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The long-run consequences of Chernobyl: Evidence on subjective well-being, mental health and welfare

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ABSTRACT

This paper assesses the long-run toll taken by a large-scale technological disaster on welfare, well-being and mental health. We estimate the causal effect of the 1986 Chernobyl catastrophe after 20 years by linking geographic variation in radioactive fallout to respondents of a nationally representative survey in Ukraine according to their place of residence in 1986. We exclude individuals who were exposed to high levels of radiation—about 4% of the population. Instead, we focus on the remaining majority of Ukrainians who received subclinical radiation doses; we find large and persistent psychological effects of this nuclear disaster. Affected individuals exhibit poorer subjective well-being, higher depression rates and lower subjective survival probabilities; they rely more on governmental transfers as source of subsistence. We estimate the aggregate annual welfare loss at 2–6% of Ukraine's GDP highlighting previously ignored externalities of large-scale catastrophes.

1. Introduction

The past 60 years have witnessed 25 serious civic nuclear accidents, the gravest of which were Three Mile Island, Chernobyl and Fukushima.[3] Such low-probability high-loss events and their consequences represent negative externalities of energy production and use. However, assessing these externalities is complicated as our understanding of the potential societal and economic costs of large-scale disasters is limited. On the one hand, technological catastrophes involve direct explicit costs for recovery work, disaster relief, and monetary compensation for

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[3] These are according to the International Nuclear Event Scale 4–7: Chalk River 1952 (USA), Kyshtym 1957 (USSR), Sellafield 1957, 1973 (UK), Los Alamos 1958 (USA), Simi Valley 1959 (USA), Idaho Falls 1961 (USA), Charlestown 1964 (USA), Monroe 1966 (USA), Lucens 1969 (Switzerland), Rocky Flats 1969 (USA), Leningrad 1974 (USSR), Belojarsk 1977 (USSR), Bohunice 1977 (CSSR), Three Mile Island 1979 (USA), Saint-Laurent 1980 (France), Chernobyl 1982, 1986 (USSR, nowadays Ukraine), Buenos Aires 1983 (Argentina), Wladiwostok 1985 (USSR), Goiânia 1987 (Brazil), Sewersk 1993 (Russia), Tokaimura 1999 (Japan), Fleurus 2006 (Belgium), and Fukushima 2011 (Japan). The International Nuclear Event Scale by the International Atomic Energy Agency (IAEA) is an internationally recognized tool to communicate the safety significance of events involving nuclear radiation. The scale uses numerical ratings: 1 "Anomaly", 2 "Incident", 3 "Serious incident", 4 "Accident with local consequences", 5 "Accident with wider consequences", 6 "Serious accident", 7 "Major accident". All levels above 3 are considered nuclear accidents. The only accidents in level 7 have been Chernobyl and Fukushima.

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victims. These costs are generally borne by the public as part of an implicit national insurance policy, because catastrophic events are hardly insurable. On the other hand, such disasters can induce higher order impacts and large implicit costs which have been mostly ignored in conventional economic and risk analyses.

In this paper we evaluate the long-run toll taken by a large-scale technological disaster on well-being, mental health and aggregate welfare. To date, these higher order effects have not been assessed in a representative, long-term setup. Our empirical analysis is based on the biggest nuclear accident on record: The Chernobyl disaster of April 26, 1986. It is among the most costly technological accidents and has triggered significant public health concerns. Ukraine's government spending to alleviate the consequences of Chernobyl, including clean-up, recovery work and liquidator[4] compensation, is estimated at USD 148 billion for 1986–2015 or 5–7% percent of annual GDP (in real terms as of 1992; Oughton et al. 2009).[5] While the largest cost share initially accrued to clean-up, resettlement and capital investments, more than 80% of contemporary expenditures relate to social benefits (Oughton et al. 2009).

Most of the early medical research and public attention was drawn to physical health consequences. However, except for the most severely affected clean-up workers and children, researchers could not unambiguously substantiate any adverse physical health effects in the low-dose population (UNSCEAR 2008). Yet, even 20 years after the accident the Ukrainian population reports poorer subjective health which is in obvious contrast to objective measures (Lehmann and Wadsworth 2011). This divergence between objective and subjective disaster related morbidity hints at psychological effects. In particular, humans dread disasters involving toxic exposure for their catastrophic and uncontrollable potential health impacts and for their contamination which is undetectable by human senses (Slovic 1987). Anxieties in the aftermath of nuclear accidents may have adverse mental health consequences (Bromet et al. 2011). This is highly relevant for public policy as reduced mental health in general and depression in particular are among the most important determinants of mortality, reduced productivity and low quality of life (European Commission 2004; WHO 2005).[6] However, no study has assessed the causal second order effects of a nuclear accident on the low-dose population (i.e., those affected by subclinical radiation doses). Such a long-term evaluation of mental health effects could not only improve our understanding of the implied aggregate welfare loss, but also contribute to the appraisal of nuclear accidents for public policy.

