The Impact of Chernobyl on Health and Labour Market Performance in the Ukraine

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Abstract

We use longitudinal data from the Ukraine to the explore relationship between health and subsequent economic performance using the variation in the level of radiation exposure from the Chernobyl accident as a potential instrument to try to establish the causal impact of poor health on labour force participation, hours worked and wages. There is a significant positive association between area-level radiation dosage and self-reported poor health status, though much weaker associations between area-level dosage and specific health conditions.

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On 26th April 1986, engineers at the Chernobyl nuclear power plant in the Ukraine began a series of tests on one of the nuclear reactors that were to lead to the world's worst civil nuclear disaster. Twenty years on, the inhabitants of the countries affected by Chernobyl are still living with the legacy. While much has been written, and argued, about the medical and physical consequences of Chernobyl[1], little has been written about the social and economic consequences of the disaster despite recent urgings along this line from the United Nations, (UNDP 2002). Health is often considered to be an important determinant of labour market outcomes, such as wages, hours of work and employment, Currie and Madrian (1999). In a transition economy such as the Ukraine, understanding the link between health and economic performance and establishing an appropriate policy response is important when budgets are tight and institutional mechanisms are still evolving. It may be that the Ukraine's transition path was altered by the diversion of resources away from education, health and investment programmes in order to deal with the consequences of the disaster. Investigating the relationship between health and economic performance then helps illuminate the costs of these actions. In what follows, we examine the relationship between this exposure and subsequent health and economic performance using longitudinal data emanating from the Ukraine.

There is a large literature on health and labour market performance, (see the references in Lleras-Muney (2005), Currie and Madrian (1999), Strauss and Thomas (1998), Kahn (1998) therein). There is also a growing literature on child health and later performance, garnered mainly from the industrialised West, see for example Case, Fertig and Paxson (2004), Currie, Shields and

[1] For example, Chernobyl Forum (2005) puts the total number of Chernobyl cancer related deaths at 4000. Greenpeace (2006) cites a figure of around 90,000 cancer related deaths with an additional 100,000 from other radiation-related illnesses.

Wheatley-Price (2004). Much of the literature is concerned with the difficulty of establishing a *causal* link between health and performance. Better health may allow better quality of education and productivity at work. Equally, better education may facilitate better health. In addition, given possible influences of genetic or parental background on both health and performance then it is essential to try and control for these influences when trying to establish a causal link. Access to longitudinal data can therefore facilitate identification of any causal examination of the effects of early health-related incidence on later socio-economic achievement. The Ukraine is fortunate in this regard since there is a panel data set, the Ukrainian Longitudinal Monitor Survey (ULMS), which has self-reported health and socio-economic data for a representative sample of individuals at, currently, three points in time, 1996, 2003 and 2004, so covering different stages of the transition process.

Strauss and Thomas (1998) suggest that local environmental conditions can act as a potential instrument for health, since conditional on health, individual productivity and performance should not be affected by environmental conditions. Almond (2006) exploits the 1918 influenza epidemic to examine long run consequences for educational attainment and labour market performance. Meng and Xiang (2006) use the 1959-61 Great Famine in China as an exogenous shock to identify health effects on individual economic performance. In this context, the Chernobyl disaster generated a potentially negative exogenous shock to the health of those exposed to the radioactive fallout and the dispersal of the fallout was such that different groups of the population were exposed to different levels of radiation that varied by geography, population density and age. This exogenous variation could then be used to identify health effects on individual economic performance.

Given information on an individual’s settlement of residence at the time of the accident it is therefore possible to assign a settlement-level radiation dosage and to establish the association between this dosage and subsequent health and performance. The first step in the project is to establish whether there is a link between proximity to Chernobyl and hence radiation dose received and the list of illness recorded in the ULMS. The second step is to see whether radiation dose itself is correlated with other observable socio-economic outcomes over the next twenty years other than through any health effects and then to begin to assess the impact of health on a range of socio-economic outcomes.

Our results show that there is a significant positive correlation between residence in radiation affect areas and certain measures of poor health. Adults living in areas considered to have received sufficiently high radiation fallout as to be continually monitored are up to 10 percentage points more likely to report being in poor health, though is less obvious manifestation of such an effect in a variety specific self-reported health conditions. Section 2 outlines the methodology used in this study along with details of the Chernobyl accident. Section 3 describes the data, while Section 4 discusses the results. Section 5 concludes.

