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Social capital, children's skills and parental inputs: four essays in empirical economics

Direttore della scuola: Ch.mo Prof. Giorgio Brunello

Supervisore: Ch.mo Prof. Luca Nunziata

Dottoranda: Francesca Marino

This thesis is dedicated to Lucio,

for his endless patience, love and support.

None of this would have been possible

without you by my side.

Introduction

This thesis is composed of four chapters in applied economics.

The first chapter "Long Term Consequences of the Chernobyl Radioactive Fallout: an Exploration of the Aggregate Data" is co-authored with Luca Nunziata. In this paper we challenge the lack of consensus on the long term health consequences of the radioactive fallout originated by the Chernobyl nuclear accident, by providing the first exploration of the combined aggregate evidence from the European regions that were not immediately adjacent to the disaster site. We match data on neoplasm incidence in eighty European regions with Caesium deposition after the nuclear disaster. The findings indicate that the radioactive fallout is positively associated with an increase in hospital discharges after treatment for neoplasms almost thirty years later, with larger effects in regions where the radioactivity was more intense and a substantial increase in curative-care expenditure. We checked the robustness of our findings to a number of tests including a placebo simulation and found that our results survive each of these checks. Using Eurostat data on health expenditure by country, we calculate what share of the 2000-2012 annual curative care expenditure may be due to the increase in hospital discharges attributable to the fallout. Around 4.4% to 4.9% of the average curative care expenditure in Austria and Czech Republic could be imputed to the consequences of the fallout. Germany and France, that received lower levels of radiations, may have spent, respectively, 3.8% and 1.9% of their total curative care expenditure because of the excess number of hospitalizations due to the fallout.

The second chapter "Radioactive Decay, Health and Social Capital: Lessons From The Chernobyl Experiment" is co-authored with Luca Nunziata. In this work we exploit the exogenous variation in health patterns across European regions that resulted from the Chernobyl nuclear disaster to provide new quasi-experimental evidence on the causal effect of health on social capital. Our instrumental variable estimations show that the radioactive fallout is positively associated with an increase in hospital discharges after treatment for neoplasms almost thirty years later. An increased incidence of neoplasms induced by the radioactive fallout generates a sizeable impoverishment of social capital at nearly all levels, including social interactions, altruism and trust toward institutions and the health care system. Our findings suggest that health care and prevention may have higher returns than previously thought since they may also contribute to a significant increase in social capital.

The third chapter "Living with an Ill Sibling: Cognitive and Noncognitive Skills of the Healthy Child" is single authored. In this paper I identify changes in cognitive and noncognitive skills among children and early adolescents due to having an ill sibling. Using data from the second wave of the Child Development Supplement in the Panel of Income Study Dynamics, this investigation adopts a Propensity Score Matching approach to compare families where one of the siblings is affected by a physical or mental illness with families where all the children are healthy. Results of the current study highlight a change in noncognitive skills among children living with an ill sibling, while cognitive skills are not affected. By analyzing noncognitive skills in light of the Big Five Personality traits, results shows that living with an ill sibling has a beneficial effect on children's Openness to Experience, Conscientiousness and Extraversion. The analysis identifies children's differences at the gender and birth order levels: living with an ill sibling seems to cause an increase in Openness to Experience among girls and an increase in Conscientiousness among boys while the increase in Extraversion observed in the overall sample may be actually due to the older children subsample. This evidence highlights how children react differently to the same phenomenon according to gender and age differences, and this appears to be useful especially in a prospective point of view, since according to literature such changes may be reflected in future socioeconomic and labour market outcomes.

