017309
crhrw2	3.942065	.6411995	6.15	0.000	.1594513
anxagw2	.0601638	.0124534	4.83	0.000	.0634776
medcow2	.1543493	.045521	3.39	0.001	.0511503
whppa	.0169296	.0032128	5.27	0.000	.0169296
anxagw1	.037082	.0098145	3.78	0.000	.0613964
medcow1	.2279902	.0987335	2.31	0.021	.0442596
whpel	.0042077	.0005386	7.81	0.000	.0067135
fdferw1	.0233261	.0084409	2.76	0.006	.0413953
injselfr	7.351131	1.240905	5.92	0.000	.1597145
cumdose1	.816826	.3214	2.54	0.011	.0210578
cumdose2	.3663854	.6716565	0.55	0.585	.0237396
cumdose3	.3322614	.582719	0.57	0.569	.0273842
anxagw1 <-					
fdferw1	0	(no path)			0
injselfr	2.892976	1.148957	2.52	0.012	.0379625
cumdose1	1.622772	.8392748	1.93	0.053	.0252673
medcow1 <-					
illw1	-.7365362	.1663692	-4.43	0.000	-.0884747
crhrw1	-.0363627	.0074339	-4.89	0.000	-.0083208
anxagw1	-.0026916	.0008694	-3.10	0.002	-.0229558
medcow1	-.0239749	.0082167	-2.92	0.004	-.0239749
fdferw1	.0045507	.000951	4.79	0.000	.0416001
injselfr	1.340715	.2902426	4.62	0.000	.1500499
cumdose1	.2116404	.1130726	1.87	0.061	.0281054

Continued ...

Table 10 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whpel <-					
depagw1	.0971381	.0214096	4.54	0.000	.0803639
depagw2	.1031965	.0358508	2.88	0.004	.058869
BSIanx	3.313161	.6398666	5.18	0.000	.3571393
medcow3	.4204212	.0822487	5.11	0.000	.0633161
illw2	11.93815	2.015953	5.92	0.000	.3107795
crhrw3	.8095343	.2991432	2.71	0.007	.0211473
BSIdep	1.990123	.4160763	4.78	0.000	.2173068
BSIposymp	.3786547	.0302193	12.53	0.000	.307504
whpsleep	.0027308	.001193	2.29	0.022	.0024463
illw1	3.533761	.712773	4.96	0.000	.0516472
illw3	3.631796	.526043	6.90	0.000	.1236717
crhrw1	1.249312	1.206203	1.04	0.300	.0347828
crhrw2	5.812623	.8765082	6.63	0.000	.1473568
anxagw2	.0989722	.0275421	3.59	0.000	.0654474
medcow2	.6260631	.1025037	6.11	0.000	.1300335
whppa	.0681165	.0129269	5.27	0.000	.042692
anxagw1	.1122646	.015144	7.41	0.000	.1164976
medcow1	1.138541	.2367738	4.81	0.000	.1385267
whpel	.0169296	.0021669	7.81	0.000	.0169296
fdferw1	.0595048	.0242578	2.45	0.014	.0661842
injselfr	12.73418	1.830304	6.96	0.000	.1734023
cumdose1	2.461321	.8477261	2.90	0.004	.039769
cumdose2	4.124993	1.906065	2.16	0.030	.1675148
cumdose3	-2.698916	1.396456	-1.93	0.053	-.1394129
fdferw1 <-					
injselfr	0	(no path)			0
cumdose1	0	(no path)			0

If we examine these panels for indirect effects, by which we mean the sums of products of links of the separate indirect paths, from perceived risk of exposure, we obtain evidence that may relate to hypothesis 5. Focusing on the positive symptom panel in Table 10, we find that significant indirect effects originate with perceived risk of exposure in waves 2 ($crhrw2\ stdized\ \beta = 0.306\ p = 0.000) and 3 (crhrw3\ stdized\ \beta = 0.036 p = 0.000$), and almost but not quite in wave 1 ($crhrw1\ stdized \beta = -0.092, p = 0.053$).

When BSI anxiety is an endogenous variable, we find statistically significant relationships originating with perceived risk of exposure at every wave. The resulting standardized indirect effect of crhrw1 = -0.193 p = 0.000; the same path coefficient for crhrw2 = 0.339 p = 0.000; and for crhrw3 = 0.008 with p=0.000.

When BSI depression becomes the endogenous variable, significant indirect effects originate from perceived risk of exposure in waves 2 (($crhrw2\ stdized\ \beta = 0.294\ p = 0.000$) and 3 ($crhrw3\ stdized\ \beta = 0.024\ p = 0.007$.) From this evidence, there appears to be additional support for hypothesis 5 were we to consider evidence from indirect effects.

