Selected Health Consequences of the

CHERNOBYL DISASTER

A Further Systematic Literature Review, Focus Group Findings, and Future Directions

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Cover photo: Chernobyl Nuclear Power Plant monument in front of the damaged reactor #4. (Source: USC)

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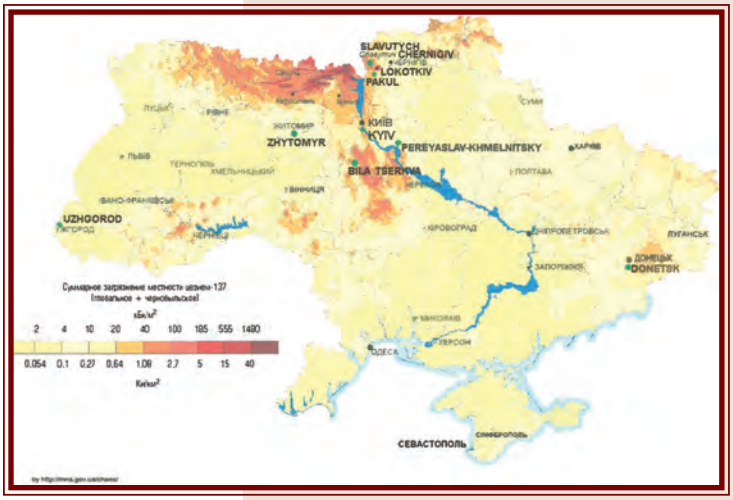
INTRODUCTION

On April 26, 1986, a nuclear disaster occurred at the Chernobyl Nuclear Power Plant, contaminating areas of what are now modern-day Belarus, Moldova, Russia, and Ukraine. In the aftermath of the widespread radiation, there were concerns about risks to human health and of using contaminated land for farming. Because of the high levels of radiation exposure to workers and to people residing adjacent to the plant, substantial emphasis was given to risk from radiation exposure, initially to acute radiation sickness and subsequently to cancer. Given the constraints posed by the circumstances of the disaster, the anticipated cancer risks from radiation have been as closely tracked as may have been feasible. Studies have addressed acute radiation effects in immediate victims (Guskova, Barabanova et al. 1988; Mettler, Gus'kova et al. 2007), leukemia and thyroid cancer occurrence among children (Astakhova, Anspaugh et al. 1998; Noshchenko, Moysich et al. 2001; Davis, Day et al. 2006; Zablotska, Ron et al. 2011), and thyroid cancer among clean-up workers (Ivanov, Chekin et al. 2008; Kesminiene, Evrard et al. 2012). General cancer rates have also been tracked with hints of possible increases for some sites, e.g. breast cancer (Cardis, Howe et al. 2006; Pukkala, Kesminiene et al. 2006; Prysyazhnyuk, Gristchenko et al. 2007).



Map of Cesium-137 contaminated areas in Ukraine. (Source: GCI)

Even though radiation risks were considered to be well understood at the time of the disaster, the epidemic of thyroid cancer in children that shortly followed the Chernobyl disaster was unexpected and still not fully explained (Williams 2002; Hatch, Ron et al. 2005). In addition, with the existing surveillance mechanisms and epidemiological cohorts, an excess of other cancers has not been detected with the possible exceptions of leukemia among the liquidation workers and

premenopausal breast cancer in women in the general population (Chernobyl Forum 2006; Chernobyl Forum 2006; World Health Organization 2006).

Substantial time has now passed since the disaster occurred and the possibility of health effects other than cancer has not been sufficiently addressed. Principal among these health effects are psychological consequences, including ongoing psychological stress, post-traumatic stress disorder, and diminished well-being. The various summary reports and publications by the World Health Organization and the International Atomic Energy Agency have uniformly noted the lack of evidence on these health effects (Chernobyl Forum 2006; Chernobyl Forum 2006; World Health Organization 2006). A systematic review by Bromet, Havenaar, and Guey (2011) reached a similar conclusion, as did the 2011 report that we completed for Green Cross (Samet and Patel 2011). The same issues are now of concern in Japan after the Fukushima disaster (Brumfiel 2013), further strengthening the need for more research on the long-term neuropsychological consequences of nuclear power accidents. There, the combined impact of the Tsunami and the power plant events led to evacuation of about 300,000 people and lasting displacement for about 60,000 people.

The village of Lokotkiv was evacuated after Chernobyl's disaster. Lubov Lomonos (pictured), 79, was the last to evacuate. Her family refused in 1992 and spent 7 more years in their house. After her husband's death in 1998, she finally moved to the village of Lineya. Since then, she comes every year for a lunch at the cemetery with her family to pay respect to the dead from the abandoned village. (Source: Franck Vogel)

Psychological and Psychiatric Consequences of the Disaster

Beyond radiation exposure, the disaster led to the imposition of diverse acute and chronic stressors on the people living around the site. Examples of these stressors include the acute stress of the disaster and its aftermath with the potential for post-traumatic stress disorder (PTSD), widespread displacement because of contamination, concern about future risks of disease, and even labeling and stigmatizing of the exposed people as a group damaged by the disaster. These types of stressors have documented potential to affect quality of life and to lead to psychological and psychiatric disorders among the victims.

LITERATURE REVIEW, FOCUS GROUP FINDINGS, AND RECOMMENDATIONS

The mental health impact of the Chernobyl disaster among the exposed populations has not been sufficiently studied. The WHO report on the health effects of the Chernobyl disaster characterizes the "mental health impact" as "...the largest public health problem caused by the accident to date" (World Health Organization 2006, pg. 95). The report notes the evidence gaps and makes a bland and general call for an appropriate "mental health policy." In a systematic review published in 2007, which identified research conducted in the 20 years following the disaster (Bromet and Havenaar 2007), only four surveys met the authors' quality criteria, but all gave indication of adverse psychological consequences due to the disaster. The review by Bromet and Havenaar also called for more studies on the clean-up workers (liquidators), who live with the knowledge of increased disease risk, as did the 2011 review by Bromet and colleagues (Bromet, Havenaar et al. 2011).

In a previous report (Samet and Patel 2011), we provided a systematic review of the evidence on neuropsychological consequences of the Chernobyl disaster along with findings of focus groups conducted in Kiev, Ukraine. The report's overall conclusion on the long-term neuropsychological consequences was "the broad findings from these two sources are convergent and clear: twenty-five years after the Chernobyl disaster, the populations affected at the time, whether by being displaces or exposed to radiation, have sustained neuropsychological consequences and these consequences remain of public health and medical significance" (Samet and Patel 2011).

The abandoned fairgrounds in Pripyat, Ukraine.
(Source: David Crump)

In this report, we extend the earlier research on neuro-psychological consequences of the disaster. We add findings from further focus groups conducted in Bila Tserkva, Ukraine, and extend the literature review to cover suicide, reproductive health, immune system and blood disorders, respiratory diseases, and cardiovascular

diseases. These are outcomes that may be plausibly affected by the stress associated with the disaster and its aftermath.

METHODS

To capture the current state of the evidence on suicides, reproductive health, respiratory diseases, and cardiovascular diseases since the disaster, we carried out a systematic review of the available literature. That is, we combed through all of the available published literature, sifting through thousands of publications that were identified to find those that were relevant. We then searched through the references of these papers for additional useful research results. We also used Google and other tools to identify papers that were not in the usual scientific literature. We conducted keyword searches using PubMed, as listed in Table 1. There were a number of non-English publications found in our search, many written in Ukrainian or Russian. For many non-English publications, only an English-translated abstract were available. Because of difficulty in finding and retrieving non-English publications in their entirety online, we only considered peer-reviewed research papers written in English and published before February, 2013. A publication was eliminated from selection by first reading through the abstract and/or summary. If the abstract or summary was relevant to the outcomes of suicide, reproductive health, respiratory disease, and cardio-vascular disease in relation to the exposure to Chernobyl, we considered the publication further. Accepted publications included those with descriptive methods and data related to those outcomes mentioned above.

Hiroshi Ueki, Japanese journalist based in Fukushima, checks for radioactivity near Slavutich, Ukraine. (Source: Franck Vogel)

In addition, sixteen focus groups were conducted in Bila Tserkva, Ukraine from July 4 to 17, 2012 by the Kiev International Institute of Sociology (KIIS), which carried out the 2011 studies. Each focus group consisted of ten participants (n=160) and was conducted in a

Dosimetric measurement taken in the Chernobyl Nuclear Power Plant during a visit in April, 2012. (Source: USC)

conference room at the central library. The participants in Bila Tserkva included displaced and non-displaced residents. KIIS recruiters found non-displaced participants (n=80), and GCU recruiters found the displaced participants (n=80). Besides relocation status, gender and age (25-50 and 50+ years old) were used to stratify the groups in Bila Tserkva. The KIIS interviewer used the same protocols as before with the focus groups in Kiev, Ukraine. However, the questions used in Bila Tserkva were refined based on previous responses to the questions used for focus groups in Kiev (provided in Appendix A). Specifically, direct questions were added for some topics, including possible consequences of Chernobyl for the health of children and grandchildren, and the attitude within the population towards the Chernobyl-affected population.

The recruiters motivated the participation of prospective respondents by appealing to the respondent's possible interest in the subject of discussion, emphasizing the scientific and social importance of the research, and providing a small monetary incentive. For complete methods, please refer to Appendix A.

RESULTS

We assembled evidence tables that highlight the main findings of the investigations conducted since the disaster. In general, the Chernobyl-affected populations targeted three major groups: 1) irradiated children and their mothers; 2) nuclear power plant operators and exposed clean-up workers (liquidators); and 3) immigrants from Chernobyl-affected areas to other countries. Non-exposed individuals selected from government databases comprised the controls for most of the studies. Below, we provide the findings by disease outcomes for these groups. Additionally, the focus groups in Bila Tserkva found several general themes among the answers, similar to those reported by the groups in Kiev (see Appendix A). Subjectively, the interviewer found the responses to be more intense than those given by the participants in Kiev.

Reproductive Health

Table 2 summarizes the findings on reproductive health outcomes and Chernobyl-related exposures. In the 14 publications, various indicators were assessed for reproductive health, including observed stillbirths, percent of abortions, and perinatal mortality. The data collected were mainly from national registries and covered Ukraine, Belarus, Russia, Finland, and other countries.

Stillbirths, malformations, and abortions. The majority of the studies in the literature review examined reproductive health, drawing on national or regional statistics on observed births, stillbirths, malformations, and abortions. Using Italy's national statistics, Bertollini and colleagues (1990) found a reduction in observed births in Italy for the first three months of 1987 and noted that exposures related to Chernobyl could be a cause for this drop. In Ukraine and Belarus, Kulakov and colleagues (1993) found decreased birth rates after the disaster in the Polessky region of Ukraine from 17% to 11.2%, and in the Chechersky region of Belarus from 17.1% to 14.4%. Both regions had high and low levels of contaminated soil, but the study included more women from Polessky who lived in places with higher levels than women from Chechersky who lived in places with higher levels (53% vs. 20%, respectively).

Comparing government data throughout Europe, Scherb and colleagues (2007) found a trend in Eastern Europe of "an absolute increase of the stillbirth proportion in 1986 as compared with 1985 and an apparent upward shift of the whole trend line from 1986 and on." In Germany, Korblein and colleagues (1994) used data for the entire country and found a significant increase in annual perinatal mortality for 1987. Using Finland's national statistics, Auvinen and colleagues (2001) found a statistically significant increase in spontaneous abortions in those residing in contaminated areas, but no marked changes were found in rates of

Larissa Yakubich and her 2-year-old daughter still reside in the contaminated village of Pakul. (Source: Franck Vogel)

induced abortions or stillbirths. In Sweden, Ericson and colleagues (1994) used data from various Swedish health registers to examine pregnancy outcomes at the national level and found that after Chernobyl, there was a reduction in conception rate, an increase in the rate of induced abortion, and no changes in the rates of spontaneous abortions and congenital malformations.

Based on pregnancy outcomes of 755,297 women recorded between 1982 to 1990 in two heavily contaminated regions (Gomel and Mogilev) and two lightly contaminated areas (Brest and Vitebsk) in Belarus, Petrova and colleagues (1997) found increased rates of congenital anomalies and respiratory disorders for those from the heavily contaminated regions. Moreover, they found that the fetal death rates rose from pre- to post-disaster in Gomel, Belarus (8% change), but such changes were not found in Mogilev, Belarus (-11%), Brest, Belarus (-14%), and Vitebsk, Belarus (0%) (Petrova, Gnedko et al. 1997). Using data retrieved from Finland's central statistical office and register of congenital malformations, Harjulehto and colleagues (1989) found that at a national level, there were no significant differences in the incidence of malformations or perinatal deaths among the exposed and control groups over the span from 1984 to 1987. However, they found that a significant increase in preterm births occurred among children who were exposed to radiation during the first trimester (Harjulehto, Aro et al. 1989).

An abandoned building near the town square of Pripyat, Ukraine. (Source: USC)

Using the Belarusian National Registry, Lazjuk and colleagues (1997) found that at the national level, the frequency of birth malformations among exposed and control groups was significantly increased from before to after the disaster ($p<0.05$). In a follow-up study, Lazjuk and colleagues (2003) calculated the percent increase in Belarus from before to after Chernobyl for registered malformations, and found an increase of 81% in high-contaminated areas, 49% in low-contaminated areas, and 43% in non-exposed areas (the control group).

Sex ratio at birth. Sex ratio at birth refers to the ratio with the number of males as its numerator and the number of females as its denominator. Previous research groups have suggested that the sex ratio at birth can serve as an indicator of stability and of reproductive health for a population, and that it can be influenced by environmental stress (Davis, Gottlieb et al. 1998; Vartiainen, Kartovaara et al. 1999; Nicolich, Huebner et al. 2000; Campbell 2001).

Using official government statistics, two research groups followed sex ratios at birth before and after the Chernobyl disaster In the Czech Republic, a study by Peterka and colleagues (2004) compared the sex ratio at birth in November, 1986 with the other eleven months of 1986. Peterka and colleagues (2004) found a significant difference in the number of males born in November 1986 compared to all other months combined ($p<0.05$). In a follow-up study, Peterka and colleagues (2007) found a "reduction in number of newborn boys after the Chernobyl explosion" and claimed it was "due to the large release of I-131 and other shorter-lived isotopes of iodine" with exposure to the expecting mothers. They also found a geographic correlation between a reduction in the number of newborn males and the Czech regions with the highest level of exposure to radioactive clouds and rain (Peterka, Peterkova et al. 2007). Scherb and colleagues (2007) used official government data from eight European countries and found an "uniform downward trend of the male birth proportion with an odds ratio of 0.9992 (0.9981-0.9997, $p=0.0025$) per year" after the disaster.

Construction workers at the Chernobyl Nuclear Power Plant. (Source: GCI).

Sperm analysis. Two studies examined the effect of Chernobyl on sperm quality of the Chernobyl clean-up workers. In Russia, Goncharov and colleagues (1998) performed hormone and semen analysis between 1993 to 1995 on 328 Chernobyl clean-up workers, stratifying the data by the radiation dose received. The

percentage of normal forms of spermatozoa in clean-up workers was significantly lower than in the control group (35 ± 13.1% vs. 42.8 ± 8.9%, respectively, $p<0.015$), even though both were within normal ranges (Goncharov, Katsiya et al. 1998). In addition, Goncharov and colleagues (1998) found the mean levels of luteinizing hormone and cortisol in clean-up workers to be significantly lower than in the control group ($p=0.013$, $p<0.001$). The mean level of testosterone was significantly higher in the clean-up workers than in the control group ($p=0.023$) (Goncharov, Katsiya et al. 1998). Nevertheless, Goncharov and colleagues (1998) concluded that "the exposure of men to relatively short-term radiation in the dose range 0.001-0.33 Gray (Gy) did not cause major long-lasting disruption of the endocrine status and spermatogenesis [for] the population of clean-up workers examined 7-9 years later." In a similar study, Fischbein and colleagues (1997) used data collected in 1996 from 18 Chernobyl clean-up workers and 18 Ukrainian control subjects, and concluded that there were no significant difference between the clean-up workers and the control group for sperm density, viability, morphology, semen volume, or biochemical markers.