The fourth and last chapter "Quality Time with the Offspring and Parenting Style: Reconsidering Parents' Equality Concerns among Families with an Ill Child" is single-authored. This paper studies parental decisions on resource allocation in a condition of a strong and evident ability imbalance among the offspring: when one of the children is considered mentally or physically disabled. Standard economic models posit that parents should optimally invest more in the more able child, however empirical evidence has shown that when deciding resource allocation parents' equality concerns seem to prevail despite children's innate ability levels. This analysis identifies causal changes in parental inputs given to children, more specifically quality time and parental attitude, due to living with an ill sibling among sibling couples in the Panel Study of Income Dynamics by using matching techniques. Parents seem to devote more quality time to girls and older children in case the other sibling is considered ill as in current setting, while they provide "warmer" parenting to boys. Moreover, they show higher levels of parental distress. Even if these results seem to confirm that parents tend to invest more on the more able child, further investigations highlight that these children are more involved in activities with the ill sibling. However emerged differences in inputs received during childhood are relevant in this setting since they may stem future effects over socioeconomic and labour market achievements.

Introduzione

Questa tesi é composta da tre capitoli in economia applicata

Nel primo capitolo "Long Term Consequences of the Chernobyl Radioactive Fallout: an Exploration of the Aggregate Data", scritto con Luca Nunziata, mettiamo in discussione la mancanza di consenso sulle conseguenze nel lungo termine sulla salute dovute al fallout radioattivo successivo all'incidente nucleare di Chernobyl. Questo studio presenta una prima esplorazione degli effetti a livello aggregato sulle regioni europee non immediatamente prossime alle zone direttamente interessate dall'esplosione nucleare. In questo studio associamo i dati sull'incidenza delle neoplasie in circa ottanta regioni europee con i dati sulla deposizione radioattiva del Cesio a seguito del fallout nucleare. I risultati indicano che il fallout radioattivo é positivamente associato ad un aumento delle dimissioni ospedaliere a seguito di trattamenti per neoplasia circa trent'anni dopo il disastro nucleare, con effetti maggiori nelle regioni in cui il fallout é stato piú intenso, e causando aumenti importanti nella spesa sanitaria. Abbiamo controllato la robustezza dei nostri risultati tramite una serie di test, tra cui una simulazione placebo. Le nostre stime sopravvivono a ognuno di questi controlli. Utilizzando i dati di Eurostat sulla spesa sanitaria per paese, le stime del nostro modello indicano che circa il 4.4 % e il 4.9 % della spesa sanitaria media per attivitá curative nel periodo 2000-2012 rispettivamente in Austria e Repubblica Ceca potrebbe essere imputata alle conseguenze della fallout. Germania e Francia, che hanno ricevuto livelli piú bassi di radiazioni, potrebbero aver speso rispettivamente, 3.8 % e il 1.9 % della loro spesa totale in attivitá curative a causa dell'aumento di dimissioni ospedaliere stimato.

Anche il secondo capitolo "Radioactive Decay, Health and Social Capital: Lessons From The Chernobyl Experiment" é co-autorato con Luca Nunziata In questo lavoro usiamo la variazione esogena dello stato di salute in alcune regioni europee a seguiro del fallout nucleare di Chernobyl per fornire nuove prove sull'effetto causale della salute sul capitale sociale. Il nostro studio utilizza questa variabile strumentale il fallout radioattivo é positivamente associato ad un aumento di dimissioni ospedaliere a seguito di trattamenti per neoplasie quasi trenta anni dopo. Tale aumento dell'incidenza di neoplasie indotte dal fallout radioattivo genera un impoverimento consistente del capitale sociale in quasi tutti i livelli, ad esempio nelle interazioni sociali, nell'altruismo e nela fiducia verso le istituzioni e il sistema sanitario. I nostri risultati suggeriscono che la spesa per l'assistenza sanitaria e la prevenzione puó avere ritorni piú elevati di quanto si potrebbe pensare in quanto é capace di contribuire significativamente a migliorare il capitale sociale.