Table 11 Total effects

(Std. Err. adjusted for 360 clusters in id)

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
Structural					
depagw1 <-					
illw1	9.557501	2.809523	3.40	0.001	.1688428
crhrw1	.4718522	.096465	4.89	0.000	.0158792
anxagw1	.4513136	.0561175	8.04	0.000	.5660844
medcow1	.311105	.1066226	2.92	0.004	.0457531
fdferw1	.0758642	.0242826	3.12	0.002	.1019924
injselfr	7.110518	1.717552	4.14	0.000	.1170345
cumdose1	12.87493	4.595587	2.80	0.005	.251449
depagw2 <-					
depagw1	.3276764	.0601607	5.45	0.000	.4752199
depagw2	.0142591	.0051057	2.79	0.005	.0142591
illw2	1.698137	.8757679	1.94	0.052	.0774937
illw1	8.387657	2.555536	3.28	0.001	.214896
crhrw1	-1.879704	1.251285	-1.50	0.133	-.0917404
crhrw2	3.855195	1.198806	3.22	0.001	.1713257
anxagw2	.472695	.0693785	6.81	0.000	.5479461
anxagw1	.1617633	.0413709	3.91	0.000	.2942607
medcow1	.244082	.0961235	2.54	0.011	.0520593
fdferw1	.0276243	.011109	2.49	0.013	.0538606
injselfr	2.873242	.9847772	2.92	0.004	.0685858
cumdose1	4.403732	1.649219	2.67	0.008	.1247313
cumdose2	.327745	.1324471	2.47	0.013	.0233316
BSIanx <-					
depagw1	.026085	.0051866	5.03	0.000	.2002015
depagw2	.0280717	.0100038	2.81	0.005	.1485577
BSIanx	-.3717607	.1421078	-2.62	0.009	-.3717607
medcow3	.1195552	.034302	3.49	0.000	.1670333
illw2	3.327951	.7473125	4.45	0.000	.803706
crhrw3	.0348463	.0128766	2.71	0.007	.0084446
BSIdep	.0856646	.0165264	5.18	0.000	.086776
BSIposymp	.0446821	.0108408	4.12	0.000	.3366244
illw1	1.699923	.2857214	5.95	0.000	.2304856
illw3	1.541239	.2455243	6.28	0.000	.4868821
crhrw1	-.745805	.230565	-3.23	0.001	-.1926297
crhrw2	1.441592	.244382	5.90	0.000	.3390357
anxagw2	.0205296	.0034764	5.91	0.000	.1259403
medcow2	-.0007224	.020995	-0.03	0.973	-.0013919
anxagw1	.0314864	.0052507	6.00	0.000	.3031115
medcow1	.0174437	.037602	0.46	0.643	.0196892
fdferw1	.0074833	.0025778	2.90	0.004	.0772151
injselfr	.8916643	.2213276	4.03	0.000	.1126394
cumdose1	.6107559	.204334	2.99	0.003	.091548
cumdose2	1.659224	.772711	2.15	0.032	.625086
cumdose3	-1.06858	.5984875	-1.79	0.074	-.5120657

Continued...

Table 11 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
medcow3 <-					
depagw1	.0197369	.0109254	1.81	0.071	.1084229
depagw2	.0034857	.0012481	2.79	0.005	.0132032
illw2	.4151136	.1106524	3.75	0.000	.0717551
illw1	-.0806767	.091075	-0.89	0.376	-.0078294
crhrw1	.6545217	.1415061	4.63	0.000	.1210006
crhrw2	.1757458	.0304846	5.77	0.000	.0295838
anxagw2	.033845	.0116083	2.92	0.004	.1486084
medcow2	.4384699	.0757898	5.79	0.000	.6047104
anxagw1	.0250984	.0036489	6.88	0.000	.172938
medcow1	.4542195	.100517	4.52	0.000	.3669618
fdferw1	-.0068827	.0065189	-1.06	0.291	-.0508311
injselfr	.7867879	.2553072	3.08	0.002	.0711397
cumdose1	.3797213	.209794	1.81	0.070	.0407391
cumdose2	.0469631	.0149013	3.15	0.002	.0126636
cumdose3	-.2802811	.1188318	-2.36	0.018	-.0961342
illw2 <-					
depagw1	.0027652	.0005077	5.45	0.000	.0878777
depagw2	.0085591	.0030647	2.79	0.005	.1875568
illw2	.0193089	.0099581	1.94	0.052	.0193089
illw1	.2041626	.0377825	5.40	0.000	.1146226
crhrw1	-.1007199	.0728619	-1.38	0.167	-.1077192
crhrw2	.4315426	.0748548	5.77	0.000	.4202487
anxagw2	.0053749	.0008499	6.32	0.000	.1365306
anxagw1	.0019424	.0004228	4.59	0.000	.0774268
medcow1	-.0107278	.0103011	-1.04	0.298	-.0501393
fdferw1	.0011326	.0004067	2.78	0.005	.04839
injselfr	.1704876	.0598795	2.85	0.004	.0891788
cumdose1	.0509451	.0234416	2.17	0.030	.0316201
cumdose2	.1153175	.0330965	3.48	0.000	.1798912
crhrw3 <-					
depagw1	.0014653	.0003004	4.88	0.000	.0464067
depagw2	.0044838	.0010059	4.46	0.000	.0979148
BSIanx	-.0092783	.0035467	-2.62	0.009	-.0382863
medcow3	.0126363	.0045976	2.75	0.006	.07285
illw2	.0992321	.0225821	4.39	0.000	.0988891
crhrw3	.0008697	.0003214	2.71	0.007	.0008697
BSIdep	.002138	.0004125	5.18	0.000	.0089367
BSIposymp	.0011152	.0002706	4.12	0.000	.0346677
illw1	.0346725	.0790531	0.44	0.661	.0193988
illw3	.0384657	.0169832	2.26	0.024	.0501422
crhrw1	.4715311	.0390555	12.07	0.000	.5025557
crhrw2	.9796535	.0181377	54.01	0.000	.9507175
anxagw2	.0058089	.0013163	4.41	0.000	.1470453
medcow2	-.00428	.0038959	-1.10	0.272	-.0340301
anxagw1	-.0000698	.0005647	-0.12	0.902	-.0027744
medcow1	-.0046021	.0015967	-2.88	0.004	-.0214348
fdferw1	.0031416	.000913	3.44	0.001	.1337605
injselfr	.9969479	.0848886	11.74	0.000	.5196817
cumdose1	.0337858	.0155241	2.18	0.030	.0208974
cumdose2	.0328521	.0209675	1.57	0.117	.0510709
cumdose3	.0117449	.0116273	1.01	0.312	.0232244