Anemia. In Polessky region of Ukraine and Chechersky region of Belarus, the rates of anemia in postnatal stages were increased after the disaster in Polessky region from 1.1% to 9.3% and in the Chechersky region from 9.1% to 15.2% (Kulakov, Sokur et al. 1993). Petrova and colleagues (1997) used a government registry on mother and child care and found "increased rates of anemia, renal insufficiency, and toxemia of pregnancy for residents of heavily contaminated regions" in Belarus.

Every year, inhabitants from nearby villages visit a cemetery of unmarked graves near the abandoned and evacuated village of Lokotkiv to pay tribute to the lives lost due to the disaster. (Source: USC)

Suicide

The findings on suicide outcomes and Chernobyl-related exposures were assessed in four publications (Table 3). The studies collected data mainly from male Chernobyl clean-up workers and predominantly used prevalence of suicidal ideation and standardized mortality rates (SMRs) to represent this outcome. Only one study included both male and female suicide rates.

Landscape of the village of Bober in the Chernobyl-restricted zone. (Source: GCU)

Standardized mortality rates. Rahu and colleagues (1997) examined a cohort of 4,742 Chernobyl clean-up workers from 1986 to 1993, and found 19.4% of deaths in the cohort to be suicides with a statistically significant SMR of 1.52 (95% CI: 1.01 - 2.19). In a follow-up study, Rahu and colleagues (2006) found a statistically significant SMR of 1.32 (95% CI: 1.03 - 1.67) between 1986 and 2002 for the same cohort of Chernobyl clean-up workers. However, with stratification of the data by time since the clean-up workers returned from Chernobyl, they found the SMRs to remain stable over subsequent follow-up time (Rahu, Rahu et al. 2006).

In Belarus, Grigoriev and colleagues (2012) used national and regional data to calculate age-standardized mortality rates from suicide (per 100,000 people) between 2005 and 2007 among males and females living in different levels of contamination. At the national level, the suicide rate for males was 50.3 while the rate for females was 7.5 per 100,000 (Grigoriev, Doblhammer-Reiter et al. 2012). The suicide rates for males were higher than for females in each region of Belarus by at least two-fold (Grigoriev, Doblhammer-Reiter et al. 2012). In the Vitebsk region of Belarus (low contamination area), Grigoriev and colleagues (2012) found the highest suicide rates to be 67.1 for males and 10.7 for females.

Suicidal ideation. In a study by Loganovsky and colleagues (2007), interviewers from Kiev International Institute of Sociology asked 295

Chernobyl clean-up workers about suicidal ideation, and their responses were compared to those from the World Mental Health Survey, a national Ukrainian survey (control group). The prevalence of suicidal ideation was higher for clean-up workers than the control group (9.2% vs. 4.1%, respectively) (Loganovsky, Havenaar et al. 2007). In addition, Loganovsky and colleagues (2007) found clean-up workers to be 2.1 times as likely to have suicidal ideation than the control group (aOR = 2.1, 95% CI: 1.1 - 4.1).

Cardiovascular Disease

The nine publications, addressing the outcomes of cardiovascular diseases and Chernobyl-related exposures (Table 4), are based on cohort studies on clean-up workers and cross-sectional studies on children, adolescents, and adults. Various indicators were assessed for cardiovascular diseases, including mortality rates, altered electro-cardiogram (ECG) findings, hypertension, and circulatory diseases.

Children and adolescents. Carrying out research at a Belarusian sanatorium, Bandazhevskaya and colleagues (2004) assessed the benefit of taking oral apple pectin for 16 days to reduce levels of Cesium-137 (Cs-137) in children. Before treatment with oral apple pectin, they found a statistically significant difference in prevalence of abnormal heart sounds, arterial hypertension, and altered ECG between high/moderate and low exposed children ($p<0.05$) (Bandazhevskaya, Nesterenko et al. 2004). After treatment, the prevalence of altered ECG was significantly reduced among high and moderate exposed children compared to baseline ($p<0.05$) (Bandazhevskaya, Nesterenko et al. 2004). Kordysh and colleagues (1995) examined exposed immigrants in Israel and did not find a statistically significant difference in prevalence of cardiovascular disorders between more exposed and less exposed children (4.5% vs. 1.5%, respectively). However, a

Warning sign of radioactivity in the Ukrainian village of Krasno. (Source: GCU)

statistically significant difference in prevalence of cardiovascular disorders was found between more exposed and less exposed adolescents (49.1% vs. 27.5%, respectively, $p<0.05$) (Kordysh, Goldsmith et al. 1995).

Deserted cemetery in the Ukranian village of Denysovychi within the Chernobyl-restricted zone. (Source: GCU)

Clean-up workers and adults. Two research groups calculated the SMR for cardiovascular diseases in clean-up workers. Using the Russian National Medical and Dosimetric Registry, Ivanov and colleagues (2001) assessed the SMR for cardiovascular diseases in a cohort of 65,905 clean-up workers in Russia between 1991 to 1998. They did not find an increase over time: 0.62 in 1991, 1.0 in 1994, 1.18 in 1997, and 0.98 in 1998. However, Eglite and colleagues (2009) tracked the percentage of total morbidity from cardiovascular diseases over time using the Latvian State Register and found an increase from 6.5% in 1998 to 11.5% in 2007 for a cohort of 5,399 Latvian Chernobyl clean-up workers.

In a 20-year follow-up study for "dyscirculatory encephalopathy" (described by the authors as encephalopathy caused by adverse structural and functional changes in the cerebrovascular circulation) involving 536 Chernobyl clean-up workers and 436 control subjects at Regional War Veterans' Hospital in Russia, Podsonnaya and colleagues (2010) found a statistically significant difference in prevalence of "dyscirculatory encephalopathy" in 1987, 1996, and 2006 compared to the control group ($p<0.001$). In addition, Podsonnaya and colleagues (2010) found clean-up workers to have a higher percentage for initial signs of cerebral circulatory failure from 1987 to 1991 compared to the control group. This trend reversed sometime after 1991, as the clean-up workers' prevalence decreased to zero for initial signs of cerebral circulatory failure in 2001 (Podsonnaya, Shumakher et al. 2010).

Ivanov and colleagues (2000) examined the dose dependency for cerebrovascular and circulatory system diseases between 1986 and 1996 in a cohort of 59,207 male Chernobyl clean-up workers who were officially registered in the Russian National Medical and Dosimetric

Registry before 1992. They found a statistically significant increase in crude incidence rate of circulatory system diseases with increasing external radiation dose ($p<0.05$). However, the calculation of excess relative risk per unit of dose (ERR) for circulatory system diseases was only 0.23 per Gray (95% CI: –0.03 - 0.50, $p=0.077$) and not statistically significant. The ERR for cerebrovascular diseases was 1.17 per Gray (95% CI: 0.45 - 1.88, $p<0.001$). In a follow-up study, Ivanov and colleagues (2006) found the ERR for cerebrovascular diseases between 1996 and 2000 to be statistically significant as well (ERR=0.45 per Gray, 95% CI: 0.11 - 0.80, $p<0.01$), despite using an updated cohort that included the same group of 59,207 clean-up workers and an additional 1,810 clean-up workers (authors stated that their same search years later upon the same registry yielded this addition because of newly completed health information, verified dose measurements, and accounted for regional migration for clean-up workers). Similar to their previous study, the ERR for circulatory system diseases was not significantly increased for the period 1996 through 2000 (0.18 per Gray, 95% CI: –0.03 - 0.39, $p=0.08$).

Two research groups examined immigrants from USSR to Israel. Kordysh and colleagues (1995) collected data between 1991 and 1992, and defined the study population into three groups: 55 Chernobyl clean-up workers, 688 more exposed immigrants (those arriving from more exposed areas of USSR, such as Gomel, Chernobyl, and Mogilev), and 817 less exposed immigrants (those arriving from less exposed areas of USSR, such as Kiev). Kordysh and colleagues assessed the prevalence of cardiovascular disorders in immigrant clean-up workers and less exposed immigrants (used as control group), and found a statistically significant difference (89.1% vs. 76.1%, respectively, $p<0.01$). Cwikel and colleagues (1997) collected data between 1994 and 1995 from the following study populations: 30 Chernobyl clean-up workers, 121 more exposed immigrants (those arriving from communities with more than 1 Ci/km^2), 253 less exposed

Inside an abandoned house within the Chernobyl-restricted zone. (Source: Semion Shevtsov)

immigrants (those arriving from communities with less than 1 Ci/km^2), and 334 control subjects (immigrants from non-exposed communities). Cwikel and colleagues recruited the more exposed and less exposed immigrants from the previous study on whole-body counts for Cs-137 by Kordysh and colleagues (1991). Cwikel and colleagues (1997) found that the more exposed immigrants were 1.88 times more likely to have a heart disease than the control group (RR=1.88, 95% CI: 1.09 - 3.22, p=0.028). Additionally, they claimed that there was a statistically significant difference in prevalence of heart disease among clean-up workers and exposed immigrants when compared to the control group but no statistical evidence was provided.

Respiratory Disease

Entrance sign of the Chernobyl region. (Source: GCU)

Table 5 gives the findings on respiratory disease outcomes and Chernobyl-related exposures. Kordysh and colleagues (1995) collected data between 1991 and 1992 on adults, children, adolescents, and clean-up workers who immigrated from USSR to Israel, and found a statistically significant difference in frequency of respiratory disorders (not specified) between clean-up workers and adult immigrants from less exposed communities (87.3% vs. 54.5%, respectively, p<0.001). A statistically significant difference in the summary frequency of multiple respiratory disorders was also found between children who immigrated from more exposed and less exposed communities (78.8% vs. 60.9%, respectively, p<0.05). Kordysh and colleagues did not find a statistically significant difference in frequencies of respiratory disorders comparing adolescents who immigrated from more exposed and less exposed communities (39.6% vs. 39.2%, respectively).

In Ukraine, Svendsen and colleagues (2010) investigated the association of Cs-137 soil contamination with spirometric lung function for 415 exposed children in Zhytomyr region between 1993 and 1998. Children living in the villages with the highest quintile of contamination were found to be 2.6 times more likely to have forced

vital capacity less than 80% of predicted than children living in the lowest quintile (OR=2.60, 95% CI: 1.07 - 6.34) (Svendsen, Kolpakov et al. 2010). Children living in the second highest quintile of contaminated villages were found to be 6.07 times more likely to have peak expiratory flow less than 80% of predicted than children living in the lowest quintile (OR=6.07, 95% CI: 2.09 - 17.62) (Svendsen, Kolpakov et al. 2010). The study concluded that "evidence of airway obstruction and restriction increased with increasing quintiles of soil Cs-137" (Svendsen, Kolpakov et al. 2010). Additionally, Svendsen and colleagues (2010) found that "all spirometry measures were significantly higher in children born after the 1986 Chernobyl incident and improved significantly with increasing time since then ($p<0.0001$)."

Immune Function and Blood Disorders

Table 6 summarizes the findings on Chernobyl-related exposures and outcomes related to immune function and blood disorders.

Immune function. Studies examining immune function and Chernobyl-related exposures used the activity and number of white blood cells as outcome measures. In Ukraine, Sheikh Sajjadieh and colleagues (2011) studied 95 children and adolescents with symptoms of irritable bowel syndrome. They found a statistically significant difference in the percentage of $CD22^{+}$ lymphocytes comparing exposed and non-exposed (healthy) children (24.33 ± 6.0 vs. 20.40 ± 3.0, respectively, $p<0.05$). Petrova and colleagues (1997) conducted analysis of blood from "apparently healthy" infants (examined by a pediatrician before entering the study) residing in areas with different levels of contamination in Belarus. They found that the average T cell count did not differ significantly among groups but the proportion of "null" lymphocytes (expressing neither T or B cells) was increased in the blood obtained from infants

Annual memorial service in Slavutich, Ukraine, honoring those affected by the Chernobyl disaster. (Source: GCI)

living in highly contaminated areas. Additionally, Kurjane and colleagues (2001) found a statistically significant difference in the number of lymphocyte subpopulations of $CD4^+$, $CD8^+$, and $CD16^+$ and in the activity level of neutrophilic phagocytes among Latvian Chernobyl clean-up workers when compared to the Latvian control group ($p<0.05$).

Inside an abandoned classroom in the Chernobyl-restricted zone. (Source: Semion Shevtsov)

Blood disorders. The outcome of blood disorders was assessed in relation to Chernobyl-related exposures by examining morbidity cases. In Belarus, Matsko and colleagues (1999) used data from the state registry and found the morbidity rate (per 100,000 people) for blood and blood-forming tissue diseases to be higher for Chernobyl clean-up workers than the comparison population (304.42 vs. 69.42 per 100,000, respectively). In addition, the morbidity rate (per 100,000 people) for blood and blood-forming tissue diseases was higher for evacuees than for the comparison population (278.55 vs. 73.88 per 100,000, respectively) (Matsko 1999). However, in a cohort of 59,207 Chernobyl clean-up workers in Russia, Ivanov and colleagues (2000) found the excess relative risk per unit of dose for blood and blood-forming organs diseases to be –0.17 per Gray (95% CI: –1.00 - 0.67) and for circulatory diseases to be 0.23 per Gray (95% CI: –0.03 - 0.50). Neither estimate was significantly increased.

Findings of Focus Groups in Bila Tserkva, Ukraine

The focus group findings discussed in this report were based on summary translated reports provided by the Kiev International Institute of Sociology (KIIS) and Drs. Gluzman and Kostyuchenko (see Appendix B for full report). The summary report provided by KIIS gave an abridged version of the responses shared during the focus groups. In this report, KIIS outlined the general themes within the discussions along with a few specific examples from the respondents.

The recorded video on the sixteen focus groups and the actual Russian transcriptions of focus group discussions were provided. The USC investigators reviewed a Google translation of the interview transcripts for general validation.

Outside of the central library where the focus groups took place in Bila Tserkva, Ukraine. (Source: USC)

The focus group discussions in Bila Tserkva centered on several general themes, similar to those reported by the groups in Kiev, including the population perception of health and wellbeing, the quality of medical care, and the possible health consequences of the Chernobyl disaster. For most respondents, health was considered one of the most important priorities in their lives; however, younger respondents prioritized health after work, family, and education. Older respondents reported more health problems and frequent doctor visits than the younger respondents. Still, all groups in Bila Tserkva connected their health problems with consequences of Chernobyl, poor ecology in the town, and unhealthy working conditions. In spite of the high level of concern about health, the focus group participants were wary and distrustful of the care available to them. For example, the phrase "we do not trust doctors" was mentioned in many groups. One participant elaborated further and said it was due to "lack of professionalism of doctors." Another participant gave two examples of how a patient went for a visit and developed hepatitis C after the visit.

Twenty-six years after the disaster, respondents in all groups in Bila Tserkva spontaneously mentioned Chernobyl as a possible threat to their health before the facilitator put the question towards the groups. The respondents were clear that the Chernobyl disaster affected their lives and that they still remember some details of events in April and May 1986. Older relocated respondents, especially women, reported having psychological trauma while all relocated respondents thought that the State robbed and abandoned them after the Chernobyl disaster. Respondents were also concerned about effects on their children and grandchildren.

The focus group participants were clear that they are stigmatized. They reported envy from others because of their benefits and bullying

of their children. In addition, they claimed to be still seen as less desirable for marriage.

In comparison with Kiev, the participants from Bila Tserkva seemed less healthy. Table 7 highlights the comparability of findings between both groups. The team that conducted both focus groups judged the intensity of concerns to be stronger in Bila Tserkva. For example, people from Bila Tserkva claimed to have more diseases, on average, than those from Kiev. This discrepancy was attributed by some to the limited access to medical care in Bila Tserkva along with poor ecology and fallout from Chernobyl.

DISCUSSION

This report provides findings of a systematic review on selected health consequences of the Chernobyl disaster that expands on a review of neuropsychological consequences completed in 2011 (Table 8). In the previous report (2011), findings of a systematic review of the evidence on neuropsychological consequences of the Chernobyl disaster along with results of focus groups conducted in Kiev, Ukraine were provided. The studies included in the first review showed persistent neuropsychological consequences in populations assessed as recently as 2003-2004 (Loganovsky et al. 2007) and 2005-2006 (Guey et al. 2008; Taormina et al. 2008; Bromet et al. 2009; Bromet et al. 2010). Other comprehensive reviews have provided parallel and confirmatory documentation of long-term neuropsychological consequences (Yablokov et al. 2010; Bromet et al. 2011). Overall studies of neuropsychological consequences in children, adults, and workers were consistent in indicating adverse effects. Since the 2011 report, there have not been any substantial additions to the literature on this topic.