Il terzo capitolo é "Living with an Ill Sibling: Cognitive and Noncognitive Skills of the Healthy Child". In questo lavoro identifico cambiamenti nella capacitá cognitive e non cognitive tra bambini e adolescenti causati dall'avere un fratello malato. Utilizzando i dati del "Child Development Supplement" facenti parte del "Panel of Income Study Dynamics" questa indagine adotta delle tecniche di matching per confrontare famiglie in cui uno dei fratelli é affetto da una malattia fisica o mentale con famiglie in cui tutti i bambini sono considerati sani. I risultati di questo studio evidenziano un cambiamento nelle capacitá non cognitive tra i bambini che vivono con un fratello malato, mentre le capacitá cognitive rimangono inalterate. Analizzando le abilitá non cognitive alla luce della teoria dei "Big Five", i risultati dimostrano che vivere con un fratello malato ha un effetto benefico sull'apertura mentale, sulla coscienziositá e sull'estroversione. L'analisi individua che i bambini presentano differenze dovute al genere e all'ordine di nascita: vivere con un fratello malato sembra causare un aumento dell' apertura mentale tra le ragazze, mentre causa un aumento di coscienziositá tra i ragazzi; l'aumento dell'estroversione osservato nel campione complessivo puó essere ricondotto al sottocampione dei fratelli piú grandi. Questi risultati evidenziano come i bambini reagiscono in modo diverso allo stesso fenomeno in base al genere e alla differenza di etá. Questo sembra essere utile soprattutto da un punto di vista prospettico, dal momento che secondo la letteratura tali caratteristiche possono influenzare le loro future condizioni socio economiche ed i futuri risultati sul mercato del lavoro.

Il quarto ed ultimo capitolo si intitola "Quality Time with the Offspring and Parenting Style: Reconsidering Parents' Equality Concerns among Families with an Ill Child". Questo capitolo studia le decisioni dei genitori sulla ripartizione delle risorse all'interno di una condizione di forte ed evidente squilibrio tra la capacitá della prole: quando uno dei figli é considerato mentalmente o fisicamente disabile. I modelli economici standard postulano che la decisione ottimale dei genitori sarebbe quella di investire di piú sul bambino piú abile. Tuttavia precedenti esplorazioni empiriche hanno mostrato che al momento di decidere i genitori sono guidati da un sentimento di equitá: le preoccupazioni su un'equa allocazione delle risorse sembrano prevalere nonostante livello di abilitá innata dei figli. Questa analisi identifica le possibili modifiche causali negli input che i genitori danno ai figli, piú specificamente il tempo di qualitá e l'atteggiamento, dovute alla presenza di un fratello malato nei bambini del "Panel Study of Income Dynamics" attraverso tecniche di matching. I genitori sembrano dedicare piú tempo di qualitá alle bambine e ai figli maggiori nel caso in cui l'altro fratello é considerato malato, mentre hanno un atteggiamento piú amorevole con i figli maschi. Inoltre tali genitori dimostrano alti livelli di stress parentale. Anche se successive analisi dimostrano che questi bambini sono piú coinvolti nelle attivitá con il fratello malato, i differenti input da parte dei genitori ricevuti in etá infantile e nella prima adolescenza potrebbero determinare effetti in etá adulta soprattutto da un punto di vista socio-economico e lavorativo.

Contents

Chapter 1

Long Term Consequences of the Chernobyl Radioactive Fallout: an Exploration of the Aggregate Data

Long Term Consequences of the Chernobyl Radioactive Fallout: an Exploration of the Aggregate Data [1]

Francesca Marino

University of Padua

Luca Nunziata[2]

University of Padua

IZA

Abstract

We challenge the lack of consensus on the long term health consequences of the radioactive fallout originated by the Chernobyl nuclear accident, by providing the first exploration of the combined aggregate evidence from the European regions that were not immediately adjacent to the disaster site. We matched data on neoplasm incidence in a number of European regions with Caesium deposition after the nuclear disaster and found that the radioactive fallout is positively associated with an increase in hospital discharges after treatment for neoplasms almost thirty years later, with larger effects in regions where the radioactivity was more intense and a substantial increase in curative-care expenditure. We checked the robustness of our findings to a number of tests including a placebo simulation and found that our results survive each of these checks.