Table 11 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
BSIdep <-					
depagw1	.013315	.0023616	5.64	0.000	.1008832
depagw2	.0175563	.0056124	3.13	0.002	.0917196
BSIanx	.2773191	.0950055	2.92	0.004	.2737671
medcow3	.0598601	.0150865	3.97	0.000	.0825607
illw2	1.870117	.3491535	5.36	0.000	.4458519
crhrw3	.5080611	.1877413	2.71	0.007	.1215462
BSIdep	.2489944	.048036	5.18	0.000	.2489944
BSIposymp	.1298738	.0104658	12.41	0.000	.9659073
illw1	.7530186	.1358734	5.54	0.000	.100791
illw3	.7104619	.1076316	6.60	0.000	.2215624
crhrw1	.0508306	.1645581	0.31	0.757	.0129606
crhrw2	1.267713	.1374132	9.23	0.000	.2943238
anxagw2	.0000421	.0067299	0.01	0.995	.0002548
medcow2	-.0024299	.0088104	-0.28	0.783	-.004622
anxagw1	.0113317	.0024767	4.58	0.000	.1076899
medcow1	.0470256	.0288178	1.63	0.103	.0523993
fdferw1	.0094752	.0027442	3.45	0.001	.0965151
injselfr	1.710285	.2640893	6.48	0.000	.2132844
cumdose1	.2998431	.1032866	2.90	0.004	.0443687
cumdose2	.7977551	.3556485	2.24	0.025	.2966921
cumdose3	-.4736815	.2683013	-1.77	0.077	-.2240818
BSIpos~p <-					
depagw1	.1420274	.026094	5.44	0.000	.1446892
depagw2	.1780019	.0622155	2.86	0.004	.1250372
BSIanx	3.111218	1.036698	3.00	0.003	.4129696
medcow3	.6056558	.1695076	3.57	0.000	.1123177
illw2	20.7132	3.836604	5.40	0.000	.6639803
crhrw3	1.117135	.4128092	2.71	0.007	.035935
BSIdep	2.746313	.529819	5.18	0.000	.3692633
BSIposymp	.4324583	.0555372	7.79	0.000	.4324583
illw1	8.270848	1.408748	5.87	0.000	.1488512
illw3	7.690405	1.214013	6.33	0.000	.322471
crhrw1	-1.605924	1.785366	-0.90	0.368	-.0550568
crhrw2	9.815865	1.520817	6.45	0.000	.3064215
anxagw2	.1026371	.026598	3.86	0.000	.0835749
medcow2	-.0076247	.1028152	-0.07	0.941	-.0019501
anxagw1	.1622606	.0267511	6.07	0.000	.2073384
medcow1	.536361	.316786	1.69	0.090	.080359
fdferw1	.0986911	.0294698	3.35	0.001	.1351677
injselfr	15.07283	2.137937	7.05	0.000	.2527385
cumdose1	3.667316	1.162241	3.16	0.002	.0729655
cumdose2	8.734018	3.834837	2.28	0.023	.4367537
cumdose3	-5.295717	2.948658	-1.80	0.072	-.3368458

Continued...