The Ukranian village of Zasillia in Chernobyl restricted area. (Source: David Crump)

This report extends the earlier report's systematic review on neuropsychological consequences of the disaster, covering additional health consequences including

suicide, reproductive health, immune function and blood diseases, respiratory diseases, and cardiovascular diseases. These outcomes were selected because the disaster might have directly or indirectly affected their occurrence and because studies of other disasters, including earthquakes, hurricanes, floods, and drought (Leor, Poole et al. 1996; Zotti, Williams et al. 2012; Kolves, Kolves et al. 2013), raise concern for them. Table 8 qualitatively lists the general findings of the systematic reviews provided in both reports.

List of rules for visiting the Exclusion Zone and Compulsory Resettlement Zone for international and national delegations. (Source: USC)

Reproductive Health. While ionizing radiation can directly affect the fetus, the effects of the Chernobyl disaster on reproductive outcomes would most likely be mediated indirectly through maternal stress or disruption of having adequate housing and nutrition. The literature includes diverse indicators of reproductive outcomes including congenital anomalies, rate of pregnancy loss, birth weight, sex ratio, and neurocognitive development. These are non-specific outcomes that have multiple determinants, including tobacco and alcohol use, nutrition, and health status.

Most of these outcomes were considered in the 14 studies identified in the literature search (Table 2). These studies reflected a range of exposure scenarios related to the disaster, depending on where the study was carried out: in Belarus (Lazjuk, Nikolaev et al. 1997; Petrova, Gnedko et al. 1997; Lazjuk, Verger et al. 2003), in the Czech Republic (Peterka, Peterkova et al. 2004; Peterka, Peterkova et al. 2007), in Finland (Harjulehto, Aro et al. 1989; Auvinen, Vahteristo et al. 2001), in Italy (Bertollini, Di Lallo et al. 1990), in Russia (Goncharov, Katsiya et al. 1998), in Sweden (Ericson and Kallen 1994), in Ukraine and Belarus (Kulakov, Sokur et al. 1993), and in other countries (Fischbein, Zabludovsky et al. 1997; Scherb, Weigelt et al. 1999; Scherb and Voigt 2007). Across these studies, the degree of maternal stress extended from those living at distances from the site with general concerns about their children to those who lived nearby and were forced to relocate.

Perhaps the most consistent finding was a drop in birth rate following the disaster that extended to multiple countries (Tables 2 and 8). The decline was greatest in the communities investigated in Belarus and Ukraine (Kulakov, Sokur et al. 1993) and far more subtle in Sweden (Ericson and Kallen 1994) and in Italy (Bertollini, Di Lallo et al. 1990). The declines may have reflected concerns about the immediate consequences of the disaster for child health and decisions to either delay pregnancy or to have an induced abortion as a result (Perucchi and Domenighetti 1990).

Suicide. Increased rates of suicide and suicidal ideation have been documented after natural disasters, although the timing is complicated in relation to the occurrence of the disaster (Kolves, Kolves et al. 2013). Additionally, rates of suicide vary widely around the world and also with age, gender, and other factors (Hawton and van Heeringen 2009; Liu 2009). The Eastern European countries most affected by the Chernobyl disaster also have particularly high suicide rates (Liu 2009; Kolves, Milner et al. 2013).

The literature search identified only four studies on suicide outcomes, including cohort studies in Estonia (Rahu, Tekkel et al. 1997; Rahu, Rahu et al. 2006), and cross-sectional studies in Belarus (Grigoriev, Doblhammer-Reiter et al. 2012) and in Ukraine (Loganovsky, Havenaar et al. 2007). The four studies address changes in suicide rates over time, geographic variation, and prevalence of suicidal ideation. The study of clean-up workers shows a doubling of the frequency of suicidal ideation, but reporting bias is of concern (Loganovsky, Havenaar et al. 2007). In the study of workers of Rahu and colleagues (1997; 2006), the SMR for suicide was elevated and dropped somewhat over time. Overall national rates for suicide in Belarus did not vary in a pattern suggestive of an effect of the disaster. In their review, Hawton and van Heeringen (2012) cite mixed evidence on major events and suicide rates. The systematic review by Kõlves and colleagues (2013) alsofound the evidence from 42 papers to be inconclusive.

Entrance sign of Pripyat, Ukraine, founded in 1970. (Source: USC)

Mother and child, living in the contaminated area outside of Zhymtir, Ukraine, receive an examination by a doctor, part of a Green Cross program. (Source: GCU)

Cardiovascular Disease. Cardiovascular diseases, including hypertension, peripheral vascular disease, coronary heart disease, and stroke, have multiple causes. Stress is a risk factor of long-standing interest and multiple studies have examined cardiovascular disease in relationship to stress from disasters (Dimsdale 2008; Steptoe and Kivimaki 2012). Acutely, heart attack rates rise at the time of earthquakes and stress has also been hypothesized as increasing risk of cardiovascular disease on a longer-term basis (Leor, Poole et al. 1996; Dimsdale 2008; Steptoe and Kivimaki 2012). Some evidence links post-traumatic stress disorder (PTSD) to an unfavorable cardiovascular risk mortality (Dedert, Calhoun et al. 2010). Consequently, we examined the literature on cardiovascular disease in relation to the Chernobyl disaster.

Multiple studies have addressed the outcomes of cardiovascular diseases and Chernobyl-related exposures, including groups in Russia (Ivanov, Maksioutov et al. 2000; Ivanov, Gorski et al. 2001; Ivanov, Maksioutov et al. 2006; Ivanov 2007), in Israel (Kordysh, Goldsmith et al. 1995; Cwikel, Abdelgani et al. 1997), in Belarus (Bandazhevskaya, Nesterenko et al. 2004), and in Latvia (Eglite, Zvagule et al. 2009). The studies identified cover both morbidity and physiological indicators and mortality. The details of study methods are lacking for a number of studies and the most sensitive and contemporary methods for investigation were not used. Mortality is an insensitive and nonspecific indicator. Thus, while most studies provide an indication of increased risk, caution is needed in interpreting the findings. Additionally, the studies generally did not account for potential confounding.

Respiratory Disease. Two studies on respiratory disease outcomes were identified through our literature search, including exposed immigrants in Israel (Kordysh, Goldsmith et al. 1995) and exposed children in Ukraine (Svendsen, Kolpakov et al. 2010). This limited body of evidence precludes any conclusion. There are no direct pathways by which the disaster would have affected respiratory function or

symptoms or the occurrence of major respiratory diseases. High doses of ionizing radiation do cause lung injury, but the general population's doses were far lower than those producing such effects. Svendsen and colleagues (2010) found reduced lung function in children living in a contaminated area of Ukraine and found that higher levels of Cs-137 were associated with lung function abnormalities. However, it seems unlikely that chronic Cs-137 exposure would affect lung growth.

Immune Function and Blood Disorders. The immune system responds to general stimuli, such as stress, as well as to radiation specifically. High doses of radiation leading to radiation sickness deplete the immune system, placing people at risk for infection. The immune system also responds to much lower doses than those causing radiation sickness. Some of these responses have been interpreted as "adaptive" rather than adverse (National Research Council 2006).

The literature review identified five studies on outcomes related to immune function and blood disorders, including groups in Belarus (Petrova, Gnedko et al. 1997; Matsko 1999), in Latvia (Kurjane, Bruvere et al. 2001), in Russia (Ivanov, Maksioutov et al. 2000), and in Ukraine (Sheikh Sajjadieh, Kuznetsova et al. 2011). These studies covered diverse outcomes, including indicators of cellular immunity and clinical syndromes (Table 6). One study addressed the excess risk for diseases of the blood (Ivanov, Maksioutov et al. 2000). Taken together, the studies suggest that the disaster may have affected immune function but through unclear mechanisms.

An abandoned building in the Chernobyl-restricted zone. (Source: Semion Shevtsov)

Focus Groups in Bila Tserkva. We arranged for focus groups in Bila Tserkva, Ukraine to extend the findings of focus groups in Kiev, Ukraine from 2011. Only 55 miles from Kiev, Ukraine and 149 miles from Prypiyat, Ukraine, Bila Tserkva is an industrial city with approximately 210,000 inhabitants. In 1986, about 1,700 families were resettled from areas surrounding the Chernobyl

Nuclear Power Plant to Bila Tserkva. According to the National Ukrainian Report on Chernobyl (2006), Bila Tserkva is considered to have higher levels of contaminated soil from radioactive fallout than Kiev, Ukraine. Table 9 describes the general characteristics of each city. With regard to the participants, the recruitment procedures were similar but participants in Bila Tserkva included displaced and non-displaced residents. The data collection procedures were the same except that the questions used in Bila Tserkva were refined to cover possible consequences of the Chernobyl disaster for the health of children and grandchildren, and attitudes of people generally towards the Chernobyl-affected population.

Inside an abandoned science classroom within the Chernobyl-restricted zone. (Source: Semion Shevtsov)

Overall, the new focus groups showed that for both displaced and non-displaced groups in Bila Tserkva the Chernobyl disaster had affected their lives. Respondents still remembered harsh details of the events in April and May of 1986 and shared emotional stories regarding them, especially about the abrupt and mysterious relocation process. All relocated respondents thought that the State robbed and abandoned them after the Chernobyl disaster. Moreover, older relocated respondents, especially women, expressed concerns about having psychological trauma rom the lengthy ordeal.

Respondents in Bila Tserkva were also passionate about inadequacies of their medical care and shared stories about their poor experiences with doctors. They attributed the poor care to physicians worrying about their own compensation from the government. Immediately after the disaster, the doctors would not be paid appropriately if diagnoses were related to Chernobyl. Several doctors falsified documents and prevented many patients from receiving care needed after the Chernobyl disaster. Even after 26 years, the respondents still remembered problems with physicians and even now only visit those recommended by family or friends.

The focus groups in Bila Tserkva confirmed several findings from the groups in Kiev (Table 7). In both locations, participants

emphasized that health is important to one's life. In addition, for serious illnesses, people would see a doctor, but for lesser illnesses, the groups stated they prefer to take care of it themselves using various non-traditional methods, including chiropractors, acupuncture, and natural healers. Similar concerns were also expressed when asked about major threats to one's health and major barriers for getting medical assistance. The Chernobyl disaster was mentioned by both sets of groups as a major threat to health along with poor ecology and poor food sources and options. With regard to medical care, high costs, long wait times, and lack of trust of doctors were major concerns in both groups.

Both groups strongly believed that their exposure to the Chernobyl disaster caused diseases for them and for people they know. When asked directly, respondents in Bila Tserkva listed more health problems than the respondents in Kiev. Respondents in Bila Tserkva shared stories about how the stigma of being exposed to Chernobyl affected them and their children. For example, within the first years of being relocated to Bila Tserkva, there was a negative attitude towards relocated children in the schools. The local classmates bullied and called the relocated children derogative names based on a popular Russian joke ("Chernobyl's hedgehogs" or "Chernobyl's foxes"). The negative attitude was also seen in relationships among adults, as single females seeking a potential husband typically demeaned single Chernobyl-exposed males. Jokes about being impotent were frequent, as one respondent recalled his dating experience.

Remnants of children dormitory in Pripyat, Ukraine. (Source: GCU)

Based on the discussions in Bila Tserkva, Drs. Kostyuchenko and Gluzman concluded that future quantitative studies and public health initiatives, which include Chernobyl-affected groups, should clarify three major topics: 1) prevalence of mental health disorders, 2) excessive fears about children's physical and mental health, and 3) PTSD and stigma (attached to being relocated from Chernobyl), especially in older women.

CONCLUSIONS AND RECOMMENDATIONS

Summary

This report complements the 2011 report (for recommendations from the 2011 report, see Appendix C), adding additional health outcomes and confirmatory focus group results. In this and the prior report, we have considered two sources of evidence on the long-term health and well-being consequences of the Chernobyl disaster: the published research evidence available in the accessible literature and the findings of focus groups conducted in Kiev and in Bila Tserkva. The broad findings from these two sources are convergent and clear with regard to the neuropsychological consequences: more than twenty-five years after the Chernobyl disaster, the populations affected at the time, whether by being displaced or exposed to radiation, have sustained neuropsychological consequences and these consequences remain of public health and medical significance. This finding is not surprising, given experience with the aftermath of disasters generally. The new systematic review on other adverse health outcomes provides mixed evidence. Many of the studies have limitations that complicate interpretation of their findings. The literature is most consistent for reproductive outcomes, especially the finding of a drop in birth rate following the disaster in multiple countries. The declines may have reflected concerns about the immediate consequences of the disaster for child health and decisions to either delay pregnancy or to have an induced abortion as a result. For malformations, there was less evidence, but one group of researchers in Belarus found a geographical correlation between level of exposure and increases in the rates of malformation from before to after the disaster. Although details of study methods are lacking for a number of studies on cardiovascular diseases, most studies provide an indication of increased risk and perhaps a large study could be carried out to investigate this further, if sufficient resources were available. The studies on outcomes related to immune function and blood disorders included

Dr. Jonathan Samet demonstrates the radiation monitoring required in all public buildings at the Chernobyl Nuclear Power Plant. (Source: USC)

indicators for diverse outcomes. Taken together, these studies suggest that the disaster may have affected immune function but through unclear mechanisms.

Overall, the new focus groups showed that the Chernobyl disaster had affected the lives of both displaced and non-displaced groups in Bila Tserkva. In spite of the high level of concern about health, the focus group participants were wary and distrustful of the care available to them. Respondents still remembered harsh details of the events in April and May of 1986 and shared emotional stories regarding them, especially about the abrupt and mysterious relocation process and the stigmatization of being exposed to the disaster. Respondents were also concerned about the effects on their children and grandchildren in relation to Chernobyl. The team that conducted both focus groups judged the intensity of concerns to be stronger in Bila Tserkva than in Kiev. For example, people from Bila Tserkva claimed to have more diseases, on average, than those from Kiev. This discrepancy was attributed by some to the fallout from Chernobyl in Bila Tserkva along with limited access to medical care and poor ecology.

Annual memorial service in Slavutich, Ukraine, honoring those affected by the Chernobyl disaster. (Source: GCI)

The Scope of the Affected Population

The literature synthesized in the two reports, along with the focus groups, documents adverse consequences for the various populations affected by the Chernobyl disaster. As a next step in characterizing the consequences of the disaster, information is needed on the size of the affected or exposed population. In making such estimation, the concept of exposure should be construed broadly, extending beyond radiation exposure to include psychological distress and longer-term, indirect forces, such as socioeconomic deprivation and stigmatization. The potential breadth of the exposures resulting from the disaster that could potentially affect health (radiation, displacement, inadequate nutrition, loss of employment, and stigmatization as major examples) complicates estimation of the size of the affected populations. While

emphasis has been given to radiation exposure, the other stressors resulting from the disaster need consideration. They would be anticipated to affect different but overlapping groups. Some, for example, may have been stressed by loss of employment and displacement but have escaped significant radiation exposure. Children born after the disaster to those displaced are at-risk for stigmatization and the consequences of socioeconomic hardship. Thus, there are diverse affected populations with different mixtures of exposures.

Table 10 provides a summary of the numbers of exposed persons, as gleaned from review of various reports (see Appendix D). The estimates came from diverse sources that have used differing methodologies, and they are not well documented. However, they are the best source and the estimates indicate that a large number of people were exposed with the upper end of the range extending to about 10 million. Refinements of these numbers and estimates of the numbers of people with diseases or conditions arising from the disaster would require careful population surveys. As noted, there are diverse affected groups with different mixes of exposures. The focus group results comparing Kiev and Beila Tserkva, for example, suggest that some locations may have more severe neuro-psychological consequences than others. Available information does not allow a more precise estimation of the numbers of people affected by Chernobyl, but the focus group findings along with those of the prior review, suggest that a large proportion of the 10 million considered affected may still suffer from lasting consequences.

The overview of the New Safe Containment over reactor #4 of the Chernobyl Nuclear Power Plant. (Source: USC)

What are the Costs?