2. Methodology

The underlying econometric model relates an outcome of and individual i at time t to health status conditional on a set of control variables X

$$Outcome_{it} = b_0 + b_1 Health_{it} + X_{1it}B + u_{it} \quad (1)$$

$$Health_{it} = d_0 + d_1 Dosage + X_{2it}G + e_{it} \quad (2)$$

where u_{it} is a residual. The essential idea is that differences in health across the population are expected to cause differences in the labour market outcomes of interest. However any endogeneity caused by omitted variables correlated with health, simultaneity between health status and the outcome of interest, or measurement error in the health variable would bias OLS estimation of this relationship. Measurement error would bias OLS estimates toward zero, whilst we might expect that omitted variable bias would bias down OLS estimates of a health effect on labour market performance, since unobserved factors that are associated with bad health are likely to be negatively correlated with labour market performance. One possibility is to instrument the health variable with another variable correlated with health but not affected by endogeneity. We argue that the Chernobyl accident constituted an exogenous exposure to radiation of certain sections of the Ukrainian population and, if correlated with health, could be a potentially useful instrument with which to assess the effect of health on socio-economic attainment.

Exposure to radiation from Chernobyl constitutes a “treatment”, the level of which depends on the distance from the reactor - though not linearly since there are several radiation “hotspots” at varying distances from the reactor caused by changes in the wind direction, differential rainfall levels and local topography across areas. The treatment level will also depend on the individual’s age at the time of the accident. Children who were 0-4 years old at the time were particularly vulnerable to thyroid cancer from exposure to radioactive iodine. Indeed the rising incidence of thyroid cancer has been one of the main health impacts of Chernobyl (WHO 2006). However children born after Chernobyl were not exposed to radioactive iodine, which has a short half-life and so quickly decays. As a result the incidence of thyroid cancers has fallen back. The range of related illnesses not restricted to cancers. Reports of lung diseases (bronchitis, emphysema), digestive and blood disorders, birth defects, immune deficiencies, fertility problems are all reported to be correlated with exposure to the irradiated areas, (Greenpeace 2006). Exposure to radiation continues for many due to internal irradiation from consumption of contaminated foodstuffs, leakage of radio-nuclides into ground water from the “graveyards” used to store intermediate waste immediately after the disaster, but unmarked and untreated subsequently. In short, continued exposure to radiation and the long latency period of many of these illness suggests the existence of long-term “at-risk” populations.

Any study that tries to identify the effects of Chernobyl by comparing groups exposed to more radioactivity than others has to address possible confounding issues. While the pattern of dispersal makes it unlikely that radiation was concentrated in areas or individuals that had worse employment prospects relative to others, it is true that certain individuals and areas subject to higher radiation were given additional resources as a direct result of the accident and these resources may affect subsequent economic performance. In what follows we control for a variety of individual and area characteristics in an effort to minimise these confounding effects.

Given repeated observations on the same individuals we can examine changes in various socio-economic indicators conditional on radiation dose received. Repeated observations on the same individuals means that by comparing the changes in behaviour of those who received a high dose with those who received a low dose we can identify the effects of radiation does on any given indicator. The use of longitudinal data also allows us to control for unobservable effects that would otherwise bias the estimation process.

Measuring Fallout

Radiation fallout from Chernobyl has been measured mainly (Ministry Of Ukraine of Emergencies 2006) by the presence of the two radioactive isotopes of most concern to the monitoring authorities – radioiodine (^{131}I) and radiocaesium-137 (^{137}C). Young children were thought to be particularly at risk of thyroid problems following exposure to ^{131}I found initially in the air and then in contaminated milk . However since it has a half-life of only 8 days the population at risk is likely to vary from that exposed to ^{137}C , which has a half-live of around 30 years and as such carries a more persistent legacy. Its particular concentration in forested areas has consequences for those consuming mushrooms, berries and game taken from contaminated areas. Background levels of ^{137}C before the accident, principally the legacy of nuclear weapons testing after the second world war, were estimated at 2 kilo Becquerel (kBq/m^3). Following the accident, wind direction, wind speed, local rainfall, the degree of forestation, urbanisation and topography all contributed to the variation in fallout as document by the pattern of ^{137}C deposits in Figure 1. As such, exposure to fallout is rather more random than a simple measure of distance from Chernobyl would suggest, (Figure 2). While almost all areas of the Ukraine received radiation doses in excess of levels observed before the accident, (see Table A1 for the ULMS sample estimates), exposure levels to ^{137}C in excess of 1480 kBq/m^3 were subject to immediate evacuation. The majority of evacuees were sent to Kiev, Zhitomir and Chernigov, areas which themselves had received lower, but non-trivial radiation doses. Individuals resident in other "highly contaminated territories" – those that received between 555 and 1480 kBq/m^3 - were not moved to purpose built towns such as Slavutich and Ternopilskie until after that year (IAEA 2006), which because of the pattern of disposition were again also contaminated by (lower but significant levels of) fallout from Chernobyl. However any exposure in excess of 37 kBq/m^3 was considered to be high and areas of contamination that received such dosages were subject to monitoring by the Soviet Authorities (European Commission 1998). These areas and their inhabitants have been subsequently monitored since 1991 by the Ukrainian successors to the Soviets, (Ministry Of Ukraine of Emergencies 2006). This health monitoring program therefore comprises the clean-up workers (liquidators), evacuees form the 30km exclusion zone, those living in contaminated areas and any children of these adult populations. The liquidators were the group estimated to be exposed to the highest radiation dosages, followed by the inhabitants of Pripyat and then the 30km exclusion zone, (IAEA 2006). Since 1986 it has become apparent that radiation dosages have fluctuated both across and within these areas over time because of differences in topography or climate.[2] As a result some areas where the initial dosage was relatively light have received larger cumulative dosages than areas where the initial exposure was