Table 11 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
whpsleep <-					
depagw1	.0958854	.0176928	5.42	0.000	.0885527
depagw2	.1209983	.043031	2.81	0.005	.0770511
BSIanx	1.439367	.6830468	2.11	0.035	.1731987
medcow3	1.230843	.237019	5.19	0.000	.2069237
illw2	14.31641	2.658751	5.38	0.000	.4160327
crhrw3	.2150638	.0794715	2.71	0.007	.0062714
BSIdep	.5287031	.6638879	0.80	0.426	.0644441
BSIposymp	.8686673	.0913862	9.51	0.000	.7874789
whpsleep	.0169296	.0073962	2.29	0.022	.0169296
illw1	4.59773	.9528987	4.82	0.000	.0750121
illw3	5.33169	.658711	8.09	0.000	.2026711
crhrw1	.8545502	1.244992	0.69	0.492	.0265588
crhrw2	6.262583	1.051278	5.96	0.000	.1772269
anxagw2	.109496	.0210921	5.19	0.000	.0808267
medcow2	.3550418	.0749528	4.74	0.000	.082318
whppa	.4222918	.080141	5.27	0.000	.2954503
anxagw1	.1174414	.0159233	7.38	0.000	.1360421
medcow1	1.08003	.2579377	4.19	0.000	.1466893
whpel	.1049558	.013434	7.81	0.000	.1171614
fdferw1	.0540726	.0192215	2.81	0.005	.0671363
injselfr	12.90229	1.752449	7.36	0.000	.1961232
cumdose1	2.471374	.8331131	2.97	0.003	.0445752
cumdose2	4.563998	1.850375	2.47	0.014	.2068966
cumdose3	-2.716446	1.366119	-1.99	0.047	-.1566365
illw1 <-					
illw1	-.0239749	.0054155	-4.43	0.000	-.0239749
crhrw1	.0481862	.0098511	4.89	0.000	.0917922
anxagw1	.0035667	.0011521	3.10	0.002	.2532415
medcow1	.0317705	.0108884	2.92	0.004	.2644836
fdferw1	-.0011391	.000796	-1.43	0.152	-.0866902
injselfr	.0648065	.0272287	2.38	0.017	.06038
cumdose1	.0331601	.0208943	1.59	0.113	.0366592

Continued ...

As for indirect effect support for hypothesis 8, we could examine indirect effects originating from perceived risk of exposure in the 3 waves for sleep, energy level, and physical ability. When we do so, we find significant indirect effects in waves 2 (*crhrw*2 *stdized* $\beta = 0.177$ $p = 0.000$) and 3 (crhrw3 stdized $\beta = 0.006$ $p = 0.007$) from perceived risk of exposure to sleep.

As for indirect effect support for that hypothesis from perceived risk of exposure to energy level, we find statistically significant effects stemming from perceived risk in waves 2 and 3 again. The standardized indirect path coefficients respectively are crhrw2 = 0.147 with p=0.000 and crhrw3 = 0.021 with p=0.007.

Table 11 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
illw3 <-					
depagw1	.0010374	.0015494	0.67	0.503	.0252051
depagw2	.0114584	.0040834	2.81	0.005	.191954
BSIanx	-.1517467	.0580061	-2.62	0.009	-.4803586
medcow3	.0488005	.0140015	3.49	0.000	.2158266
illw2	1.358416	.3050409	4.45	0.000	1.038483
crhrw3	.0142237	.005256	2.71	0.007	.0109115
BSIdep	.0349669	.0067458	5.18	0.000	.1121249
BSIposymp	.0182385	.0044251	4.12	0.000	.4349584
illw1	.6020331	.1138677	5.29	0.000	.2583933
illw3	-.370891	.0593534	-6.25	0.000	-.370891
crhrw1	-.3089601	.0942429	-3.28	0.001	-.2526077
crhrw2	.5884347	.0997528	5.90	0.000	.438074
anxagw2	.0083799	.001419	5.91	0.000	.1627297
medcow2	-.0002949	.0085698	-0.03	0.973	-.0017985
anxagw1	-.0000357	.0013838	-0.03	0.979	-.0010876
medcow1	.0041305	.0148474	0.28	0.781	.0147583
fdferw1	.0005385	.000793	0.68	0.497	.0175897
injselfr	.1626433	.0724028	2.25	0.025	.0650386
cumdose1	.010993	.0204584	0.54	0.591	.0052161
cumdose2	-.1552335	.2159441	-0.72	0.472	-.1851256
cumdose3	.2363362	.1812398	1.30	0.192	.3585049
crhrw1 <-					
illw1	-.4856184	.1096918	-4.43	0.000	-.2549246
crhrw1	-.0239749	.0049014	-4.89	0.000	-.0239749
anxagw1	-.0017746	.0005732	-3.10	0.002	-.0661433
medcow1	-.0158073	.0054175	-2.92	0.004	-.0690795
fdferw1	.0005668	.000396	1.43	0.152	.0226423
injselfr	.7028616	.0944193	7.44	0.000	.3437644
cumdose1	-.0164987	.0107197	-1.54	0.124	-.0095749
crhrw2 <-					
depagw1	.0000345	6.33e-06	5.45	0.000	.001126
depagw2	.0001068	.0000382	2.79	0.005	.0024032
illw2	.0127189	.0065594	1.94	0.052	.0130607
illw1	-.0404268	.0859196	-0.47	0.638	-.0233067
crhrw1	.5443032	.0409257	13.30	0.000	.5977723
crhrw2	.0053848	.000934	5.77	0.000	.0053848
anxagw2	.0035404	.0012156	2.91	0.004	.09235
anxagw1	.0008506	.0001788	4.76	0.000	.0348195
medcow1	-.0015327	.0004593	-3.34	0.001	-.0073561
fdferw1	.0028671	.000832	3.45	0.001	.1257918
injselfr	.9264514	.0844453	10.97	0.000	.4976324
cumdose1	.0325218	.0129323	2.51	0.012	.0207278
cumdose2	.0446846	.0172148	2.60	0.009	.0715796

Continued...