Given the size of the affected population, an appropriate question is the magnitude of the costs of the disaster, whether arising directly or indirectly. Table 11 identifies the broad categories of costs from the disaster, separating those from the damage to the reactor and the site

from those related to the affected populations. Specific cost estimates related to the disaster were found in various sources (Appendix E). From an interview by Mikhail Gorbachev in the Discovery Channel's 2006 film entitled The Battle of Chernobyl to the 2006 Chernobyl Forum report, these sources lack in-depth methods on the estimations and a precise clarification on whether these estimations are accounting for costs related to affected people or technical damages. According to Mr. Gorbachev, 18 billion rubles were spent in around 1986 to contain the disaster and decontaminate the affected areas (Johnson 2006). According to the 2006 Chernobyl Forum report, government estimates from the 1990s show a huge fiscal impact on governments and "put the cost of the accident, over two decades, at hundreds of billions of dollars" (Chernobyl Forum 2006). According to the Institute of Economics of the Belarusian National Academy of Sciences (2001), the total projected damages over the first 30 years in Belarus are estimated at 235 billion dollars. From 1991 to 2001, the Belarusian government allocated 2.4 billion dollars to mitigate the Chernobyl consequences. Between 1991 and 2003, the total costs by Belarus related to Chernobyl were estimated at more than 13 billion USD (Chernobyl Forum 2006). Likewise, Ukraine has devoted five to seven percent of government spending each year to Chernobyl-related benefits and programs (Chernobyl Forum 2006). From 1992 to 1996, the sum of government spending related to Chernobyl was 5.25 billion dollars, according to the World Bank's 1997 report on Ukraine's public expenditure. According to the Chernobyl Interinform Agency in Ukraine (2002), the total projected damages in Ukraine for the first 30 years are 201 billion dollars. Appendix E lists the estimated costs found in various sources, but these general estimates are not comprehensive and the approaches used to make them need further understanding. One specific, well-documented cost is the New Safe Containment over reactor #4, at about 2 billion USD (European Bank for Reconstruction and Development 2013).

Memorial in Slavutich, Ukraine dedicated to the victims of the Chernobyl disaster. (Source: Franck Vogel)

Less attention has been given to the costs related to the affected

population, reflecting the complexities of doing so. The items included in Table 11 related to the population do generate real costs, but estimating them is difficult. Beyond knowing the size of the affected population, information is needed on the numbers of people having specific conditions and diseases arising from being affected by the disaster. A next step is to assign monetary values to these individual health consequences. Cost estimates are needed that come with sufficient certainty to make them useful for public health, planning, and other purposes. Thus, developing cost estimates that would be credible would be a substantial undertaking, needing the expertise of an economist.

Recommendations

In proposing follow-up to the reports, there is little need to make the inevitable call for more research on neuropsychological outcomes. Studies of neuropsychological consequences in children, adults, and workers are consistent in indicating adverse effects. The focus groups are confirmatory and speak more directly to the need for medical services and interventions that would reduce the persistent burden of neuropsychological morbidity. In our first report, we made suggestions for more systematic approaches to investigation in this area, but the need for community services and health care related to neuropsychological consequences is evident. For other health outcomes, further research is clearly needed, particularly for the major non-communicable diseases, such as cardiovascular disease. While the disaster may have had indirect effects on reproductive outcomes, there is little basis for anticipating such effects now, so long after the disaster.

At the Slavutich orphanage, supported by Green Cross, Maxime Gatchimko, 3, is a difficult child. He says "No" to everything. He has been here for over one and half years because his mother is an alcoholic and his father was sent to prison for murder. (Source: Franck Vogel)

The current context needs careful consideration in planning further data collection and programs. Twenty-seven years after the disaster there are various initiatives in place but further capacity to carry out informative studies is still needed. Additionally, there is now a lengthy

history of government and non-government programs, apparently of variable effectiveness. A notable challenge is a general lack of trust on the part of affected populations that can reach to governmental and non-governmental organizations and affect the collaboration of organizations with the beneficiaries in a negative way.

Photo of reactor #4 of the Chernobyl Nuclear Power Plant taken on April 25, 2012. (Source: USC)

The new literature review covered a range of health outcomes relevant to the Chernobyl disaster. The review is revealing for the paucity of information available and the mixed quality of the studies carried out. Some of the studies raise concern, e.g., those on reproductive outcomes, but the sets of studies reviewed leave questions unanswered. The studies have been carried out pragmatically and with limited resources. At this point, nearly three decades after the disaster, identifying those affected and characterizing their exposures, whether to radiation or to psychological stressors is difficult and a number of the studies in the literature lack adequately developed comparison populations.

Thus, we recommend further research on non-communicable diseases, such as cardiovascular diseases, only if sufficient resources can be identified to carry out studies that will give meaningful results that will benefit the survivors. If a decision is made to carry out a new population-based epidemiological study, a sufficiently large population would be needed for cardiovascular diseases; both Chernobyl-affected people and controls would need to be included; and careful and comprehensive assessment of exposures and outcomes would be requisite. Ideally, the study population would come from the four most affected countries. Clearly feasibility and costs are a constraint, perhaps over-riding. Studies of cardiovascular diseases have typically been costly because of the population sizes needed and the intensity of data collection.

Recommendations for SOCMED Program

The Green Cross Social and Medical (SOCMED) program strives to improve the lives of people suffering from long-term health

consequences of disasters and to reduce the socio-economic impacts resulting from disasters. The program has been implemented in several countries, including Vietnam, Russia, Belarus, and Ukraine. The SOCMED projects cover health care, social care, economic development, and education needs specific to the local populations.

In Belarus and Ukraine, the current SOCMED programming is heavily focused in the Chernobyl-affected communities. The programming for children and adolescents in Belarus comprises education and therapy camps. These camps are used to examine, rehabilitate, and enrich the participants' lives beyond just living in the Chernobyl-affected communities. The programs targeted toward children and adolescents in Ukraine cover oral health prevention (Caries Prevention project), psychological rehabilitation and treatment (therapy camps), and prevention of chronic illnesses (Health for the Future). Family clubs and social cooperatives are operated in both Belarus and Ukraine. Family clubs and social cooperatives, tailored mainly for mothers and young women, are sources for rural development, increasing education on health prevention and diseases, and promoting active and healthier lifestyles within the Chernobyl-affected communities.

Children receiving treatment at a therapy camp, organized and supported by Green Cross. (Source: GCU)

From the recent published SOCMED quantitative results, it is quite apparent that the program has been effective in every participating country with the current activities. We offer suggestions to supplement and strengthen these activities around some of the topics covered in this report, as a first step to a larger long-term strategy. Extending the successful and integrated components of the SOCMED programming to cover additional regions, supplementing further outreach efforts, and including specialized interventions would be an appropriate long-term strategy. Additional activities could include:

1) Reversing stigmatization can be a challenging task, but efforts should be made within the SOCMED projects or within the program as a whole. For example, a large media campaign, including well-known and respected opinion leaders (such as politicians, athletes, and movie stars who belong to affected

families), could be a starting point to bring this discussion to the forefront and help change public perception.

2) Reversing adverse lifestyle risk factor profiles should be given consideration. It is known that cardiovascular diseases can be enhanced by direct and indirect factors, such as stress and lifestyle. These are key determinants of risk for cardiovascular diseases. The adults in the affected countries have high prevalence rates of well known disease risk factors – smoking and excessive alcohol, for example, and obesity is rising. The SOCMED program should embed health promotion and countermeasures in its activities. For example, educating and monitoring blood pressure among the participants, especially those in the family clubs, could help.

Vicka Tisma (16 years old), her brother Micha (15 years old), and her two sisters Bagdana (10 years old) and Dasha (7 years old) live in at Slavutich orphanage, supported by Green Cross because their parents are alcoholics and have no money. Their parents went 500 km away to live and find a job. (Source: Franck Vogel

3) Depression, anxiety, and suicide remain critical concerns also for focus group participants. Consideration should be given to roles of the SOCMED projects in identifying, educating, and referring affected people to receive appropriate support. For example, creating dialogue about these topics in family clubs and therapy camps could help bring attention to these problems and perhaps allow participants to share their own stories which help them in finding solutions. In addition, strategic partnerships with local institutions should be considered to allow participants or people identified by the SOCMED outreach team to receive help at affordable or no cost.

4) Many additional activities could be proposed to strengthen the SOCMED projects (for example, examining the causes of low-vision among children at the therapy camps, and further examining the blood-related problems in the family clubs). An approach for strengthening activities and giving priorities is needed; a formal evaluation of existing programs may be of benefit in this regard. Conducting a comprehensive program evaluation and needs assessment for the SOCMED program, especially for the medical approach in the projects, will identify opportunities to integrate and strengthen projects further for additional health issues.

5) Strengthen the existing nutrition projects within the SOCMED program, which currently focus in reducing the uptake of radionuclides via food consumption and assuring that any excess radiation dose is minimized. Such interventions could be strengthened in the family clubs and therapy camps. Nutrition projects could also include education on healthy diet and the use of dietary supplements, such as vitamins. For example, the consumption of folic acid has shown to reduce neural tube defects. Nutritional deficiencies could contribute to anemia, found in some studies.
6) In addition, the SOCMED program could be an opportunity to further investigate the long-term health consequences of the Chernobyl disaster. Using routine activities and programming, the SOCMED program might be able to collect and evaluate data from participants in the projects, accumulating a cohort for follow-up. We recommend an evaluation of this opportunity.

Chernobyl Nuclear Power Plant monument in frontof the damaged reactor #4. (Source: USC)

TABLE 1: SEARCH RESULTS

Keywords (in conjunction with Chernobyl/ Chornobyl)	Non-English Total	Accepted/ Total[1]
Ideation, suicidal, suicide, suicides, suicide and death, suicides and death, suicide and mortality, suicides and mortality	5	4/34
Abortion, birth malformations, congenital effect, fetal death, induced abortion, infant death, perinatal mortality, pregnancy, reproductive and health, reproductive health, spontaneous abortion, still and birth, stillbirth	91	14/272
Aneurysm, atherosclerosis, blood and circulation, blood circulation, cardiovascular and diseases, cardiovascular and disorders, cardiovascular diseases, cardiovascular disorders, cardiovascular morbidity, cardiovascular mortality, cardiovascular system, cerebrovascular, circulatory and disease, circulatory disease, coronary, CVD, electrocardiography, heart, heart and death, heart and disease, heart disease, heart morbidity, hypertension, ischemic, stroke	151	9/288
Chest, chest pain, immune function, immune system, immune system processes, immunology, lung, lung and disease, lung disease, pulmonary, pulmonary and disease, pulmonary disease, respiration, respiration disorders, respiratory disease, respiratory disorders, respiratory disorders, respiratory tract, respiratory tract infections, thorax	281	7/217

[1] Total is the number of publications found within the search, excluding non-English publications. Accepted is the number of publications used in our review.

TABLE 2. LITERATURE REVIEW: FINDINGS ON REPRODUCTIVE HEALTH

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Lazjuk, Nikolaev et al. 1997)	Used Belarusian National Registry and data obtained from pregnant women living in Minsk (controls), Gomel and Mogilev (contaminated areas) to examine birth malformations at different levels of contamination.	Belarus, 1982 to 1994, Males & Females	Adults & Infants	Incidence of birth malformations per 1,000 neonates (significant difference between each group's values for 1982-1985 and for 1987-1994, $p<0.05$): Between 1982-1985: for high contaminated areas = 3.87, for moderate contaminated areas = 4.57, for controls = 3.90 Between 1987-1994: for high contaminated areas = 7.00, for moderate contaminated areas = 6.80, for controls = 5.58
(Lazjuk, Verger et al. 2003)	Follow-up of previous study using Belarusian National Registry on congenital anomalies to examine birth malformations at different levels of contamination.	Belarus, 1979 to 2000, Males & Females	Adults & Infants	RR for having one of nine congenital anomalies: In low contaminated areas = 1.0, in high contaminated areas = 0.88 (95% CI 0.85-0.91).
(Petrova, Gnedko et al. 1997)	Used government registry at Mother and Child Care Institute in Minsk, Belarus to review all pregnancies recorded between 1982 to 1990 in two heavily contaminated areas (Gomel and Mogilev) and two lightly contaminated areas (Brest and Vitebsk).	Belarus, 1982 to 1990, Females (100%)	755,297 Adults	Fetal death rate per 1,000 live births: Between 1982-1985: in Gomel = 6.7, in Mogilev = 7.0, in Brest = 8.1, in Vitebsk = 6.6 Between 1987-1990: in Gomel = 7.1, in Mogilev = 6.2, in Brest = 7.0, in Vitebsk = 6.6 Neonatal death rate per 1,000 live births: Between 1982-1985: in Gomel = 7.5, in Mogilev = 6.7, in Brest = 7.2, in Vitebsk = 6.2 Between 1987-1990: in Gomel = 7.2, in Mogilev = 6.1, in Brest = 6.5, in Vitebsk = 7.2 Post-neonatal death rate per 1,000 live births: Between 1982-1985: in Gomel = 10.1, in Mogilev = 8.2, in Brest = 8.0, in Vitebsk = 8.6 Between 1987-1990: in Gomel = 5.7, in Mogilev = 5.2, in Brest = 5.5, in Vitebsk = 5.7

TABLE 2. LITERATURE REVIEW: FINDINGS ON REPRODUCTIVE HEALTH

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Scherb, Weigelt et al. 1999)	Used national stillbirth statistics for 23 European countries and various other databases including WHO and EUROSTAT, from 1980-1992 to evaluate time trends in stillbirths and linear regression models.	23 European countries, 1980 to 1992	Infants	Number of observed stillbirths for Belarus and Ukraine: In 1984 = 9,079, in 1985 = 9,108, in 1986 = 9,144, in 1987 = 8,751, in 1988 = 7,866.
(Scherb and Voigt 2007)	Used official government data of live birth and stillbirth statistics from Czech Republic, Denmark, Finland, Germany, Hungary, Norway, Poland, and Sweden from 1982-1992 to investigate trends in sex ratios at birth before and after the Chernobyl accident.	8 European countries, 1982 to 1992, Males (51%) & Females (49%)	22,272,509 Infants, Less than 1	As a whole, found an "uniform downward trend of the male birth proportion with an odds ratio of 0.9992, i.e., a 0.1% change annually (0.9981-0.9997, p=0.0025) per year" after Chernobyl.
(Peterka, Peterkova et al. 2004)	Used official national demographic data registered by the Czech Statistical Office to conduct time series analysis for monthly sex ratios at birth (1950-1999).	Czech Republic, 1950 to 1999, Males & Females	Infants	From 1950 to 1999, only November 1986 had more females born than males (F: 50.65%, M: 49.35%).
(Peterka, Peterkova et al. 2007)	Used official national demographic data registered by the Czech Statistical Office to conduct time series analysis for monthly sex ratios at birth (1950-1999) and the numbers of spontaneous abortions (1970-1999).	Czech Republic, 1950 to 2006, Males & Females	Infants	Found fewer numbers of newborn males in Nov. 1986 for Czech regions with highest radioactive cloud and rain exposure. Percent of spontaneous abortions for 1985 to 1987 varied between 7-9% with no evidence of impact due to Chernobyl. Number of male newborns in North Monravia (contaminated region): for Nov. 1986 = 948, for 1986 = 1178.9 ± 15 (mean ± SE). Number of female newborns in North Monravia (contaminated region): for Nov. 1986 = 1,078, for 1986 = 1,110.3 ± 12 (mean ± SE).