[2] Effective radiation doses are measured in millisieverts, (mSv). The average annual worldwide dose of background radiation is around 2.4mSv (IAEA (2006)). The IAEA estimates that liquidators received accumulated doses of around 100mSV over three years and residents of the monitored areas received, on average, between 10-30 mSV over twenty years. This represents an annual effective radiation dose around 1mSV over and above normal background doses.

relatively high. In what follows we measure exposure based both on area-level dosage and self-reported status in regard to the accident.

3. Data

We have access to the 2003 and 2004 Ukrainian Longitudinal Monitor Surveys (ULMS), a longitudinal survey of around 4,300 households and approximately 8,800 individuals aged 16 and over, undertaken for the first time in the spring of 2003.[3] A household questionnaire contains items on the demographic structure of the household, its income and expenditure patterns together with living conditions. An individual questionnaire elicits detailed information concerning both the labour market experience of Ukrainian workers and on, self-defined, health status and specific health conditions. In addition some fifty percent of the ULMS were also sampled in 1995 and 1996 as part of World Bank sponsored living standard survey series. Alongside detailed socio-demographic and income information, these earlier surveys also contain responses to a basic question on health status which appears in all four surveys "How would you evaluate your health?" to which the possible responses are ; very good, good, average, bad . IAEA (2006) suggests that the psychological rather than the physical legacy of Chernobyl may ultimately be more important. If so, then perceptions of health would be as likely to be correlated with perceived exposure to radioactivity from Chernobyl as the actual dosages received. In this way the determinants of self-reported health status may be a relevant variable to examine. In 2003 and 2004 we also have self-reported height and weight and so can construct Body Mass Indices for the sample as an additional covariate that will allow us to control for adult health risk factors.

There is a question in the 2003 ULMS which asks respondents where they were living in December 1986, the year of the Chernobyl disaster. The responses allow us to pinpoint the

[3] This constitutes a 0.02% sample of the adult population of 40 million.

location to the nearest village. Some 760 settlements are identified among the list of responses. Given this information we can map in the radiation dose the settlement is estimated to have received in April 1986 according to EC/ICGE (2001) which provide detailed "contour maps" of ^{137}C deposits in May 1986 for each country in Europe. Given this we can generate variables that measure the initial dosage – at the settlement level - and the cumulative dosage over twenty years at the level of the rayon. We also generate dummy variables to group radiation dosages into very high (in excess of 37 ^{137}C kBq/m^3), high (25-36 ^{137}C kBq/m^3 and the rest. Given this information we can then follow individuals and their children over an 18 year period and monitor their circumstances conditional on the radiation dose the town in which they were living at the time of the accident received. Since the young and those in the womb appear to be more vulnerable to radiation exposure (Almond et al (2007), we can interact the dosage with age at the time of the accident. We can, in principle, identify those who were in utero at the time of the accident, but the sample size for this group is small (144 and just 11 in the monitored raions) and the set of labour market related potential outcomes that can be measured is limited given that none of these children will have graduated from high school by 2003. Instead we generate a dummy variable to indicate whether the individual was a child (under 13) at the time of the accident and interact this with the dummy variable for residence in the affected areas.[4]

Since we only have information from December 1986, we miss sampling the area of residence of the 100,000 or so residents who were living within 30km of the plant who were evacuated before the end of 1986. We can however identify these evacuees in the data set. In addition other Chernobyl staff and families were moved to Kiev in the autumn of 1986 – to an area where there had also been lower fallout Yahotin (BBC website). Similarly we can also identify the liquidators, for whom area of residence at the time of Chernobyl is less important than the radiation dose they received as a consequence of the clean-up operations. Table A1 documents

[4] This precludes use of this interaction variable as an instrument in the 1996 data since none of these individuals will be older than 22 in 1996.

the dispersion of estimated dosages excluding those in the sample known to be on military service, liquidators or who were evacuated immediately. Most (66%) individuals in the sample were living in areas that received an (immediate) dose of less than 10 ^{137}C kBq/m^3. Just over 4% of the sample were resident in areas that exceeded the 10 ^{137}C kBq/m^3 monitoring threshold.