Table 11 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
anxagw2 <-					
depagw1	.0099338	.0018238	5.45	0.000	.0124282
depagw2	.0307481	.0110098	2.79	0.005	.0265254
illw2	3.661826	1.888486	1.94	0.052	.1441565
illw1	.7334457	.1357321	5.40	0.000	.0162106
crhrw1	-.3618322	.2617533	-1.38	0.167	-.0152343
crhrw2	1.550299	.2689128	5.77	0.000	.059434
anxagw2	.0193089	.0030533	6.32	0.000	.0193089
anxagw1	.2901172	.0488822	5.94	0.000	.4552698
medcow1	-.038539	.0370064	-1.04	0.298	-.007091
fdferw1	.0632408	.014795	4.27	0.000	.1063705
injselfr	5.01603	1.264771	3.97	0.000	.1032917
cumdose1	3.977033	1.446319	2.75	0.006	.0971755
cumdose2	.4142735	.2214121	1.87	0.061	.0254412
medcow2 <-					
depagw1	.0018511	.0003399	5.45	0.000	.0073734
depagw2	.0057297	.0020516	2.79	0.005	.0157369
illw2	.6823606	.2549446	2.68	0.007	.0855248
illw1	-.6426149	.1684051	-3.82	0.000	-.0452192
crhrw1	1.498835	.3176902	4.72	0.000	.2009138
crhrw2	.2888895	.0501104	5.77	0.000	.0352608
anxagw2	.0035981	.000569	6.32	0.000	.0114556
anxagw1	.0171394	.007088	2.42	0.016	.0856314
medcow1	1.025497	.2306111	4.45	0.000	.6007335
fdferw1	.005573	.0010205	5.46	0.000	.0298439
injselfr	1.532667	.4336291	3.53	0.000	.1004835
cumdose1	.2580294	.1374226	1.88	0.060	.0200728
cumdose2	.0771975	.0324122	2.38	0.017	.0150937
whppa <-					
depagw1	.0285456	.0082435	3.46	0.001	.0376806
depagw2	.0742795	.0262397	2.83	0.005	.0676078
BSIanx	-.3099424	.4296613	-0.72	0.471	-.0533068
medcow3	.6364747	.1153407	5.52	0.000	.1529385
illw2	8.73241	1.741805	5.01	0.000	.3627068
crhrw3	.2615679	.0966559	2.71	0.007	.0109021
BSIdep	.6430268	.1313719	4.89	0.000	.1120286
BSIposymp	.3591676	.0364348	9.86	0.000	.4653832
whpsleep	.0407685	.0178111	2.29	0.022	.058271
illw1	1.205755	.7173914	1.68	0.093	.0281174
illw3	3.572673	.8506582	4.20	0.000	.1941102
crhrw1	3.476472	1.247265	2.79	0.005	.1544322
crhrw2	3.942065	.6411995	6.15	0.000	.1594513
anxagw2	.0601638	.0124534	4.83	0.000	.0634776
medcow2	.1543493	.045521	3.39	0.001	.0511503
whppa	.0169296	.0032128	5.27	0.000	.0169296
anxagw1	.037082	.0098145	3.78	0.000	.0613964
medcow1	1.217242	.3296649	3.69	0.000	.2363023
whpel	.2527461	.0323507	7.81	0.000	.4032652
fdferw1	.0233261	.0084409	2.76	0.006	.0413953
injselfr	12.49814	1.831584	6.82	0.000	.2715412
cumdose1	.816826	.3214	2.54	0.011	.0210578
cumdose2	.3663854	.6716565	0.55	0.585	.0237396
cumdose3	.3322614	.582719	0.57	0.569	.0273842

Table 11 continued:

	Coef.	Robust Std. Err.	z	P>|z|	Std. Coef.
anxagw1 <-					
fdferw1	.2089858	.0508552	4.11	0.000	.2239984
injselfr	15.55263	3.314408	4.69	0.000	.2040862
cumdose1	13.39982	4.493389	2.98	0.003	.2086416
medcow1 <-					
illw1	-.7365362	.1663692	-4.43	0.000	-.0884747
crhrw1	1.480335	.3026381	4.89	0.000	.3387414
anxagw1	.0149702	.0067321	2.22	0.026	.1276781
medcow1	-.0239749	.0082167	-2.92	0.004	-.0239749
fdferw1	.0045507	.000951	4.79	0.000	.0416001
injselfr	1.340715	.2902426	4.62	0.000	.1500499
cumdose1	.2116404	.1130726	1.87	0.061	.0281054
whpel <-					
depagw1	.0971381	.0214096	4.54	0.000	.0803639
depagw2	.1031965	.0358508	2.88	0.004	.058869
BSIanx	1.344232	.9437159	1.42	0.154	.1449003
medcow3	1.727531	.312265	5.53	0.000	.260169
illw2	11.93815	2.015953	5.92	0.000	.3107795
crhrw3	.8095343	.2991432	2.71	0.007	.0211473
BSIdep	1.990123	.4160763	4.78	0.000	.2173068
BSIposymp	1.13367	.1093062	10.37	0.000	.920649
whpsleep	.1640328	.0716632	2.29	0.022	.1469442
illw1	3.533761	.712773	4.96	0.000	.0516472
illw3	3.631796	.526043	6.90	0.000	.1236717
crhrw1	1.249312	1.206203	1.04	0.300	.0347828
crhrw2	5.812623	.8765082	6.63	0.000	.1473568
anxagw2	.0989722	.0275421	3.59	0.000	.0654474
medcow2	.6260631	.1025037	6.11	0.000	.1300335
whppa	.0681165	.0129269	5.27	0.000	.042692
anxagw1	.1122646	.015144	7.41	0.000	.1164976
medcow1	1.138541	.2367738	4.81	0.000	.1385267
whpel	.0169296	.0021669	7.81	0.000	.0169296
fdferw1	.0595048	.0242578	2.45	0.014	.0661842
injselfr	12.73418	1.830304	6.96	0.000	.1734023
cumdose1	2.461321	.8477261	2.90	0.004	.039769
cumdose2	4.124993	1.906065	2.16	0.030	.1675148
cumdose3	-2.698916	1.396456	-1.93	0.053	-.1394129
fdferw1 <-					
injselfr	13.84293	4.125713	3.36	0.001	.1694766
cumdose1	7.764987	3.359776	2.31	0.021	.1128014