TABLE 2. LITERATURE REVIEW: FINDINGS ON REPRODUCTIVE HEALTH

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Auvinen, Vahteristo et al. 2001)	Used Finland's national statistics and data to examine the effects of Chernobyl fallout on birth rate, induced abortions, and pregnancy loss in Finland.	Finland, 1977 to 1992, Female (100%)	Adults, 15 to 44	RR for stillbirths between 1977-1985: lowest exposure group = 1.0, highest exposure group = 0.74 (95% CI 0.64-0.86). RR for spontaneous abortions between 1977-1985: lowest exposure group = 1.0, highest exposure group = 0.93 (95% CI 0.87-1.00). RR for induced abortions between 1977-1985: lowest exposure group = 1.0, highest exposure group = 0.68 (95% CI 0.48-0.95).
(Harjulehto, Aro et al. 1989)	Used Finnish register of congenital malformations and data from central statistical office of Finland to examine congenital malformations, preterm births, and perinatal deaths at national level.	Finland, 1984 to 1987	Infants, less than 1	No significant differences in the incidence of malformations or perinatal deaths among the groups but significant increase in preterm births occurred among children who were exposed to radiation during the first trimester.
(Bertollini, Di Lallo et al. 1990)	Used national data to analyze birth outcomes in Lombardia (highest level of radioactive exposure in Italy), Lazio (moderate level of radioactive exposure), and Campania (low level of radioactive exposure) between 1977 and 1986.	Italy, 1977 to 1986	Infants	Percent increase of Induced abortions (compared to previous month): In Lombardia (high exposure): for June 1986 = 1.6%, for July 1986 = 3.4% In Campania (low exposure): for June 1986 = 12.7%, for August 1986 = 4.3%.
(Goncharov, Katsiya et al. 1998)	Used hormone and semen analysis on Chernobyl clean-up workers (stratified by radiation dose received: <0.1 Gy, 0.1-0.2 Gy, & >0.2 Gy), to compare with a control group matched by occupation and not suffering any clinical disorders.	Russia, 1993 to 1995, Males (100%)	416 Workers & Controls, 25 to 45	Percentage of normal forms of spermatozoa: in workers = 35 ± 13.1% in control group = 42.8 ± 8.9% ($p<0.015$).

TABLE 2. LITERATURE REVIEW: FINDINGS ON REPRODUCTIVE HEALTH

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Ericson and Kallen 1994)	Used various Swedish health registers, including Hospital Discharge Registry and Medical Birth Registry, to examine pregnancy outcomes at national level.	Sweden, 1985 to 1991	Adults & Infants	RR of perinatal mortality among infants born in June-July 1986 compared to infants born in June-July 1985: for Swedish regions exposed to less than 5 kBq/m^2: 1.62 (95% CI, 1.17-2.24), for Swedish regions exposed to greater than 5 kBq/m^2: 0.92 (95% CI, 0.45-1.82).
(Kulakov, Sokur et al. 1993)	Used 7,000 labor histories of newborns in Polessky region (Ukraine) and Chechersky region (Belarus) to analyze health risks and outcomes for pregnant women and their babies. Both regions have high levels of contaminated soil, but the study included 53% of women from Polessky region who lived in higher levels of contamination and 20% of women from Chechersky region who lived in higher level of contamination.	Ukraine & Belarus, 1983 to 1990, Females (100%)	688 Adults & Children, Less than 19 to 29 & older	Percentage of stillbirths and early neonatal deaths from total pregnancies: Between 1983-1985: for Polessky region = 15.9%, for Chechersky region = 11.5% Between 1986-1988: for Polessky region = 17.8%, for Chechersky region = 7.3% In 1990: for Polessky region = 29.4%, for Chechersky region = 15%
(Fischbein, Zabludovsky et al. 1997)	Used quantitative ultra morphological analysis to evaluate fertility of Chernobyl clean-up workers and a Ukrainian control group.	Unknown (not specified), 1996, Males (100%)	36 Workers & Controls, 18 & older	No significant difference was observed for sperm density, viability, morphology, semen volume, or biochemical markers.

TABLE 3. LITERATURE REVIEW: FINDINGS ON SUICIDE

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Grigoriev, Doblhammer-Reiter et al. 2012)	Used National Committee of Statistics of Belarus (Belstat) to examine regional trends in overall and cause-specific mortality in Belarus from 1990 to 2007.	Belarus, 1997 to 2007, Males & Females	Adults	Age-standardized rates for suicides (per 100,000) in Belarus are the following: 50.3 for males & 7.5 for females. Highest male and female suicide rates (67.1 & 10.7 respectively) were found in Vitebsk (low contamination area). In Gomel, male and female rates were 53.3 and 7.2, respectively.
(Rahu, Tekkel et al. 1997)	Used several data sources, including General Staff of Estonian Defense Forces and former Estonian Chernobyl Radiation Registry, to examine and calculate standardized mortality rates (SMRs) of Chernobyl clean-up workers in Estonia from 1986 to 1993 and compared with rest of country's male population.	Estonia, 1986 to 1993, Males (100%)	4,742 Workers, 20 to 60 & older	SMRs: in 1986-1993 = 1.52 (95% CI, 1.01-2.19), in 1991-1992 = 1.71 (95% CI, 0.78-3.24), in 1992-1993 = 1.44 (95% CI, 0.87-2.25).
(Rahu, Rahu et al. 2006)	Follow-up of previous cohort study to examine SMRs of Chernobyl clean-up workers in Estonia from 1986 to 2002, compared with the country's male population.	Estonia, 1986 to 2002, Males (100%)	4,786 Workers, 20 to 60 & older	SMRs: in 1986-2002 = 1.32 (95% CI, 1.03-1.67), in 1986-1993 = 1.54 (95% CI, 1.03-2.21), in 1994-2002 = 1.21 (95% CI, 0.86-1.64). Adjusted suicide RRs for time since return from Chernobyl: < 5 years = 1.0, 5 to 9 years = 1.09 (95% CI, 0.56-2.10), 10+ years = 1.00 (95% CI, 0.48-2.05).
(Loganovsky, Havenaar et al. 2007)	Interviewed clean-up workers sent to Chernobyl between 1986 to 1990 via KIIS and compared with responses from the World Mental Health Survey (control group).	Ukraine, 2002 to 2004, Males (100%)	692 Workers & Controls, 26 to 51	Prevalence of suicidal ideation since 1986: 27/295 (9.2%) for workers, 16/397 (4.1%) for controls; aOR = 2.1 (95% CI, 1.1-4.1).

TABLE 4. LITERATURE REVIEW: FINDINGS ON CARDIOVASCULAR DISEASES

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Bandazhevskaya, Nesterenko et al. 2004)	Using Belarusian sanatorium Silver Spring of Svetlogorsk, looked at cohort of volunteer children from Gomel, Belarus for frequency of cardiovascular symptoms in relation to levels of Cs-137 exposure. In addition, studied the effect of apple pectin on Cs-137 level and health.	Belarus, 2003, Males (49%) & Females (51%)	94 Children, 7 to 17	Prevalence of abnormal heart sounds: 16/33 (48%) from low contamination, 26/31 (84%) from moderate contamination, & 27/30 (90%) from high contamination ($p<0.05$). Prevalence of arterial hypertension: 3/33 (9%) from low contamination, 8/31 (26%) from moderate contamination, & 15/30 (50%) from high contamination ($p<0.05$). Prevalence of altered ECG at start of study: 17/33 (52%) from low contamination, 26/31 (84%) from moderate contamination, & 28/30 (93%) from high contamination ($p<0.05$).
(Kordysh, Goldsmith et al. 1995)	Used self-reported and physician-diagnosed questionnaires on USSR immigrants who were exposed to Chernobyl disaster and moved to Israel. Comparison group consists of immigrants arriving from less exposed areas of USSR.	Israel, 1991 to 1992, Males (44%) & Females (56%)	1,560 Adults, Children, & Workers, 0 to 59 & older	Prevalence of cardiovascular disorders: 89.1% for workers & 76.1% for adults ($p<0.01$), 49.1% for higher exposed adolescents & 27.5% for low exposed adolescents ($p<0.05$), 4.5% for higher exposed children & 1.5% for low exposed children.
(Cwikel, Abdelgani et al. 1997)	Using list of names from another study (Kordysh et al. 1991), two waves of interviews on exposed immigrants to Israel that were matched by age, gender, year of immigration, and exposure level.	Israel, 1994 to 1995, Males (43%) Females (57%)	1,228 Adults & Workers, 18 & older	Prevalence of heart disease: 10/30 (33%) for workers, 22/74 (30%), for most exposed group, 57/201 (28%) for low exposed group, & 35/214 (16%) for comparison group (author indicated significant exposure effect). RR for heart disease comparing most exposed group and comparison group = 1.88 (95% CI, 1.09-3.22), $p=0.028$.

TABLE 4. LITERATURE REVIEW: FINDINGS ON CARDIOVASCULAR DISEASES

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Eglite, Zvagule et al. 2009)	Used Latvian State Register to compare health occurrences between Latvian Chernobyl clean-up workers and general Latvian population.	Latvia, 1987 to 2007, Males (100%)	5,636 Workers & Controls, 15 to 30 & older	Percentage of cardiovascular diseases from total morbidity: in 1998 = 6.5, in 2007 = 11.5 (Data presented not easily understood).
(Ivanov, Maksioutov et al. 2000)	Examined dose dependency for non-cancer outcomes of Chernobyl clean-up workers registered in the Russian National Medical and Dosimetric Registry before 1992.	Russia, 1986 to 1996, Males (100%)	59,207 Workers, older than 18	Excess Relative Risk (Gy^{-1}) for circulatory diseases = 0.23 (95% CI, –0.03-0.50).
(Ivanov, Gorski et al. 2001)	Examined cause-specific mortality for Chernobyl clean-up workers registered in the Russian National Medical and Dosimetric Registry before 1999.	Russia, 1991 to 1998, Males (100%)	65,905 Workers, older than 18	Number of deaths (SMR, 95% CI): for circulatory system diseases = 1,728 (1.07, 1.03-1.13), for all causes = 4,995 (0.85, 0.82-0.87). SMRs for cardiovascular diseases: in 1991 = 0.62 (95% CI, 0.48-0.78), in 1994 = 1.0 (95% CI, 0.84-1.12), in 1997 = 1.18 (95% CI, 1.07-1.28), in 1998 = 0.98 (95% CI, 0.88-1.1).
(Ivanov, Maksioutov et al. 2006; Ivanov 2007)	Follow-up of previous cohort study examining dose dependency for non-cancer outcomes of Chernobyl clean-up workers registered in the Russian National Medical and Dosimetric Registry before 1992.	Russia, 1986 to 2000, Males (100%)	61,071 Workers, older than 18	Excess Relative Risk (Gy^{-1}): for circulatory system diseases = 0.18 (95% CI: –0.03-0.39), for essential hypertension = 0.36 (95% CI: 0.005-0.71), for ischemic heart disease = 0.41 (95% CI: 0.05-0.78), for cerebrovascular diseases = 0.45 (95% CI: 0.11-0.80).

TABLE 4. LITERATURE REVIEW: FINDINGS ON CARDIOVASCULAR DISEASES

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Podsonnaya, Shumakher et al. 2010)	Twenty years of observations on Chernobyl clean-up workers and control subjects at Regional War Veterans' Hospital in Russia for "dyscirculatory encephalopathy" (described by the authors as encephalopathy caused by adverse structural and functional changes in the cerebrovascular circulation).	Russia, 1986 to 2006, Males (100%)	972 Workers & Controls, less than 20 to 49	Prevalence of initial signs of cerebral circulatory failure: 9.9% for workers & 5.6% for controls in 1987 ($p<0.01$), 51.9% for workers & 37.9% for controls in 1991 ($p<0.001$), 10.6% for workers & 42.9% for controls in 1996 ($p<0.001$), 0% for workers & 14.8% for controls in 2006.

TABLE 5. LITERATURE REVIEW: FINDINGS ON RESPIRATORY DISEASES

Reference	Source Description	Dose	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Kordysh, Goldsmith et al. 1995)	Used self-reported and physician-diagnosed questionnaires on USSR immigrants who were exposed to Chernobyl disaster and moved to Israel. Comparison group consists of immigrants arriving from less exposed areas of USSR.	Lung	Israel, 1991 to 1992, Males (44.2%) & Females (55.8%)	1,560 Adults, Children, & Workers, 0 to 59 & older	Frequencies of respiratory disorders: in workers = 87.3% & in adult immigrants = 54.5% ($p<0.001$), in high exposed children = 78.8% & in less exposed children = 60.9% ($p<0.05$), in high exposed adolescents = 39.6% & in low exposed adolescents = 39.2%
(Svendsen, Kolpakov et al. 2010)	Used standardized spirometric lung function and linear & logistic mixed-effects models to investigate the association of Cs-137 soli contamination and spirometric lung function for children at different levels of exposure in Zhytomyr oblast of Ukraine.	Lung	Ukraine, 1993 to 1998, Males (48.9%) & Females (51.1%)	415 Children, 2 to 17	Risks for airway obstruction and airway restriction were significantly higher among children living in the highest exposed soil (OR for forced vital capacity less than 80% of predicted = 2.60 [1.07-6.34] and OR for forced expiratory volume in 1 sec to forced vital capacity less than 80% = 5.08 [1.02-25.19])

TABLE 6. LITERATURE REVIEW: FINDINGS ON IMMUNE FUNCTION AND BLOOD DISORDERS

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Petrova, Gnedko et al. 1997)	Conducted blood analysis on "apparently healthy" infants (examined by pediatrician before entry) residing in Gomel, Mogilev, Brest, and Vitebsk and compared to infants residing in non-exposed areas of Belarus.	Belarus, 1982 to 1990, Males & Females	757 Infants, 18 months & younger	Average T cell count did not differ significantly among groups but the proportion of "null" lymphocytes (expressing neither T cell or B cell) was increased in blood obtained from infants living in highly contaminated areas.
(Matsko 1999)	Used Belarus State Register to compare morbidity of evacuees from Chernobyl, Chernobyl clean-up workers, and general population in Belarus.	Belarus, 1995, Males & Females	Adults & Workers, 18 & older	Morbidity cases per 100,000 people for blood and blood-forming tissue diseases: 304.42 for workers & 69.42 for comparison population (RR = 4.38); 278.55 for evacuees & 73.88 for comparison population (RR = 3.77).
(Kurjane, Bruvere et al. 2001)	Used physical examinations, immunological investigations (indirect immunofluorescence of lymphocyte subpopulations), blood analysis, urine lead concentrations, and ultrasonography of thyroid on Latvian Chernobyl clean-up workers and compared with healthy age/sex-matched donors.	Latvia, 1998 to 1999, Males (100%)	432 Workers & Controls, 33 to 63	Decreased number of lymphocytes subpopulations of $CD4^+$, $CD8^+$, and $CD16^+$ among workers (with and without thyroid pathology) when compared to control group ($p<0.05$). Lower activity level of neutrophil phagocytic among workers (with and without thyroid pathology) when compared to control group ($p<0.05$).
(Ivanov, Maksioutov et al. 2000)	Examined dose dependency for non-cancer outcomes of Chernobyl clean-up workers registered in the Russian National Medical and Dosimetric Registry before 1992.	Russia, 1986 to 1996, Males (100%)	59,207 Workers, older than 18	Excess Relative Risk (Gy^{-1}) for blood and blood-forming organs diseases = –0.17 (95% CI, –1.00-0.67).

TABLE 6. LITERATURE REVIEW: FINDINGS ON IMMUNE FUNCTION AND BLOOD DISORDERS

Reference	Source Description	Country, Period, Sex	Size (N) Type, Age (years)*	Results
(Sheikh Sajjadieh, Kuznetsova et al. 2011)	Used gamma-ray spectrometry (internal whole body radiation activity) and analyzed lymphocytes & serum immunoglobulins of children and adolescents with symptoms of irritable bowl syndrome at outpatient radiation treatment program at Ukraine-based specialized hospital and compared with healthy children and adolescents (control group).	Ukraine, 2009, Not specified	95 Children & Adolescents, 4 to 18	Percentage of $CD22^{+}$ lymphocytes was significantly higher among exposed children than control (24.33 ± 6.0 vs. 20.40 ± 3.0, $p<0.05$).

TABLE 7. SUMMARIZED FINDINGS FROM BILA TSERKVA AND KIEV (FOR COMPARISON)

Themes:	Bila Tserkva, Ukraine	Kiev, Ukraine
General Perception of Health	Health is top priority in life.	Health is the most important thing in life.
Acting in Case of Illness	Most people would only see doctors for serious illnesses, and for small ones, most people prefer to deal with it by themselves.	For serious illness, people would see a doctor, but for smaller illnesses, most would deal with it by themselves.
Satisfaction with Medical Services	High level of dissatisfaction with the medical services. Main complaints are costly ineffective treatments, low quality of doctors, and lack of empathy from doctors.	Most people are not satisfied with medical services. Satisfaction is determined by personal attention, appropriate diagnosis, and total cost of visit.
Types of Medical Facilities	Mainly visit State medical institutions. Limited access to private or specialized medical facilities due to cost and location.	Private medical facilities are better than State medical facilities, but cost is a huge barrier for most people to have access.
Alternative/ Non-traditional Medical Facilities	Various non-traditional medical clinics are present, such as massage parlors, chiropractors, and natural healers.	Various alternative medical clinics are present in Kiev, such as Korean massage stores and acupuncture.
Barriers for Getting Medical Assistance	Main barriers are lack of money, lack of trust with doctors, and long lines in medical facilities.	Main barriers are lack of trust with doctors, fear that doctor and medical institution causes more harm to patient's health, and lack of money.
Threats to Health	Main threats are consequences of Chernobyl (like radiation level, contaminated soil, etc), poor ecology (like air and water pollution), and poor food sources and options.	Main threats are poor ecology (like air, water, and soil pollution), radiation received from Chernobyl, and poor food sources and options.
How did Chernobyl Affect Lives	Groups strongly believed that Chernobyl caused damages to their health and health of people they know. Strong feeling of being robbed and abandoned by the State.	Groups, specifically with older respondents, believed Chernobyl affected everybody who lives in Kiev and in Ukraine at large in a negative way.