Since the behaviour of this group subject to evacuation and subsequent attempts at compensation, may be different from those not evacuated, it is important that we can isolate the two groups in our data set. For example, it is known that special treatment was given to both evacuees and liquidators including extra schooling, additional health care checks and assisted holidays, (Ministry Of Ukraine of Emergencies 2006) which may affect subsequent outcomes of interest. The 2003 ULMS does contain information that should allow us to identify anyone who was evacuated because of Chernobyl and the date at which they moved. In addition the 1995 and 1996 surveys can identify those who received any compensation because of Chernobyl, including the "liquidators", individuals, not necessarily from the locality, who volunteered to help with the on-site clean-up process workers, and who as a consequence were also exposed to higher doses of radiation than otherwise.

The labour market related data contained in the ULMS allow us to observe whether an individual is in employment, the number of weekly hours worked and the log of monthly wages.[5] Mean values of these and the other covariates used in the analysis are given in Table A1 of the appendix. Around 60% of the prime age adult sample are in work and working, on average, some 41 hours a week. Some 0.8% of the sample of adults in 2003 can be identified as liquidators and 0.6% of the sample identify themselves as evacuees.[6]

4. Results

[5] Those not in work are set to zero hours in the regression reported in Table 3. We make no attempt to control for the effect of wage arrears on monthly wages.

[6] 0.2% of the sample were evacuated in 1986.

Table 1 shows the results of the 1st stage of the estimation process, examining whether there is a link between self-reported poor health and Chernobyl-related radiation exposure. For the sample of all adults, there is a significant positive association in 2003 between area level dosage – specifically those living in areas that received in excess of 37 ^{137}C kBq/m^3 and poor health status, in addition to significant positive effects for residents of the monitored areas and liquidators. There is no association for those evacuees in the sample. Interestingly the estimated effect for those who were children (aged 12 or under) living at the time of the accident in what were to be monitored areas, is negative. So their self-reported health status is better than those living in other areas.[7] Most of these significant effects persist when the sample is restricted to prime age workers aged 23 to 55, (column 3), with the exception of the high dosage dummy variable. The addition of oblast (broad region) and education controls makes little difference to the size or significance of the estimated effects of living in the monitoring zone or of being a liquidator. Adults aged 30-55 who live in the monitored areas are some 11 percentage points more likely to report being in poor health than others outside the monitoring zones. Liquidators are, on average, some 15 points more likely to report being in bad health. However when the regressions are repeated one year later for those who remain in the sample, the associations are much weaker. The liquidator effect is no longer significant and the size of the monitor zone effect, while still significant, has fallen by around one half.[8]

Table 2 replaces the dependent variable used in Table 1 with other health conditions identifiable in the ULMS data set using the same set of controls as Column 6 of Table 1. In general these radiation related variable estimates are much less significant than in Column 6 of Table 1. The liquidators are more likely to report heart, spine and blood pressure problems than the rest of the

[7] The total effect is the sum of the coefficients on monitor and the interaction term. Note this interaction term includes children who were in utero at the time of the accident but not those who had not been conceived.
[8] This is not caused by sample attrition. If the regression for 2003 is run on the subset who remain in 2004, the estimates are broadly similar to those reported in the upper half of Table 1.

23-55 year old population, but the monitor zone variables are generally insignificant, with the exception of gastrointestinal problems.

It would seem then that the best candidate variable to be instrumented by radiation-related variables is the poor health status. Table 3 presents OLS and IV-feasible GMM estimates of the effect of this variable in equations explaining the incidence of employment, the number of hours worked and the log of monthly wages for the sample of prime age adults in 2003, (columns 1, 3 and 5 respectively). In each case the poor health status variable is negative and significant, confirming the impression given in Figure A1 that health and employment are negatively correlated. When we instrument using the monitor zone and liquidator dummy variables, while the instruments are significant in the first stage regression and the null of exogeneity in the Hansen test overidentifying restrictions is not rejected, columns 2, 4 and 6 show that the IV/GMM estimates of the effect of bad health are always insignificant.[9] The second panel shows that the OLS estimates of the effect of health are not affected by the removal of evacuees and liquidators from the sample. This suggests that the possible confounding effects of interventions by the authorities on the relative labour market performance of the populations most exposed to radioactivity are small. However the GMM/IV estimates are little changed by the removal of these groups from the sample[10]

When the data is pooled over 2003 & 2004 the pooled OLS estimates again suggest a negative association between poor health and labour market performance. The random effects estimates tend to reduce the size of the estimated effect, again consistent with the idea that unobserved heterogeneity biases down the estimated OLS effects of poor health. However when the poor

[9] The Pagan-Hall tests for heteroskedasticity are all significant, indicating that 2-step GMM would be the most efficient consistent IV estimator.
[10] Estimates available from authors on request.

health variable is instrumented using random effects IV, the poor health variable is insignificant or imprecisely estimated.[11]

5. Conclusion

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[11] Similarly if we pool the 1996, 2003 & 2004 data.