Similarly, significant standardized indirect path coefficients stem from waves 2 and 3 of perceived exposure to physical ability, also shown in Table 10. ($crhrw2\ stdized\ \beta = 0.159\ p = 0.000$) and 3 (crhrw3 stdized $\beta = 0.011$ $p = 0.007$) from perceived risk of exposure to physical ability. If we were to permit this evidence to be included in the assessment of the effects testing hypothesis 8, we would have additional empirical evidence of a relationship between perceived risk of exposure to radiation and the physical health outcomes of the Nottingham mentioned here.

4.2.3 Findings regarding the total effects among females

If we maintain the assumption of linearity and additivity, the total effects consist of adding the direct to the indirect effects. To properly evaluate the support for these hypotheses among the females we could consider the total effects to summarize the empirical support for our hypotheses. The findings regarding total effects may be found in Table 11 listing those effects. Because the metric has been a mixture of direct effects, which measure we know, and a set of indirect effects comprising different, mixtures we only use standardized coefficients for the analysis of the indirect and total effects.

In Table 11, we refer to the BSI positive symptom panel, located on page 51. At the bottom of the listing of sources of total effects in the left-most column of the table, we examine those relating to cumulative dose. We observe that two total effects extending from dose to BSI positive symptom are statistically significant– one originating in wave 1 and another in wave 2. The total effect from wave two appears to be larger in magnitude than that from wave one ($cumdose1\ stdized\ \beta = 0.253\ with\ p = 0.002\ and\ cumdose2\ stdized\ \beta = 0.438\ with\ p = 0.023.$) Nevertheless, both of these total effects lend support to the hypothesis 4 that radiation can predict or explain psychological health as measured by subscales of BSI–in this case, the positive symptom subscale.

We also find in Table 11 information pertaining to hypothesis 4 in connection to BSI anxiety. On page 49, we find the total effects extending from cumulative dose to wave 3 BSI anxiety at the bottom of the table on this page. We observe that the waves 1 and 2 total effects from cumulative external dose to BSI anxiety are found to be statistically significant ($cumdose1\ \beta = .092\ with\ p = 0.003$) and ($cumdose2\ \beta = 0..625\ with\ p = 0.032$). The total effects from radiation to anxiety are found in two out of three waves to be statistically significant, which comprises more evidence in support of hypothesis 4.

When we examine the total effects extending from cumulative does to BSI depression, we refer to the upper panel of Table 11 on page 51 for the findings. At the bottom of the upper panel, we discover again that for waves 1 and 2, the total effects from cumulative external dose to BSI depression are statistically significant ($cumdose1\ \beta = 0.044\ with\ p = 0.004\ and\ cumdose2\ \beta = 0.297\ with\ p = .0.025$). For each of these BSI measures of psychological health we find empirical evidence of a relationship between two waves of radiation and the BSI subscale under consideration, as postulated by hypothesis 4.

To examine the tests for hypothesis 5, we look to perceived risk of exposure as the exogenous variable, whether it stems from wave 1, 2, or 3 and the target endogenous BSI psychological health measure. We revisit the panel of Table 11 relating to endogenous BSI positive symptom subscale on page 51, and we turn to the point of origin of the total effect– respectively, crhrw1, crhrw2, and crhrw3. We find that the wave 1 perceived risk of exposure total effect is not statistically significant (p = 0.368), but that the wave 2 perceived risk of exposure total effect is indeed significant (crhrw2 $\beta = 0.306\ with\ p = 0.000$) and the wave three is also statistically significant (crhrw2 $\beta = .0.036\ with\ p = 0.007$). We have found partial confirmation for hypothesis 5 for female total effects with the BSI positive symptom subscale.