TABLE 7. SUMMARIZED FINDINGS FROM BILA TSERKVA AND KIEV (FOR COMPARISON)

Themes:	Bila Tserkva, Ukraine	Kiev, Ukraine
Affect of Chernobyl Disaster on Health	Groups strongly believed that Chernobyl caused more diseases in them and in people they know, such as thyroid issues, cardiovascular diseases (CVDs), high blood pressure, headaches, impotency, skin cancer, psoriasis, diabetes, allergies, cysts, loss of teeth, weakness of bone system and vision and feet problems.	Groups believed that Chernobyl caused more diseases in them and in people they know, such as thyroid issues, breast cancer, foot pain, skin and blood diseases, headaches, impotency, respiratory diseases, CVDs, and vision issues.
Seeing Doctors because of Chernobyl	Younger respondents stated they avoid seeing doctors due to lack of trust and time, but older respondents, especially chronically ill, see doctors regular.	Respondents stated they do not rely on doctor's diagnoses in relation to Chernobyl due to doctors being instructed not to connect illnesses to Chernobyl.
Possible Consequences of Chernobyl for the Health of Children or Grandchildren	Groups in Bila Tserkva were directly asked and stated several concerns such as impotency.	Indirectly mentioned with the groups in Kiev and suggested there are possible consequences.
Attitude toward Detailed Medical Examination	Liked the idea of detail exams but worry about the costs.	Liked the idea of detail exams but worry about the costs.
The Attitude within Population toward Affected by Chernobyl	Groups in Bila Tserkva were directly asked and stated a general negative attitude.	Indirectly mentioned with the groups in Kiev and stated a general negative attitude.
The Attitude toward Affected by Chernobyl in Past	Groups in Bila Tserkva were directly asked and stated a general negative attitude.	Indirectly mentioned with the groups in Kiev and stated a general negative attitude.

TABLE 8. SUMMARY OF FINDINGS FROM THE SYSTEMATIC REVIEWS

Topics (N= # of studies)	Key Findings – 2011 Review
Anxiety (N=14)	Exposed groups had higher anxiety scores than non-exposed groups. Mothers of exposed children had higher level of concern regarding their child's health and had greater fear for future Chernobyl consequences. Unclear whether increased time since the disaster lessened the anxiety caused by the disaster. Two studies showed that within the exposed groups, the level of anxiety experienced was inversely related to distance from the accident site.
Depression (N=11)	Exposed groups had less favorable scores for depression than non-exposed groups. Unclear whether increasing time since the disaster was associated with decreased depression symptoms. Two studies showed that within the exposed groups, the amount of depression experienced was inversely related to distance from the accident site.
Post-Traumatic Stress Disorder (PTSD) (N=7)	Exposed groups had higher PTSD scores than non-exposed groups. Evacuated mothers were twice as likely to have health concerns regarding PTSD for their children than non-evacuated mothers. One study showed increasing time since the disaster was associated with lower PTSD scores. Two studies showed that within the exposed groups, the frequency of PTSD experienced was inversely related to distance from the accident site.
Well-being (N=23)	Exposed groups had higher scores related to poor well-being than non-exposed groups. Unclear whether increased time since the disaster reduced the poor well-being caused by the disaster. Two studies showed that within the exposed groups, the loss of well-being experienced was inversely related to distance from the accident site.
Cognition (N=18)	Exposed groups generally had lower cognitive scores than non-exposed groups, but mixed results were found in children who were irradiated in utero. Unclear whether increasing time since the disaster or levels of exposure were associated with poorer cognitive functioning.

TABLE 8. SUMMARY OF FINDINGS FROM THE SYSTEMATIC REVIEWS

Topics (N= # of studies)	Key Findings – 2013 Review
(N= # of studies) Reproductive Health (N=14)	Decreased birth rates were found immediately after the disaster in Ukraine, Belarus, Italy, and Sweden. Two studies found birth malformations to significantly increase from before to after the disaster in Belarus. Two studies showed a reduction in number of newborn boys after the disaster in Czech Republic. One study found lower percentage of normal forms of spermatozoa in Chernobyl clean-up workers than control group, but another study found no difference between the clean-up workers and the control group.
Suicide (N=4)	Significantly increased SMR for suicide was found between 1986 and 2002 for a cohort of Chernobyl clean-up workers. Suicidal ideation was more prevalent in clean-up workers than in controls.
Cardiovascular Disease (N=8)	Two studies found no increase in SMR for cardiovascular diseases in a cohort of Chernobyl clean-up workers after the disaster. Three studies found higher prevalence of cardiovascular disorders in more-exposed groups than less-exposed groups,
Respiratory Disease (N=2)	One study found higher frequency of respiratory disorders in Chernobyl clean-up workers and exposed children when compared to less-exposed groups. One study showed that airway obstruction and restriction in children increased with higher levels of soil contamination.
Immune Function and Blood Disorders (N=5)	Three studies showed that the activity and number of white blood cells in clean-up workers and exposed children were generally not significantly different to the non-exposed groups, except for few lymphocyte subpopulations. One study found the morbidity rate for blood and blood-forming tissue diseases in Belarus was higher for clean-up workers and evacuees when compared to non-exposed groups.

TABLE 9. GENERAL PROFILES OF KIEV AND BILA TSERKVA

	Kiev, Ukraine	Bila Tserkva, Ukraine
Population (2001)	2,611,327	200,131
Population (2012 estimation)	2,814,258	210,551
Driving Distance to Prypiyat, Ukraine	95 miles	149 miles
Residents in 1986	89,170	51,500
Cs-137 in soil in 1986 (kBq/m^2)	21	58
Average total internal and external exposure doses in 1986 (mSv)	0.81	2.4
Average total internal and external exposure doses from 2001 to 2005 (mSv)	0.14	0.24

Sources: 2001 National Census Data (http://ukrcensus.gov.ua/eng/), 2006 National Report

TABLE 10. ESTIMATED NUMBERS OF PEOPLE EXPOSED

Country	Number of people exposed to the Chernobyl disaster	Number of people living in the contaminated territories
Belarus	1.82 – 2.6 million	1.57 – 3.7 million
Russia	2 – 3 million	1.79 – 2.7 million
Ukraine	2.6 – 4 million	1.14 – 3.5 million

Sources: Yablokov, Nesternko, & Nesterenko, 2009; Cardis et al., 1996; UNDP et al., 2002; Pflugbeil et al., 2011; Khudoley et al., 2006; Greenpeace, 2006; European Committee on Radiation Risk, 2006; Kennan Institute, 2006; World Bank, 2002

TABLE 11. SOURCES OF COSTS FROM THE CHERNOBYL DISASTER

Related to the Reactor and Site

- Short-term
  - Direct damage to the reactor
  - Economic loss from not generating power
  - Sealing the reactor and mitigating consequences in the exclusion zone

- Long-term
  - Maintenance of the site
  - Further encapsulation of the reactor
  - Environmental monitoring
  - Research
  - Inability to use the land in exclusion zone

Related to the exposed population

- Short-term
  - Loss of property
  - Costs of displacement and resettling
  - Lost earnings
  - Health care costs

- Long-term
  - Diminished employment opportunities and earnings
  - Provision of social and development programs
  - Health care costs
  - Loss of well-being

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Findings of Focus Groups in Bila Tserkva, Ukraine

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INTRODUCTION

In 2011, we carried out focus groups to identify the most critical concerns of residents in Kiev (Kyiv), Ukraine. The findings were of value for assessing support needs and research directions on the neuropsychological consequences of the Chernobyl disaster. The findings from the focus groups in 2011 provided evidence complementary to the literature review done at the time. Both sources showed that populations affected by the Chernobyl disaster have sustained long-term neuropsychological consequences and that these consequences remain of public health and medical significance more than 25 years after the disaster.

To extend the findings from 2011, we arranged for focus groups in Bila Tserkva, Ukraine, an industrial city with approximately 210,000 inhabitants (Figure 1). In 1986, 1,700 families were resettled from areas surrounding of the Chernobyl Nuclear Power Plant to Bila Tserkva. Only 55 miles from Kiev, Ukraine and 149 miles from Prypiyat, Ukraine, Bila Tserkva is considered to have higher levels of contaminated soil from the radioactive fallout than Kiev {National Ukrainian Report 2006}.

As for Kiev, the intent of the focus groups in Bila Tserkva was to obtain additional understanding of the views of men and women affected by the disaster at different points in their lives. The findings from the focus groups in Bila Tserkva provide supplemental evidence to the previous focus groups in Kiev. In addition, the findings offer insights into the possible effects of displacement on the Chernobyl-affected families.

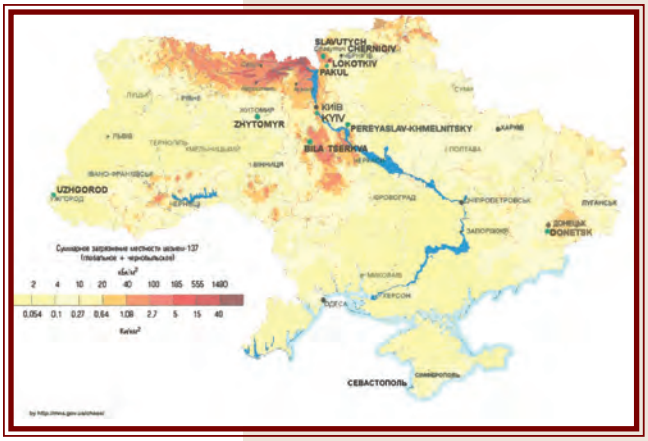

Figure 1. Map of Cesium-137 contaminated areas in Ukraine. (Source: GCI)

APPENDIX A

METHODS

Sixteen focus groups were conducted in Bila Tserkva, Ukraine from July 4 to 17, 2012 by the Kiev International Institute of Sociology (KIIS), which carried out the 2011 studies. Each focus group consisted of ten participants (n=160) and was conducted in a conference room at the central library. The discussions were in Russian and lasted approximately an hour and half. The moderator was a trained and experienced sociologist who recorded the discussions for proper transcription. This same individual had also carried out the foucs groups in Kiev.

The KIIS interviewer used the same protocols as before with the focus groups in Kiev, Ukraine. However, the questions used in Bila Tserkva were refined based on previous responses to the questions used for focus groups in Kiev. Specifically, direct questions were added for some topics, including possible consequences of Chernobyl for the health of children and grandchildren, and the attitude within the population towards the Chernobyl-affected population. The following questions were given to the KIIS interviewer:

1) What are your thoughts about your health or the health of your relatives? How much are health problems important for you and your families?
2) What are your actions in case of an illness? If you have the flu? What about if you have a chronic or serious disease? How often do you visit medical facilities? What types of facilities – state, private or alternative / non-traditional would you visit? In what ways, do your relatives or friends deal with diseases?
3) Do you have any barriers / difficulties in visiting a doctor when you need medical care? If so, what kinds (location, money, other)? What types of barriers do you think other people have in order to receive needed medical care?
4) Were you satisfied by the medical services you received? What about the quality of medical care you received? What was your experience from the medical care you received? Some examples of both positive and negative experiences? How did your relatives or friends think of the quality of medical care they received?

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5) Are there reasons for concerns about your health or for your relatives or friends? Are there threats towards your health? If so, what are they (like what diseases?)?
6) What do you think about Chernobyl disaster consequences in terms of your lives? What happened (changed) into your lives (into lives of your relatives or friends) after the Chernobyl disaster? Did you live near the area of the disaster?
7) How did Chernobyl affect the general health of the people? In what way did the disaster affected your health and/or wellbeing of your relatives or friends? Is there something wrong with your health because of Chernobyl? General health? Sleep? Appetite? Work performance? Tiredness? Fatigue? Depression? Anxiety? What types of health problems in your life are due to the Chernobyl disaster?
8) Are there reasons to see a doctor because you have consequences of Chernobyl in your health? If so, what reasons? What problems with your health could be linked with Chernobyl disaster?
9) Are you afraid of possible future consequences for the health of your children? Of your grandchildren? Of yourself? If so, what specifically affected the lives of your children? Of grandchildren? What kinds of possible consequences? Cancer? Genetic risk? Other risks?
10) Do you think that you and/or your children need more detailed medical examination to define possible consequences of Chernobyl disaster for your health? If so, what types – detailed interview, blood tests? Is there a bad attitude within the population towards those affected or upon the children whose parents were exposed?

APPENDIX A

Participant Recruitment

KIIS and Green Cross Ukraine (GCU) carried out the recruitment of participants. KIIS recruiters found non-displaced participants by stopping people randomly on the busiest main streets in Bila Tserkva. GCU recruiters found the displaced participants through a snowball process within their social networks. GCU recruiters' social networks were comprised of people known to the staff and people referred by the index participants. This referral process continued until GCU had sufficient potential participants with general characteristics representing the target population.

Recruiters motivated the participation of the prospective participants by appealing to the respondent's possible interest in the subject of discussion, emphasizing the scientific and social importance of the research, and providing a small monetary incentive. The recruiters used Table 1 in selecting prospective respondents for the focus group discussions. The characteristics for each group can be found in Table 2.

Table 1. Selection Criteria
1. Gender – as assigned in Table 2 (Group Characteristics)
2. Age – as assigned in Table 2 (Group Characteristics)
3. Educational level - to ensure distribution of respondents with different educational levels within each group.
4. Household well-being - to ensure distribution of respondents with different socioeconomic status within each group.
5. Profession and place of work - to ensure that people working in health-care/medicine will not participate in the groups (since they will not have common but expert opinions on the discussion topic).

APPENDIX A

Table 2. Group Characteristics			
Group Number	**Gender**	**Age**	**Relocation**
1A	Men	25-50	Yes
1B	Men	25-50	Yes
2A	Men	50+	Yes
2B	Men	50+	Yes
3A	Women	25-50	Yes
3B	Women	25-50	Yes
4A	Women	50+	Yes
4B	Women	50+	Yes
5A	Men	25-50	No
5B	Men	25-50	No
6A	Men	50+	No
6B	Men	50+	No
7A	Women	25-50	No
7B	Women	25-50	No
8A	Women	50+	No
8B	Women	50+	No

In addition, we continued collaboration with Drs. Gluzman and Kostyuchenko. Dr. Semyon Gluzman is the President of Ukrainian Psychiatric Association, and Dr. Stanislav Kostyuchkeno is the Head of Department of Medical and Social Rehabilitation at Kiev City Clinical Psychiatric Hospital. Both Drs. Gluzman and Kostyuchenko have been investigating mental health issues in Ukraine for many years (see representative publications, (Gluzman and Kostyuchenko 2006; Bromet, Gluzman et al. 2008). Dr. Kostyuchenko observed the focus groups while they were in progress at the central library in Bila Tserkva. In addition to offering their expertise and analysis, they also

examined the Russian transcriptions and the summary report provided by KIIS to ensure accuracy throughout the focus group process.

The focus group findings discussed in this report were based on summary translated reports provided by KIIS and Drs. Gluzman and Kostyuchenko. The summary report provided by KIIS gave an abridged version of the responses shared during the focus groups. In this report, KIIS outlined the general themes within the discussions along with a few specific examples from the respondents. The recorded video on the sixteen focus groups and the actual Russian transcriptions of focus group discussions were provided. The USC investigators reviewed a Google translation of the interview transcripts for general validation.

RESULTS

The focus group discussions in Bila Tserkva found several general themes, similar to those reported by the groups in Kiev, including: the population perception of health and wellbeing, the quality of medical care, and the possible health consequences of the Chernobyl disaster (Table 3).