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Figure 1. Distribution of Radiation Fallout Across Ukraine, April 1986

(source: Office for Official Publication of the European Community 2001)

Figure 2. Settlement –Level Initial Dosage (^{137}C k/Bq m^{2}) ULMS Sample

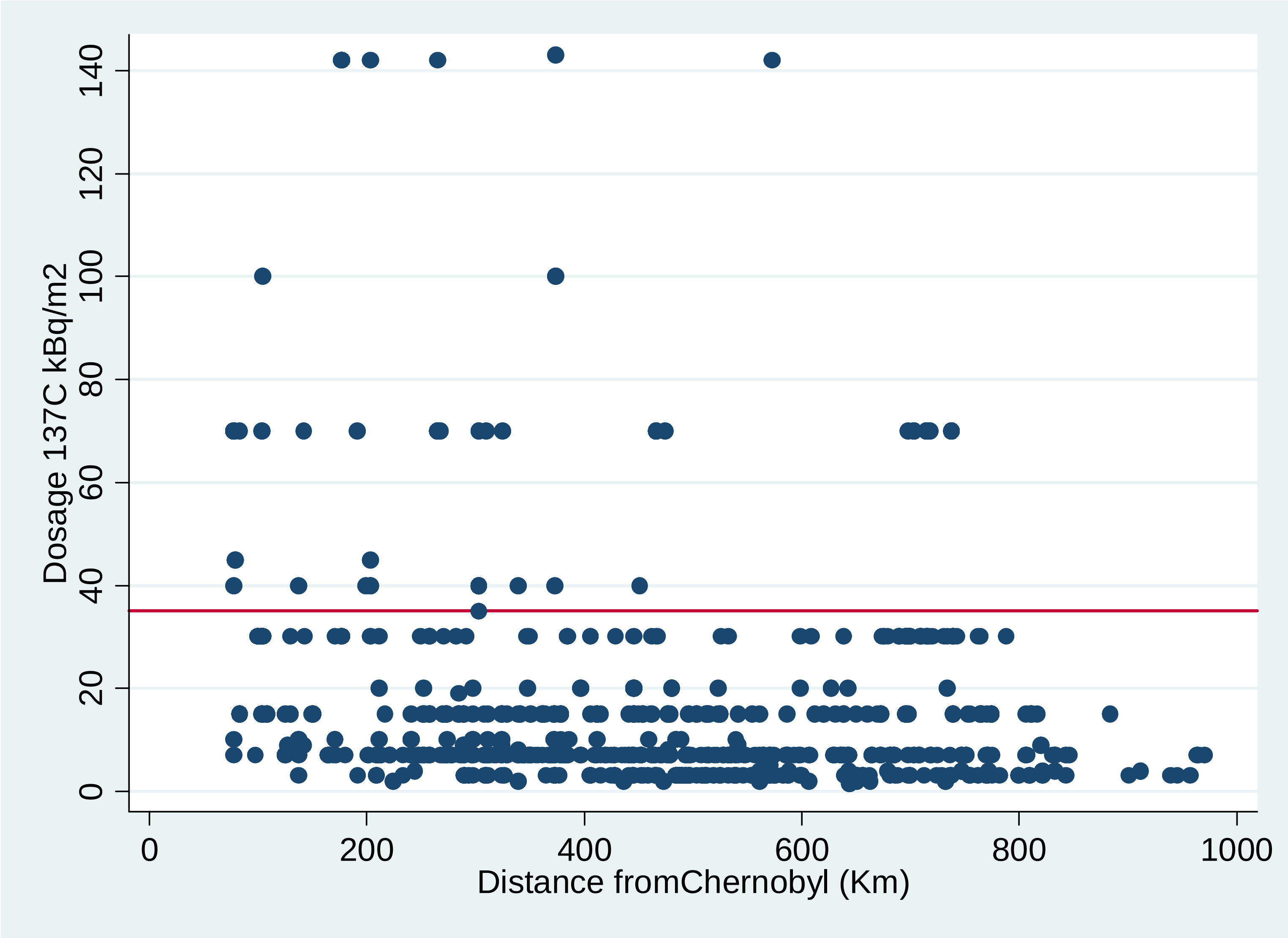


Table 1. Self-Reported "Bad" Health & Chernobyl Exposure

	Age 16+	Age 16+	Age 23-55	Age 23-55	Age 23-55	Age 23-55
2003	1	2	3	4	5	6
Area Dosage>37 KBqm^2	0.065	0.048	0.023	0.009	0.012	
	(0.024)**	(0.026)*	(0.029)	(0.031)	(0.031)	
Monitor Area_then	0.065	0.074	0.085	0.110	0.107	0.111**
	(0.021)**	(0.026)**	(0.025) **	(0.031) **	(0.031) **	(0.029)
Monitor*Age<13_then	-0.176	-0.163	-0.104	-0.099	-0.102	-0.102
	(0.031)**	(0.031)**	(0.037)**	(0.037)**	(0.037)**	(0.037)**
Liquidator	0.145	0.151	0.154	0.151	0.151	0.151
	(0.056)**	(0.056)**	(0.064)**	(0.065)**	(0.065)**	(0.065)**
Evacuee	0.039	0.033	0.017	0.011	0.006	
	(0.062)	(0.063)	(0.071)	(0.068)	(0.067)	
Region controls	No	Yes	No	Yes	Yes	Yes
Education	No	No	No	No	Yes	Yes
N	8476	8476	4908	4908	4908	4908
2004						
Area Dosage>37 KBqm^2	0.039	0.045	0.014	0.011	0.011	
	(0.025)	(0.028)	(0.030)	(0.032)	(0.032)	
Monitor Area_then	0.030	0.034	0.056	0.069	0.066	0.069
	(0.022)	(0.029)	(0.027)**	(0.034)**	(0.034)*	(0.032)**
Monitor*Age<13_then	-0.138	-0.123	-0.096	-0.089	-0.084	-0.083
	(0.029)**	(0.029)**	(0.034)**	(0.034)**	(0.035)**	(0.035)**
Liquidator	0.098	0.111	0.041	0.043	0.041	0.042
	(0.056)*	(0.056)**	(0.059)	(0.058)	(0.058)	(0.059)
Evacuee	0.072	0.071	0.008	0.013	0.001	
	(0.069)	(0.068)	(0.078)	(0.074)	(0.074)	