We continue to test hypothesis 5 by proceeding to the BSI anxiety panel in Table 11 on page 49. We go to perceived risk of exposure as the exogenous variable, where it stems from wave 1, 2, and 3 and the target endogenous BSI psychological health measure of BSI anxiety. We turn to the point of origin of the total effect– respectively, crhrw1, crhrw2, and crhrw3, and discover that all three waves of perceived risk of exposure have statistically significant total effects. Wave 1 perceived risk of exposure total effect is significant (crhrw1 $\beta = -0.193$ *with* $p = 0.001$). Wave 2 Chornobyl related heath risk ((crhrw2 $\beta = .339$ *with* $p = 0.000$) is statistically significant as is the wave 3 measure (crhrw3 $\beta = .0.008$ *with* $p = 0.007$). Once again, with both direct combined with indirect effects, we have discovered partial confirmation for hypothesis 5 for women with the BSI anxiety subscale.

We continue to test hypothesis 5 by proceeding to BSI depression as the endogenous variable. We go to perceived risk of exposure as the exogenous variable, whether it stems from wave 1, 2, or 3 and the target endogenous BSI psychological health measure of BSI depression (BSIdep) on page 51 and we turn to the point of origin of the total effect– respectively, crhrw1, crhrw2, and crhrw3. We discover that waves 2 and 3 of perceived risk of exposure have statistically significant total effects. Wave 1 perceived risk of exposure total effect is significant (crhrw1 $\beta = 0.013$ *with* $p = 0.757$) so we can dismiss that relationship. Wave 2 Chornobyl related heath risk ((crhrw2 $\beta = .294$ *with* $p = 0.000$) is statistically significant as is the wave 3 measure (crhrw3 $\beta = .0.122$ *with* $p = 0.007$). Once again, with both direct combined with indirect effects, we have discovered partial confirmation for hypothesis 5 for women with the BSI anxiety subscale.

We need to ascertain whether there is an empirical basis for support of hypothesis 8, that perceived Chornobyl exposure risk explains and/or predicts Nottingham measures of physical health. To test hypothesis 8 on our female subsample, we use three measures of Nottingham physical health relating to sleep, energy level, and physical ability with the results already organized in Table 11 from those tests. We first turn to page 53 where we find the Nottingham sleep panel. In this hypothesis, we focus on the relationships between perceived risk of exposure and the sleep as a physical behavior, necessary for proper biological functioning in the human body. What we find is that there are two statistically significant total effects from perceived risk of exposure to radiation and sleep in wave two (crhrw2 $\beta = 0.177$ *with* $p = 0.000$) and wave 3 ((crhrw3 $\beta = 0.006$ *with* $p = 0.007$). The relationship in wave 1 is not statistically significant (p = 0..492).Once again, with both direct combined with indirect effects, we have discovered partial confirmation and three.

To learn whether there is evidence to support hypothesis 8 with regard to the Nottingham subscale of energy level (whpel), we turn to page 56, where we find the whpel panel in Table 11. As we found with the Nottingham sleep measure, we find two statistically significant total effects extending from perceived risk of exposure to external radiation does in wave 2 and wave 3 to the endogenous variable, of Nottingham energy level.

We examine the test of hypothesis 8 with our female subsample with respect to perceived risk of exposure in any and all waves on the one hand and Nottingham physical ability on the other. The data are in Table 11 on page 55. In the whppa panel, we observe that all three waves of perceived Chornobyl health risk are statistically significantly related to the Nottingham physical ability measure among the females $crhrw1\ \beta = 0.154\ with\ p = 0.000$), ($crhrw2\ \beta = 0.159\ with\ p = 0.000$), $and\ crhrw3\ \beta = 0.11\ with\ p = 0.007$). Whether the relationship is between perceived risk of exposure and sleep, energy level, or physical ability, there seems to be at least partial confirmation of hypothesis 8.

5 The Explanatory and Predictive power of the models

Once a model is believed to be a valid model, it can be used not just for hypothesis testing, but for model-building, and prediction. In order for a regression model to be deemed valid, the assumptions of the model would have to be tested. The results of these tests would have be passed by the nature of the model. The model would be tested for independence of observations, residual normality, residual homoskedasticity, lack of substantial collinearity, lack of residual serial correlation, lack of structural breaks or regime shifts, as well as a means of controlling outliers from creating problems. But this is not enough to guarantee a good forecasting model. Neural networks often fail to forecast well because they tend to overfit the data. Overfit models will yield very high R^2 but provide very poor forecasts because they are not designed to be flexible enough to adapt to the situation.

What has not been answered is how well a model can predict the endogenous variable. For an evaluation of that purpose, we have to set up a situation where an information set is constructed at one time period and an estimate is made for what is to hold in the next time period. This is easily done when the time periods are sufficiently plentiful and they are equidistant in temporal spacing. WHen deviations from these conditions obtain, then the best way to evaluate it is to divide the dataset into two periods, an estimation period and a validation period. The forecasting model is estimated on the historical or estimation period, and predictions are made over the validation period. Then the forecasts are compared to the real data in the validation period to determine who large is the lack of fit or error. Measures such as the mean absolute deviation and the mean absolute percentage error are computed to evaluate the imperfection of the prediction.