For most respondents, health was considered one of the most important priorities in their lives; however, younger respondents prioritized health after work, family, and education. Older respondents reported more health problems and frequent doctor visits than the younger respondents. Still, all groups connected their health problems with consequences of Chernobyl, poor ecology in the town, and unhealthy working conditions. In spite of the high level of concern about health, the focus group participants were wary and distrustful of the care available to them.

Twenty-six years after the disaster, respondents in all groups spontaneously mentioned Chernobyl as a possible threat to their health before the facilitator put the question towards the groups. The respondents were clear that the Chernobyl disaster affected their lives and that they still remember some details of events in April and May 1986. Older relocated respondents, especially women, reported having psychological trauma while all relocated respondents thought

that the State robbed and abandoned them after the Chernobyl disaster. Respondents were concerned about effects on their children and grandchildren.

The focus group participants were clear that they are stigmatized. They reported envy from others because of their benefits and bullying of their children. In addition, they claimed to be still seen as less desirable for marriage.

In comparison with the groups in Kiev, the groups from Bila Tserkva appeared less healthy. For example, one person from Bila Tserkva claimed to have more diseases, on average, than a person from Kiev. This person attributed this discrepancy due to the limited access to medical care in Bila Tserkva along with poor ecology and fallout from Chernobyl.

Table 5 provided a comparison of major findings in Kiev and Bila Tserkva. The table highlights the comparability of findings. However, the team that conducted the focus groups found the intensity of concerns to be stronger in Bila Tserkva.

Table 3. General Findings from Groups in Bila Tserkva, Ukraine (2012)

Themes:	**Summarized Findings**
General Perception of Health	Health problems are very important for inhabitants relocated to Bila Tserkva. For non-relocated inhabitants, health problems were a priority after work, family, and education/ children education. All groups connected their health problems to consequences of Chernobyl, poor ecology in the town, and unhealthy working conditions.
Acting in Case of Illness	For serious illnesses, people would see a doctor, but for "small" illnesses, people stated they would prefer to deal with it by themselves using traditional means, such as teas, herbs, and vodka. The main reasons for avoiding the doctors were because of previous experiences of getting wrong diagnoses and costly ineffective treatments
Types of Medical Facilities	Most respondents visit state institutions only because they cannot afford private medical institutions (mainly private practice). Non-traditional medicine, such as massage parlors, chiropractors, and natural healers, is popular for healing some illnesses, but is not considered as a complete alternative to traditional medicine.

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Themes:	Summarized Findings
Barriers for Getting Medical Assistance	The main barriers are lack of money (even in state facilities doctors expect to be paid privately) and lack of trust of the doctors.
Satisfaction with Medical Services	Most people are unsatisfied with the medical services provided in Bila Tserkva. The main complaints are costly ineffective treatments, low quality of doctors, and lack of empathy from doctors.
Threats to Health	Respondents spontaneously mentioned Chernobyl as a threat to their health in all groups. Other threats include poor ecology (for example, overdose of radiation due to Chernobyl, added radiation from radon sources in town, pollution of water, air and soil from plants and the old military airport), poor food options (either unnatural or over-radiated), and poor lifestyle (children do not get enough physical activity).
How did Chernobyl Affect Lives	Relocated respondents (mainly older women) had strong offences to the State and received psychological trauma from the relocation process. Almost all relocated groups thought the State robbed and abandoned them.
Affect of Chernobyl Disaster on Health	Older relocated respondents claimed most of their health problems are due to Chernobyl. Younger respondents offered similar health problems but connected them to Chernobyl and poor ecology.
Seeing Doctors because of Chernobyl	Older respondents were told by doctors not to connect health problems with Chernobyl. This meant they could not apply for injured status and receive State benefits. Younger respondents avoid seeing doctors for any health problems because they have no time for it and do not trust the doctors.
Possible Consequences of Chernobyl for the Health of Children or Grandchildren	Respondents reported that their children and grandchildren already have diseases that they should not have at their young age, such as headaches, foot pain, and cysts. In addition, there is a mention of a belief that the newer generation is generally weaker and has a lower immune system than the older generation partially due to Chernobyl.
Attitude toward Detailed Medical Examination	Most respondents liked the idea of detailed medical examinations, especially preventive screenings and care as seen in Soviet times. Main concerns were about the cost of such exams and which specific analyses would be helpful.

Themes:	Summarized Findings
The Attitude within Population toward Affected by Chernobyl	Relocated respondents experienced negative attitude by the population because of receiving the State benefits given to Chernobyl families. This negative attitude could be caused by jealously and/or suspicion that a certain person has a valid Chernobyl certificate.
The Attitude toward Affected by Chernobyl in Past	Relocated respondents experienced negative reactions from the local people due to compensation of apartments. In addition, many relocated respondents described their children being bullied by classmates (offensive nicknames and physical harm).

Table 4. General Findings From Groups in Kiev, Ukraine (2011)

Themes:	Summarized Findings
General Perception of Health	Health is the most important thing in life. Health is the base for happy life and you cannot enjoy life and work without good health.
Acting in Case of Illness	For serious illnesses, some people would see a doctor, but for "small" ones, most people prefer to deal with it by themselves using traditional medicine, such as tea, herbs, and homeopathic drugs. Lack trust with doctors, saving valuable time, high costs, and negative attitude to pharmaceutical ("chemical") drugs are reasons why most people prefer dealing with "small" illness themselves.
Quality of Medical Care	Satisfaction with medical care depends on the presence of personal attention by doctor towards the patient, appropriate diagnosis by the doctors, and total cost of visit.
State and Private Medical Facilities	Private medical facilities are perceived to be better and have higher rates of satisfaction than State medical facilities. The higher cost of services at private medical facilities is a huge barrier for most people.
Alternative Medical Facilities	Various alternative medical clinics are present in Kiev, such as Korean massage stores and acupuncture. Most people are interested in alternative medicine but they are suspicious about it and its outcomes.
Barriers to Visit a Doctor	Main reason for not visiting a doctor is lack of trust. Patients feel that doctors are more concerned about earning additional money from treatments than actually healing patients.

APPENDIX A

Themes:	**Summarized Findings**
Threats to Health	Main risks are connected with urban problems (air and water pollution), modern economy and lifestyle (poor sources of food).
Perception of Chernobyl Disaster Today	The influence of the Chernobyl disaster on today's life is not big, especially for younger generation. Nobody questions the negative consequences of the accident, as other health threats are more prominent like air pollution, water pollution, and poor sources of food.
Influence of Chernobyl Disaster on Health	Some people connect their current health problems to Chernobyl disaster, such as thyroid problems, spine problems, and skin diseases. Others feel that there is an uncertainty about the connection of their health problems with Chernobyl instead of some other causes such as, age, environmental pollution, poor sources of food.
Doctor's Diagnoses in Connection to Chernobyl Disaster	People do not rely on doctor's diagnoses in relation to Chernobyl because in the past, doctors were not allowed to say that a health problem was caused by Chernobyl. However, doctors now say many health problems are connected to Chernobyl, just so they do not trouble themselves in finding a real explanation.
Threats of Possible Future Consequences of Chernobyl Disaster	Most people do not think about possible future consequences due to Chernobyl. When asked, most thought about other threats, such as poor ecology. Most did know that radiation does not go away and should be still considered as a threat. There were few who thought about a possible human adaptation with radiation.
Perception of Possible Medical Examination Related to Consequences of Chernobyl Disaster on Health	If available, many people would go for it if free and not time consuming. Some people stated they would not do partake with the examinations because they see no sense in such diagnostic exams; as it does not heal just create a potential psychological trauma.

APPENDIX A

Table 5. Summarized Findings from Bila Tserkva and Kiev (for comparison)		
Themes:	**Bila Tserkva, Ukraine**	**Kiev, Ukraine**
General Perception of Health	Health is top priority in life.	Health is the most important thing in life.
Acting in Case of Illness	Most people would only see doctors for serious illnesses, and for small ones, most people prefer to deal with it by themselves.	For serious illness, people would see a doctor, but for smaller illnesses, most would deal with it by themselves.
Satisfaction with Medical Services	High level of dissatisfaction with the medical services. Main complaints are costly ineffective treatments, low quality of doctors, and lack of empathy from doctors.	Most people are not satisfied with medical services. Satisfaction is determined by personal attention, appropriate diagnosis, and total cost of visit.
Types of Medical Facilities	Mainly visit State medical institutions. Limited access to private or specialized medical facilities due to cost and location.	Private medical facilities are better than State medical facilities, but cost is a huge barrier for most people to have access.
Alternative/ Non-traditional Medical Facilities	Various non-traditional medical clinics are present, such as massage parlors, chiropractors, and natural healers.	Various alternative medical clinics are present in Kiev, such as Korean massage stores and acupuncture.
Barriers for Getting Medical Assistance	Main barriers are lack of money, lack of trust with doctors, and long lines in medical facilities.	Main barriers are lack of trust with doctors, fear that doctor and medical institution causes more harm to patient's health, and lack of money.
Threats to Health	Main threats are consequences of Chernobyl (like radiation level, contaminated soil, etc), poor ecology (like air and water pollution), and poor food sources and options.	Main threats are poor ecology (like air, water, and soil pollution), radiation received from Chernobyl, and poor food sources and options.

APPENDIX A

Themes:	**Bila Tserkva, Ukraine**	**Kiev, Ukraine**
How did Chernobyl Affect Lives	Groups strongly believed that Chernobyl caused damages to their health and health of people they know. Strong feeling of being robbed and abandoned by the State.	Groups, specifically with older respondents, believed Chernobyl affected everybody who lives in Kiev and in Ukraine at large in a negative way.
Affect of Chernobyl Disaster on Health	Groups strongly believed that Chernobyl caused more diseases in them and in people they know, such as thyroid issues, cardio-vascular diseases (CVDs), high blood pressure, headaches, impotency, skin cancer, psoriasis, diabetes, allergies, cysts, loss of teeth, weakness of bone system and vision and feet problems.	Groups believed that Chernobyl caused more diseases in them and in people they know, such as thyroid issues, breast cancer, foot pain, skin and blood diseases, headaches, impotency, respiratory diseases, CVDs, and vision issues.
Seeing Doctors because of Chernobyl	Younger respondents stated they avoid seeing doctors due to lack of trust and time, but older respondents, especially chronically ill, see doctors regular.	Respondents stated they do not rely on doctor's diagnoses in relation to Chernobyl due to doctors being instructed not to connect illnesses to Chernobyl.
Possible Consequences of Chernobyl for the Health of Children or Grandchildren	Groups in Bila Tserkva were directly asked and stated several concerns such as impotency.	Indirectly mentioned with the groups in Kiev and suggested there are possible consequences.
Attitude toward Detailed Medical Examination	Liked the idea of detail exams but worry about the costs.	Liked the idea of detail exams but worry about the costs.
The Attitude within Population toward Affected by Chernobyl	Groups in Bila Tserkva were directly asked and stated a general negative attitude.	Indirectly mentioned with the groups in Kiev and stated a general negative attitude.
The Attitude toward Affected by Chernobyl in Past	Groups in Bila Tserkva were directly asked and stated a general negative attitude.	Indirectly mentioned with the groups in Kiev and stated a general negative attitude.

APPENDIX B

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Analysis of focus group discussions problems related to health and Chernobyl disaster consequences with citizens of Bila Tserkva

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Summary

Recent literature reviews including systematic reviews of studies on psychological consequences of disaster at Chernobyl Nuclear Power Plant in 1986 stressed on importance of such studies but on other hand emphasized heterogeneity of assessment methods employed in the studies and lack of possibility to make definite conclusions regarding the negative consequences for affected population mental health and prevention measures for prophylaxis of the negative mental health effects in persons affected by nuclear radiation exposure. With the aim to determine possible consequences for mental health and target groups for future studies in affected population we conducted focus groups discussions with permanent resettled after Chernobyl disaster residents of Bila Tserkva. The discussion questions were related to possible negative consequences of the disaster for physical and mental health. Our findings suggest that both man and women respondents in all age groups respondents regardless resettlement status are concerned over future negative consequences of radioactive contamination for their health, especially in the future. Resettled respondents in older age groups, especially women, described obvious symptoms of posttraumatic stress even 25 years after accident. In all groups there were noticed fears of respondents about physical and mental health of their children and negative effects of Chernobyl accident for kids' development. Resettled respondents in older age groups till now perceive themselves as stigmatized after Chernobyl accident. Thus, future quantitative studies should clarify prevalence of mental disorders symptoms in population affected by Chernobyl nuclear power plant accident, the situation with excessive fears about children physical and mental health also needs further clarification, and symptoms of posttraumatic stress and stigma in older resettled population, especially in women, require urgent response and at least effective public health interventions.

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Kyiv, Ukraine, 2nd August 2012

APPENDIX B

Introduction

In 2011 Green Cross Foundation proposed an initiative to conduct focus group discussions with population affected by consequences of Chernobyl Nuclear Power Plant accident. In spring 2011 we conducted focus group discussions in Kyiv [1]. In 2012 we continued the work at Bila Thserkva — an industrial center in 80 km from Kyiv, its population is approximately 210,000 inhabitants. In addition to numerous ecological problems area of the city acknowledged as contaminated after Chernobyl disaster. In 1986 1,700 families were evacuated to Bila Tserkva from 30 km zone of Chernobyl Nuclear Power Plant accident. The aim of such discussions with permanent resettled after Chernobyl disaster residents of Bila Tserkva was to determine possible negative consequences for mental health and target groups for future quantitative studies in population affected

Methods and Participants

Methods, participants, recruitment procedures and list of questions for focus group discussions are described in separate report of Kyiv International Institute of Sociology. This year we made few changes in arrangement of the discussions. First, we choose other place. Second, we employed other principles for selection of participants. And third, minimal changes were made in questions for discussions.

We conducted 16 focus group discussions, separate groups with men and women, participants were divided into two age groups (25–49 years and 50+), and according to their resettlement status (permanent residents of Bila Tserkva and those who was evacuated in the city from contaminated areas near Chernobyl Nuclear Power Plant).

In questions list some questions were refined and added questions related to possible future consequences for physical and mental health in children and a question on stigmatization of person experienced evacuation from contaminated areas.

Main Results

General Health

Discussions in focus groups showed that issues related to health are very important for participants. It was expected that older participants reported about more problems with health, more frequent visits to the doctors, but participants in all groups were interested to keep good health and to improve it. We should note a trend among younger participants: the main priorities for permanent residents of Bila Tserkva were work, family, own education or children education and later they noted problems with health. For evacuated participants the health was a priority problem, they said that the State do not care about them, it is not ready to help them to copy with their problems and later they spoke about work, families

etc. However participants of all groups said that their children health is an issue for serious concerns.

Use of Medical Services and Access to them

In all groups participants mentioned problems with access to medical services. The main problem was the high costs of medical services. The high costs are unofficial payments to medical institution or physicians because health care officials state that medical care in Ukraine is free of charge. Furthermore, participants said about low qualification of physicians, there are absent some highly specialized medical services, e.g., allergologists, immunologists.

Health Threats

Participants listed a lot of possible threats for their health, in all groups were called radioactive contamination after Chernobyl disaster, other threats were: poor ecological environment in Bila Tserkva, poor water quality, air prolusion and poor quality of food. Most respondents agreed that Chernobyl disaster could have serious negative impact on their health and local ecological risk factors could worsen the impact. Also we should note that almost in all groups when was announced a topic of discussions many participants spontaneously said about their poor health or their health could not be good because they live in radioactive contaminated area.

Impact of Chernobyl Disaster on participants Lives and Health

Permanent residents of Bila Tserkva described impact of Chernobyl disaster on their lives in general words, they said about the fact of the accident, later the city was acknowledged as contaminated region as a result of the disaster, many families from Chernobyl in the city, some men in older groups reported that they were been involved in liquidation of consequences of the disaster.

Evacuated participants especially in groups of older women described their lives and the events occurred in April-May 1986 with more dramatic details. Their stories were abound in details when and where they got to know about the disaster at Chernobyl Nuclear Power Plant, about chaos of evacuation, about sufferings experienced that days: loss of houses, disruption of relations with their relatives and friends, fears of invisible negative impact radiation on their health. Interestingly that younger evacuees noted that their parents very often recollect the event of first days of the accident, cry, regret about missed native places.