Region controls	No	Yes	No	Yes	Yes	Yes
Education	No	No	No	No	Yes	Yes
N	6916	6916	3964	3964	3964	3964

Notes; Source ULMS. Each regression also controls for age, gender and ethnicity.

Table 2. Health Conditions & Chernobyl Exposure (Age 23-55)

	Health Status	*Any Health*	*Smoke*	*Drink*	*Heart*	*Lung*
2003						
Monitor Area_then	0.092	0.039	-0.058	-0.048	-0.014	0.018
	(0.051)	(0.037)	(0.030)	(0.032)	(0.026)	(0.016)
Monitor*Age<13_t	-0.128	-0.098	0.113	0.066	-0.042	0.007
	(0.086)	(0.068)	(0.058)	(0.058)	(0.030)	(0.034)
Liquidator	0.256	0.122	-0.012	0.047	0.207	-0.048
	(0.087)**	(0.068)	(0.067)	(0.054)	(0.063)**	(0.019)*
	Liver	***Kidney***	***Gastrointestinal***	***Spine***	***Other***	***Diabetes***
Monitor Area_then	0.034	0.033	0.087	0.055	0.014	0.011
	(0.025)	(0.022)	(0.029)**	(0.027)*	(0.030)	(0.010)
Monitor*Age<13_t	-0.043	-0.050	-0.103	-0.116	-0.008	-0.015
	(0.039)	(0.033)	(0.051)*	(0.032)**	(0.054)	(0.008)
Liquidator	0.089	0.057	0.031	0.183	0.070	0.062
	(0.052)	(0.044)	(0.052)	(0.064)**	(0.058)	(0.036)
	Heart Attack	***Blood Pressure***	***Stroke***	***Anemia***	***Tuberculosis***	***BMI***
Monitor Area_then	0.003	0.016	0.009	0.019	-0.001	0.083
	(0.004)	(0.026)	(0.008)	(0.015)	(0.005)	(0.366)
Monitor*Age<13_t	-0.000	-0.073	-0.006	-0.036	-0.009	-0.838
	(0.006)	(0.023)**	(0.007)	(0.026)	(0.006)	(0.475)*
Liquidator	0.025	0.176	0.007	0.023	0.031	1.110
	(0.027)	(0.063)**	(0.019)	(0.027)	(0.026)	(0.679)

Notes; Source ULMS. Each regression controls for age, gender and ethnicity, region and education.

Table 3. OLS & IV(GMM) Estimates of Effect of "Bad" Health on Labour Market Outcomes