This paper provides the first empirical assessment of the psychological long-term implications of the Chernobyl catastrophe for the lives of the vast majority of Ukrainians for whom the disaster was—technically speaking—a low-exposure catastrophe. We deliberately exclude the small fraction of the population that received high levels of radiation and attracted most of the previous academic attention. Instead, we focus on the 96% of the population for whom the average additional radiation received in the first eight months after the disaster equaled half the annual dose of natural background radiation in Ukraine. This additional dose is low and comparable to 10 medical chest X-rays. Our paper makes three contributions: First, we exploit the natural experiment implied by the random variation in radioactive fallout to establish the causal link between the Chernobyl disaster and its impact on mental well-being. We match geographic variation in post-accident radiation doses of iodine-131 and caesium-137 with large-scale, representative survey data containing information on individual place of residence in the year of the disaster. Mental well-being is measured 20 years after the catastrophe with the following indicators: life satisfaction, diagnosed depressions and subjective survival probabilities. It is important to note that our research differs from the literature on the negative "news effect" of catastrophes on subjective well-being, which tends to measure transitory short term distress (e.g., Berger 2010; Kimball et al. 2006; Metcalfe et al. 2011). Second, by focusing on long-term mental health outcomes in the low-dose population we dissect a previously ignored welfare component of catastrophes. We compute the monetary equivalent of the aggregate welfare loss using the life satisfaction approach. This method has been used in the economics literature to evaluate the compensating differential for negative life events or environmental conditions (e.g., Clark and Oswald 2002; Frey et al. 2010; Levinson 2012; Lüchinger 2009; Lüchinger and Raschky 2009; van Praag and Baarsma 2005; Winkelmann and Winkelmann 1998). We further apply the method to estimate the value of a statistical life year from the perceived risk of premature death. Third, we complement the welfare analysis by highlighting another possible externality of the disaster, namely the greater reliance of individuals on government transfers as a source of livelihood.

Our results indicate, first, that even sub-clinical radioactive exposure has a significant and considerable negative effect on subjective well-being and mental health 20 years after Chernobyl. These results are surprising as they can be neither caused nor explained by actual physical health impairments. According to our estimates, one additional dose of natural background radiation leads to a reduction of subjective well-being by 20% of a standard deviation. This result proves robust to several sensitivity checks and the use of an objective depression indicator. Our findings on significantly reduced subjective survival probabilities furthermore suggest that worries about future individual health are one possible transmission channel through which the catastrophe impacts mental well-being. Second, the annual aggregate welfare loss for the low-dose population equals 2.2–5.5% of contemporary Ukrainian GDP. These numbers add to Ukraine's current recovery, clean-up, and liquidator compensation costs of about 5–7% of GDP per year. Third, Chernobyl indeed increases the reliance on the state as provider of subsistence. Affected working-age adults are more dependent on governmental social transfers; the fiscal equivalent of these additional benefits amounts to 0.5–0.6% of annual GDP.

Our findings have important implications for public policy: The psychological effects of a nuclear catastrophe are large and persistent, even for those exposed to extremely low, subclinical radiation doses. This matters because mental health is considered crucial not only for personal well-being and public health but also for productivity and economic growth (WHO 2013). Furthermore, the overall welfare loss is substantial and must be interpreted as an externality of nuclear electricity production. The explicit and implicit costs of large nuclear accidents can easily exceed the fiscal latitude of single states.

The remainder of the paper is as follows. Section 2 provides background information on the Chernobyl disaster and its consequences. Section 3 describes and discusses the identification strategy, the data sets as well as the methodological approach. This is followed by the empirical results for different mental well-being measures and one potential transmission channel in Section 4. This section also contains a discussion of the findings and further evidence on behavioral implications. Section 5 presents the monetary evaluation of the aggregate welfare loss caused by Chernobyl. Section 6 assesses the value of a statistical life year from the perceived risk of premature death due to Chernobyl. Section 7 concludes.

2. Background

2.1. The Chernobyl accident and its consequences

The meltdown and explosion of reactor 4 of the nuclear power plant in Chernobyl on April 26, 1986 (located in northern Ukraine) resulted in

[4] The clean-up workers assigned to deal with consequences of the Chernobyl disaster were called liquidators.

[5] The direct costs associated with the Three Mile Island (1979) accident range between 1–3 billion USD for the first decade (Faure and Skogh 1992). Note, the paper does not clarify whether these dollar amounts are nominal or real.

[6] For instance, to foster awareness for mental disorders and improve mental health care around the globe the WHO set up a Mental Health Action Plan (WHO World Mental Health Survey Consortium 2004).