Withhut the sample splitting, cross-validation may be used for assessment of the fit and the gain or lift or mean square error can be computed. We can also try a newer approach. We can split the sample and estimate the model on one half, and predict to the other. We can then reverse process and form a finite mixture model from a combination of the two equations. This method was suggested by a Professor Jianquing Fang from the Financial Engineering Department at

Princeton University at a conference on High Frequency Econometrics at the Cass Business School in London three years ago [2].

The model that would be formed to generate the forecast could be an autoregressive model. It could also be a simple regression model. The explanatory power of the model could be assessed by a measure of goodness of fit– such as the R^2. This could assess the extent to which the endogenous variable is explained when using mere model fitting. When applying the model to forecasting other requirements may be necessary. The quick and dirty approach would be just to obtain an adjusted R^2 value. But the forecast evaluation would require the mean absolute error and the mean absolute percentage error to be computed.

To test the power of explanation, we can form an auxiliary regression model from the variables used and nowcast the value for the current wave from previous waves. We can compare that estimate with the actual value for an assessment.

Consider the power (R2) of the regression model to explain the target endogenous variable. It appears that those with an effect size (estimated by the proportion of variance explained greater than 0.5 would be those models with an opportunity to provide an acceptable forecast. With respect to hypothesis 4 and 5, most of the regression models predicting BSI positive symptoms would have an opportunity to do that. Unfortunately, the regression models using the variables that we have used to explain or predict BSI anxiety or BSI depression would not be likely to have that power, without the addition of auxiliary variables, to boost the adjusted R^2 of those models to a level where the model could serve as a reliable basis for explanation and prediction.

Table 12 R^2 and adjusted R^2 for models with same variables included

Multivariate regression R^2

endog var	males	females
BSIpossymp	.623	.558
BSIanx	.474	.478
BSIdep	.349	.335

	R^2		R^2adjusted	
Trimmed univariate	males	females	males	females
BSIpossymp	.609	.552	.599	.542
BSIanx	.451	.459	.437	.445
BSIdep	.340	.307	.322	.308
Trimmed univarirate	males	females	males	females
whpsleep	.390	.414	.379	.408
whpel	.312	.397	.312	.390
whppa	.313	.417	.294	.405

We tested these univariate regressions with a modification of the Theil-Mincer-Zarnowitz (TMZ) regression test [4] for weak forecast rationality. Our modification is to use a reversal of this equation in evaluation of weak nowcasting rationality.Equation 4 is that of TMZ, whereas the equation we used was equation 5. We obtain a nowcast estimate or predicted value from our model and then perform the test described in equation 5.

$$Actual = constant + b * forecast \tag{4}$$
$$Estimate = constant + b * actual \tag{5}$$

where either equation serves as the basis for a joint test for constant=0 and b= 1 indicating weak forecast rationality.

According to that test, we regress the predicted value on the actual value and jointly test for statistical significance whether the coefficient b = 1 and that of the constant = 0. If both of these conditions hold, there would be no level or slope bias in the model. We reversed the procedure and regressed the estimated value on the actual to test the results In so doing, we obtain the fitted values and regress the fitted on actual values. The expectations of weak forecast rationality remain the same. None of the models satisfied the conditions for such rationality, however, as can be seen from the results in Table 13 below.

Table 13 Theil-Mincer-Zarnowitz regression test results

P-Values for Weak forecast rationality tests
where p=0.000 indicates weak forecast non-rationality

Trimmed univariate

	males		females	
BSIpossymp	F(2,337)= 148.66	p = 0.000	F(2,359)=145.72	p= 0.000
BSIanx	F(2,337)= 354.40	p= 0.000	F(2,359)=212.63	p= 0.000
BSIdep	F(2,337)= 593.97	p= 0.000	F(2,359)=409.23	p= 0.000

Trimmed univarirate

	males		females	
whpsleep	F(2,337)= 299.22	p= 0.000	F(2,359)= 251.04	p= 0.000
whpel	F(2,337)= 316.37	p= 0.000	F(2,359)= 271.34	p= 0.000
whppa	F(2,337)= 577.15	p= 0.000	F(2,359)= 250.07	p = 0.000

The variables themselves do not provide enough forecast power over the last wave. Auxiliary variables would be needed to enhance the power of the regression in order to use the regression equation as a basis for forecasting. It is likely that this could be done with AutoMetrics. The statistical significance of the relationship does not by itself supply sufficient power for a good forecasting model.

References

[1] Cohen, J. and Cohen, P. 1983 Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences Hillsdale, NJ: Lawrence Earlbaum As-

sociates, 359-360.

[2] Fang, Jianqing 2009 personal communication with Prof. Fang in London, U.K.

[3] Joreskog, K. and Sorbom, D. 11989 LISREL 8 Users manual Chicago, Ill: Scientific Software International, Inc., 9, 136-137.

[4] Mincer, J. and Zarnowitz, V. 1969 The Evaluation of Economic Forecasts J.Mincer, ed Economic Forecasts and Expectations

[5] Nagel, E. 1961 *The Structure of Science* New York: Harcourt, Brace, and World, 56-78.

[6] StataCorp Release 12 Structural Equation Modeling 2011 College Station, TX:Stata Press, Inc., 209-219.