	Work		Actual Hours>=0		Actual Hours>0		Log Monthly Wage	
	OLS	IV/GMM	OLS	IV/GMM	OLS	IV/GMM	OLS	IV/GMM
2003								
Bad Health	-0.199	-0.148	-7.873	-16.300	0.102	-12.783	-0.129	0.528
	(0.020)**	(0.209)	(0.950) **	(10.338)	(0.804)	(10.758)	(0.033) **	(0.552)
Pagan-Hall		216.6 (14) **		45.4 (14)**		22.0 (13)*		64.3 (14)**
Hansen J		0.91		3.67		4.39		4.73
Kleibergen-Papp rk F stat.		8.42		8.06		9.02		7.85
Region controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4908	4908	4813	4813	3007	3007	2878	2878
Without evacuees, liquidators								
Bad Health	-0.203	-0.226	-8.116	-22.161	0.105	-11.670	-0.134	0.169
	(0.020)**	(0.232)	(0.958)**	(12.081)*	(0.851)	(10.506)	(0.033) **	(0.568)
Pagan-Hall		184.7 (13)**		39.8 (13)**		22.4 (13)**		69.8 (13)**
Hansen J		0.71		2.67		4.23		4.24
Kleibergen-Papp rk F stat.		9.35		9.20		9.08		9.89
Region controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	4846	4846	4753	4753	2966	2966	2840	2878

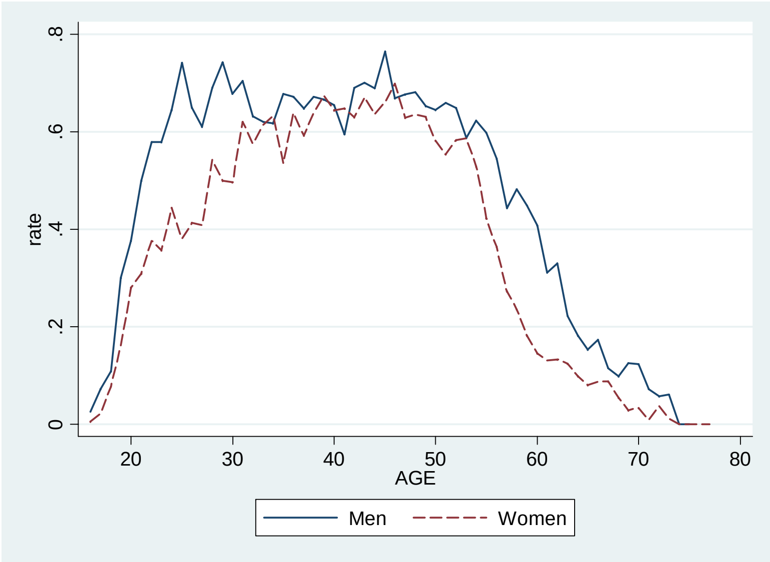
Notes; Source ULMS. Sample adults aged 23-55. Each regression controls for age, gender and ethnicity, region and education. Robust standard errors on OLS estimates. Instruments: Monitor_then, Monitor_then*Age<13, Liquidator. Stock-Yogo (non-robust) 5% and 10% IV relative bias thresholds are 13.91 & 9.08 respectively. The 15 and 20% maximal endogenous parameter rejection rate thresholds are 11.59 and 8.75 respectively.

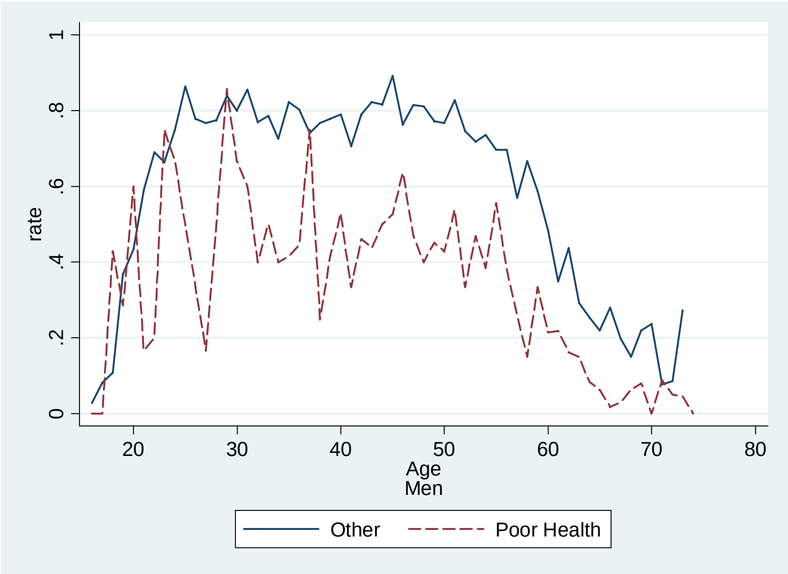
Table 4. Panel IV Estimates of Effect of "Bad" Health on Labour Market Outcomes

	Work			Hours			Log Monthly Wage		
	Pooled OLS	Random Effects	IV Random Effects	Pooled OLS	Random Effects	IV Random Effects	Pooled OLS	Random Effects	IV Random Effects
2003/2004									
Bad Health	-0.219 (0.016)**	-0.141 (0.015)**	-0.459 (0.303)	-8.608 (0.773)**	-6.216 (0.758)**	-40.933 (17.200)*	-0.119 (0.027)**	-0.078 (0.022)**	-0.442 (0.664)
Region controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7654	7654	7654	7528	7528	7528	3590	3590	3590

Notes; Source ULMS. sample adults aged 23-55. Each regression controls for age, gender and ethnicity, region and education. Instruments: Monitor_then, Monitor_then*Age<13, Liquidator.