As examples of possible consequences of Chernobyl disaster for their health they told about their illness and illness in their relatives and friends after the disaster — cancer or thyroid diseases. Although very often they said about diseases that could not be a result of direct effects of nuclear radiation exposure, for instance, in older groups such examples were ischemic heart disease, hypertension, in younger groups — gastritis, poor vision and infertility. Some examples of possible negative

consequences were very similar in different groups of participants regardless sex, age or resettlement status, e.g., pain in bones and legs, frequent colds, participants of one group believed that their own or their relatives or friends cases of common colds, parotitis and infectious mononucleosis were consequence of radiation exposure after Chernobyl disaster.

Among possible consequences of Chernobyl disaster for mental health in themselves or in their relatives or friend participants reported about weakness, tiredness, disturbed sleep, frequent head aches, dizziness and irritability. Such reports were more common in groups of older participants and in all women groups regardless status of resettlement. Furthermore, some participants described typical examples of panic attacks (attacks of anxiety or fears accompanied with various unpleasant somatic symptoms). In all groups the participants were concerned with the possible negative mental health consequences of radioactive contamination exposure in their children (see below). A few respondents (sporadic reports) said about seeking help in psychologist or psychiatrist because they felt themselves weak, had dizziness or irritable but there was no benefit after such visits. Many participants said that they have a desire to seek a help in mental health specialists in cases of psychological or emotional problems but they noted that there are virtually absent to seek such help.

Possible Future Consequences of Chernobyl Disaster

Participants reported about poor health spoke up fears about worsening their health problems in future. Participants in all groups regardless sex and age actively discussed possible future consequences of Chernobyl disaster in their children. They reported about frequent illness in children, their movements are sluggish, their sleep is bad, and they are irritable, unable to concentrate. Such 'disturbances' will affect on their future development.

The need to health studies in Bila Tserkva residents

Participants in all groups were interested in detailed health studies and medical investigations to assess health status and possible effects of living at area contaminate as result of Chernobyl disaster. But participants' requirements for such future studies are: medical investigations should be free of charge and medical care if it would be needed after health study assessments also should be adequate and free of charge.

Stigma

Participants in all groups said that in past there were negative attitude towards evacuees. In the first years after disaster many people afraid evacuees because they are 'contaminated with radiation', felt envy because evacuees got new houses and additional social welfare or privileges and there were some conflicts with new neighbors, children at school could experience bounding or scornful nicknaming. But participants in younger and older groups of permanent residents and younger

groups of evacuees denied such negative attitude now. The groups of older resettled participants in details described examples of negative attitude towards them in past but they insisted on such attitude now. The examples of such stigmatization were: 'If local people had such negative attitude to us in thee past it could not be changed till now', 'The physicians do not prescribe medicines for us for free because they look at us as hopeless patients', 'Drivers in public transport forced us to pay fare although we as people affected by Chernobyl should use pulic transport for free', 'The State gave up to care about us and last year our social well fare were cut off'.

Discussion

The focus group discussions were a continuation of such discussions started in spring 2011 in Kyiv [1]. Although our primary goal was to detect possible consequences of Chernobyl disaster in affected population groups most of our question related to physical health. The reasons for that were following: (1) our previous experience in conducting of population mental health surveys suggested that in Ukraine exists strong stigma of having any mental disorders, so that in questionnaires and interviews we included introduction questions about general physical health [2–4]; (2) such approach allowed us to collect important information about physical health and common pattern of use of medical services; and (3) in the study such approach helped us to ask respondents about their fears about negative effects of Chernobyl disaster on their health.

In comparison with our previous focus group discussions in Kyiv residents of Bila Tserkva more often seek medical care, primarily in state medical services. But many participants were unsatisfied with quality of medical services; treatment is associated with high costs and the high costs is not a guarantee for getting adequate medical treatment. The participants perceived that various negative environmental risk factors could enhance negative effects of Chernobyl disaster on their health.

Findings from the focus groups discussions are in line with the conclusion of Chernobyl Forum Report on Chernobyl disaster consequences for health [5], in the report was noted that population health and state of health care in contaminated areas is poor and very far from modern western standards of medical care. Such situation makes many difficulties for assessment of direct negative health effects of radioactive contamination in affected population.

Among possible consequences for participants' mental health we should note serious fears and concerns about negative impact on health living in the area of radioactive contamination. Some studies and systematic reviews demonstrated the key role of such fears and concerns in determination of poor psychological wellbeing and mental health in proximal period of nuclear accidents in affected population [6, 7], it was confirmed in recent study of rescue workers at Fokusima Nuclear Station in Japan [8] among rescue workers most of them were medical

professionals who are well informed on size and risk of radioactive contamination the fears determined psychological wellbeing in one year after accident. In affected population in Ukraine we could speak about presence of such fears 26 years after disaster and there is a need to explore the role of them in 'remote' period after accident in determination of mental health of affected population.

The posttraumatic stress symptoms especially in evacuated older women require a special attention, such our findings are in line with other studies conducted in Kyiv region [9, 10]. We think that our findings on stigmatization among older groups of evacuated respondents are very important. The above mentioned facts require not only further investigations but also urgent response and the response is in dimension educational and public health initiatives and activities [7, 8].

Till now remains unclear the issue on effects of radioactive exposure on mental health and development of children who were born or grew up in contaminated areas. The serious concerns in all groups of participants about possible negative consequences of Chernobyl disaster on mental health of their children emphasize the need of further investigations in this direction to respond to the parents concerns.

Conclusions

Thus, future quantitative studies should clarify prevalence of mental disorders symptoms in population affected by Chernobyl nuclear power plant accident, the situation with excessive fears about children physical and mental health also needs further clarification. Symptoms of posttraumatic stress and stigma in older resettled population, especially in women, require urgent response and at least effective public health initiatives and interventions.

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APPENDIX C

Recommendations from the 2011 Report

- A systematic assessment of ongoing research and programs related to neuropsychological consequences of the disaster should be carried out. At the least, the survey should cover Ukraine, Belarus, Russia, and Moldova. This assessment could be carried out using the resources of the Green Cross offices within each country.

- Data should be collected that will directly address the need for services and other interventions in the populations that continue to be affected by the Chernobyl disaster. These populations can be defined on a geographic basis.

    - The literature reviewed in this report, the focus group findings, and the expertise of researchers and practitioners in the affected areas should be the basis for developing a brief instrument that could be readily implemented and that would provide findings useful for guiding program development.

    - There are a number of institutions with relevant expertise and experience that should be collectively involved in developing the instrument and the general approach. There are also researchers external to Eastern Europe who should be involved, e.g., Dr. Evelyn Bromet.

    - While ideally, data would be collected through population surveys, more practical and feasible approaches might be used, such as approaching people in clinics, worksites, and educational institutions.

    - Multi-country studies carried out with standardized instruments and uniform protocols may be particularly informative.

- A major uncertainty, not addressed in this report, is the potential for further data to motivate action, whether by governmental or non governmental organizations. A "mapping" or a description of the "actors" in each country would be valuable and needed to understand how further data collection on the neuropsychological consequences of the disaster could make a difference.

- Further research, beyond the programmatically-oriented data collection proposed above, could be useful. There have been studies of the long-term neuropsychological consequences of disasters of various types, but the exposures of Chernobyl are unique. Information might be gained that would relevant to the current crisis in Japan.

- We concur with the recommendation made recently by Bromet et al. (Bromet et al. 2011) that the possibility of augmenting ongoing epidemiological studies to address neuropsychological consequences of the disaster should be explored.

- At the 25th anniversary year of the disaster, it would be timely to give greater discussion to the topic of long-term neuropsychological consequences. The planned 25th anniversary conference, for example, “Twenty-five Years after Chernobyl Accident. Safety for the Future”, Kyiv, April 20-22, 2011, does not appear to give any emphasis to this topic.

    - Funding should be sought for holding a conference with the goals of further characterizing the current state of the evidence, obtaining input into developing a data collection instrument, defining further research needs, and establishing a network of collaborators.

APPENDIX D

Sources for Estimated Numbers of People Exposed

Reference	Region specific (if given)	Year for given estimation	Living in contaminated territories	Exposed to Chernobyl disaster
Belarus				
UNSCEAR, 2000	Within the 30-km zone	1986	11,358	
UNSCEAR, 2000	Areas of Strict Control	1986-1987	109,000	
Pflugbeil et al., 2011		1995	1,880,000	2,500,000
Cardis et al., 1996	Regions with Density of Cs 137 1-15 Ci/km^2	1996	3,700,000	
Cardis et al., 1996	Regions with Density of Cs 137 >15 Ci/km^2	1996	270,000	
UNDP, UNICEF, UNOCHA, WHO, 2002		2000		
Khudoley et al., 2006	Contaminated territories	2001	1,571,000	
World Bank, 2002 (based on Ministry of Statistics and Analysis, Belarus)		2001	1,571,000	
European Committee on Radiation Risk, 2006		NS	1,565,000	2,600,000
Greenpeace, 2006		NS		2,600,000
Kennan Institute, 2007 (based on panelist David Marples)		NS		1,820,000
Yablokov, Nesternko, & Nesterenko, 2009	Regions with Density of Cs 137 >1 Ci/km^2	NS	2,000,000	

NS = Not Specific

APPENDIX D

Reference	Region specific (if given)	Year for given estimation	Living in contaminated territories	Exposed to Chernobyl disaster
Russia				
UNSCEAR, 2000	Areas of strict control	1986-1987	111,800	
Pflugbeil et al., 2011		1995	1,983,000	3,000,000
Khudoley et al., 2006	Contaminated territories	1999	1,789,000	
Kennan Institute, 2007 (based on panelist David Marples)	Soviet Union	2000	4,500,000	7,100,000
UNDP, UNICEF, UNOCHA, WHO, 2002		2000	1,788,600	
European Committee on Radiation Risk, 2006		NS		2,400,000
Greenpeace, 2006		NS		2,400,000
Kennan Institute, 2007 (based on panelist David Marples)		NS		> 2,000,000
Yablokov, Nesternko, & Nesterenko, 2009	Density of Cs 137 >1 Ci/km^2	NS	2,700,000	

NS = Not Specific

APPENDIX D

Reference	Region specific (if given)	Year for given estimation	Living in contaminated territories	Exposed to Chernobyl disaster
Ukraine				
World Nuclear Association, 2012	30 km radius	1986	115,000-135,000	
UNSCEAR, 2000	Chernobyl town	1986	13,591	
World Nuclear Association, 2012	Chernobyl	1986	12,500	
UNSCEAR, 2000	Pripyat	1986	49,360	
World Nuclear Association, 2012	Pripyat	1986	49,000	
UNSCEAR, 2000	Areas of Strict Control	1986-1987	52,000	
Chernobyl Forum, 2006	People designated as permanently disabled	1991		200
Chernobyl Forum, 2006	People designated as permanently disabled	1997		64,500
Pflugbeil et al., 2011		1995	1,296,300	3,500,000
Kennan Institute, 2007 (based on panelist David Marples)		2000		> 3,000,000
UNDP, UNICEF, UNOCHA, & WHO, 2002		2000	1,140,813	
Chernobyl Forum, 2006	People designated as permanently disabled	2001		91,219
Khudoley et al., 2006	Contaminated territories	2002	2,290,000	
Danzer & Danzer, 2011	Registered as victims to State	2004		2,772,060
Danzer & Danzer, 2011	Registered as victims to State	2005		2,646,106
Loganovskiy, 2005		2005		4,000,000

NS = Not Specific

APPENDIX D

Reference	Region specific (if given)	Year for given estimation	Living in contaminated territories	Exposed to Chernobyl disaster
Kennan Institute, 2007		2006		2,600,000
National Report of Ukraine, 2006	2293 villages	2006	2,600,000	
European Committee on Radiation Risk, 2006		NS		3,200,000
Greenpeace, 2006		NS		3,200,000
Kennan Institute, 2007 (based on health panel)	Residents of strict-control zones (1986-2005)	NS		270,000
Shcherbak, 1996		NS		2,600,000
Yablokov, Nesternko, & Nesterenko, 2009	Density of Cs 137 >1 Ci/km^2	NS	3,500,000	

NS = Not Specific

APPENDIX D

Reference	Region specific (if given)	Year for given estimation	Living in contaminated territories	Exposed to Chernobyl disaster
Overall Disaster Areas				
RIA Novosti, 2011		1986-2005	5,000,000	
World Health Organization, 2005		2005	5,000,000	
Chernobyl Forum, 2006		2006		> 5,000,000
TORCH, 2006		2006	5,000,000	
Pflugbeil et al., 2011		2009	8,300,000	
Chernobyl Forum, 2006		NS	5,000,000	
UNSCEAR, 2011	Contaminated territories	NS		6,400,000
UNSCEAR, 2011	Worldwide	NS		98,000,000

NS = Not Specific

APPENDIX E

Specific Cost Estimates Related to the Disaster

Source	Estimated Amount	Targeted Countries	Notes
Chernobyl Forum (2006)	13 billion USD[1]	Belarus	[1] Costs by Belarus between 1991 and 2003
Institute of Economics of the Belarusian National Academy of Sciences (2001)	43.3 billion USD[2]	Belarus	[2] Economy of Belarus will suffer this amount of losses in the first 30 years
Institute of Economics of the Belarusian National Academy of Sciences (2001)	235 billion USD[3]	Belarus	[3] Total projected damage over first 30 years Ivan Kenik, Belarus's Chernobyl minister mentioned same estimates in interview in 2002. Also, many news articles use this estimate as well, including Forbes article.
World Bank – Belarus: Chernobyl Review (2002)	2.4 billion USD ["~20% of 2001 GDP"][4]	Belarus	[4] Estimated resources spent on the mitigation of Chernobyl consequences between 1991 and 2001 Report does not attempt to calculate full costs of the disaster, but focus on current situation today.
World Bank – Belarus: Chernobyl Review (2002)	2.1 billion USD[5]	Belarus	[5] Projected costs for implementing social programs between 2001 and 2011 (stipulated by National Program 2001)
World Bank – Joint Country Portfolio Performance Review (2010)	80 million USD[6]	Belarus	[6] Loan given by World Bank (paid in 2006 and 2010) to "improving the livelihood" in Oblasts of Brest, Gomel, and Mogiliev
Ministry of the Russian Federation for Civil Defense Affairs (2001)	3.8 billion USD[7]	Russia	[7] Costs between 1992 and 1998 (of sum, 3 billion USD used as compensation to victims and helpers)
Chernobyl Interinform Agency (2002)	201 billion USD[8]	Ukraine	[8] Projected economic damage to Ukraine between 1986 and 2015
World Bank – Ukraine: Public Expenditure Review (1997)	5.25 billion USD[9]	Ukraine	[9] Sum of estimated Chernobyl Fund spending between 1992 and 1996
European Bank for Reconstruction and Development (2013)	2.01 billion USD[10]	Ukraine	[10] Current estimated costs of the Shelter Implementation Plan (includes cost of New Safe Confinement)

APPENDIX E

Source	Estimated Amount	Targeted Countries	Notes
Sherman & Yablokov (2011)	Exceeded 500 billion USD[11]	Ukraine, Belarus, and Russia	[11] Direct economic damage to Belarus, Ukraine and Russia Article in San Francisco Bay View but article rejected by The Bulletin of Atomic Scientists
Gorbachev interview in The Battle of Chernobyl (2006)	18 billion rubles[12]	USSR	[12] Amount spent in 1986 to contain the disaster and decontaminate the affected areas

About Green Cross Switzerland

www.greencross.ch

Green Cross Switzerland facilitates overcoming consequential damages caused by industrial and military disasters and the clean-up of contaminated sites from the period of the Cold War. Central issues are the improvement of the living quality of people affected by chemical, radioactive and other types of contamination, as well as the promotion of a sustainable development in the spirit of co- operation instead of confrontation. This includes the involvement of all stakeholder groups affected by a problem.

About USC Institute for Global Health

http://globalhealth.usc.edu

The USC Institute for Global Health is a campus-wide initiative dedicated to enhancing interdisciplinary activities and research related to emerging global health issues. In partnership with faculty and students from schools across the university, the USC Institute for Global Health fulfills its aim to improve global health by educating future and current global health leaders, carrying out trans-disciplinary research, and assuring that the evidence collected informs policy and practice to make a difference. For more information on the USC Institute for Global Health's programs and activities, please visit: http://globalhealth.usc.edu.

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