Figure A1. Employment Rate by Age, Gender & Health Status, Ukraine 2003/4





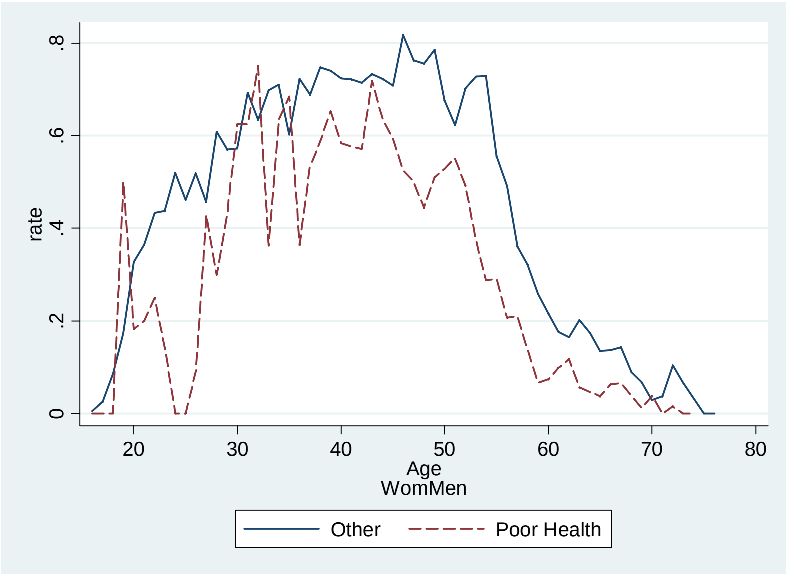


Table A1. Sample distribution of Radiation Dosage & Other Characteristics

	Percent		
Dosage ^{137}C kBq/m^3			
<4	22.2	In Work (Age 16+)	42.9
4-10	46.2	In Work (Age 23-55)	61.3
11-34	27.4		
35-99	3.7	In Bad Health (Age 16+)	22.1
99+	0.5	In Bad Health (Age 23-55)	15.0
Monitor Area	7.5	Actual Weekly Hours>=0	26.2 (22.6)
Monitor Area*Age<13	2.2	Actual Weekly Hours>0	41.8 (12.9)
Liquidator	0.8		
Evacuee	0.6	Gross Monthly Wage (Hrv)	309 (220)
Female	56.8		
Age 16-24	17.9		
Age 25-44	33.7		
Age 45-60	27.7		
Age 61+	20.7		
Kyiv	5.0		
University	12.8		
Technical Diploma	40.0		
High School	18.5		
Russian	16.7		
Other	3.8		

Note: Sample ULMS 2003. Standard errors in brackets.

Table A2. Self-reported Health Status

	2003			2004		
	Total	male	female	Total	male	female
All Adults						
Any	50.0	41.2	56.5	44.3	35.3	50.7
Very Good	1.7	2.7	1.0	1.5	2.4	1.0
Good	22.9	30.3	17.2	23.5	29.8	19.1
Average	52.6	49.8	55.0	53.1	51.2	54.9
Bad	22.5	17.2	26.6	21.4	16.6	25.0
Age 23-55						
Any	48.9	36.7	51.2	38.3	38.0	43.8
Very Good	1.3	2.4	0.7	1.4	2.3	1.0
Good	23.9	32.4	15.4	24.6	31.2	18.7
Average	59.0	53.1	56.2	59.8	54.8	55.9
Bad	15.7	12.1	27.7	14.2	11.8	24.4

Source:ULMS.

Table A3. Self-reported Health Across Waves

		2004			
		Very Good	Good	Average	Bad
	Very Good	22.9	48.6	24.8	3.8
2003	Good	3.3	51.7	41.7	3.4
	Average	0.7	17.6	68.7	13.0
	Bad	0.3	3.1	36.2	60.4
		Any	None		
2003	Any	63.0	37.0		
	None	73.5	26.5		

Table A4. Self-reported Health Conditions Simple Correlation Coefficients

	Any Health Bad
Any Health Problems	**0.4291**
Smoke	**-0.0947**
Drink	**-0.1899**
Heart	**0.3697**
Lung	**0.1538**
Liver	**0.2053**
Kidney	**0.1946**
Gastrointestinal	**0.1840**
Spinal	**0.1801**
Other	**0.2196**
Diabetes	**0.1583**
Heart Attack	**0.1318**
Blood Pressure	**0.3106**
Stroke	**0.1977**
Anemia	**0.0465**
Tuberculosis	**0.0766**
b.m.i.	**0.1867**