Keywords: Health, Chernobyl, Radioactive Fallout, Neoplasm, Cancer, Hospitalization, Environment, Disaster, Economic Cost.

JEL Classification: I13, O15, Z13.

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[2]Corresponding author. Dept. of Economics, University of Padua, Via del Santo 33, 35121, Padua, Italy, e-mail: *luca.nunziata@unipd.it.*

1.1 Introduction

The health consequences of the exposure to radioactive fallout resulting from the Chernobyl nuclear disaster in 1986 are still debated in the medical literature, as reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (UNSCEAR, 1998, 2000, 2008). After the explosion of the Chernobyl nuclear reactor, the continuous release of radioactivity into the atmosphere over a ten-day period and the accompanying meteorological conditions resulted in a complex dispersion pattern across Europe. As a result, most European regions were exposed to radioactive fallout in a randomly fashion, producing a natural experiment that can be exploited to investigate the long-term health effects of the exposition to the radioactive fallout. Considering that the half-life of ^{137}Caesium is 30.17 years, part of the radioactivity is still present today in the regions that were subject to fallout.

Using data provided by the Atlas of Caesium Deposition on Europe after the Chernobyl Accident, published by the European Commission, we compare the health consequences of radioactivity about thirty years after the accident in several European regions that were characterised by heterogeneous ^{137}Caesium fallout patterns.

We find that the regions that experienced more intense radioactive fallout than others are characterised by a higher incidence of neoplasms today. The effect is large, statistically significant, and increasing with the intensity of the fallout; it does not depend on GDP per capita, population density and age patterns. It is also robust to a number of robustness checks, including controlling for the distance from Chernobyl, life expectancy in 1985, the environmental characteristics of the regions, and the characteristics of the health care sector. In addition, a placebo test confirms that our findings are unlikely to result from randomness. Finally, we show how such an increase in hospital discharges is associated with a substantial increase in curative care expenditure in affected countries.

The paper is organised as follows: section 1.2 presents our research design and discusses how the Chernobyl nuclear disaster can be considered a natural experiment. Section 1.3 presents the data, and section 1.4 presents our empirical findings. Finally, section 1.5 concludes.

1.2 The Chernobyl Nuclear Disaster as a Natural Experiment

The notorious accident at the Chernobyl nuclear power plant happened on 26 April, 1986, during the scheduled shutdown of one of the plant's least powerful reactors. Even though almost thirty years have passed since the accident, there is still an ongoing debate about its health effects on the population of the affected countries.

According to UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation)'s official reconstructions, the explosion destroyed the core of the reactor and the building that contained it

(UNSCEAR, 1998). Besides the immediate release of radioactive materials in the proximity of the plant, the disaster resulted in a diffused release of nuclear particles over vast territories for several days (UNSCEAR, 2000).

Various factors contributed to the disposition of radionuclides in the soil, with four main mechanisms determining the conditions of the fallout: the release of radioactive materials over a ten-day period; the height dispersion of radionuclides inside the plume, depending on their form and weight; winds blowing in different directions on different days interacting with plume heights (UNSCEAR, 1998); and the plume's exposure (or not) to rain during its passage over each territory (IAEA, 2006) (Figure S.1). The joint combination of these factors created the conditions of a random deposition of the radioactive fallout on European regions.

The significant differences in disposition of radionuclides in European soil is explained by the presence or absence of precipitation during the passage of the cloud. The composition of the cloud, depending on the chemical forms of the radionuclides and the distance from the explosion, also affected how those elements were deposited on the ground. When deposition was not caused by rainfall, the radioactivity levels were lower but composed of more radio-iodine isotopes. In the areas where disposition was caused by rain, the fallout composition was similar to that of the originating radioactive cloud (IAEA, 2006). The result was a fragmented deposition of radionuclides over the European soil with different concentrations of ^{137}Cs over Europe.

Surveys undertaken in May 1986, immediately after the accident, by dose rate meters and airborne gamma spectrometers, measured the soil deposition of ^{137}Cs in several European and Asian countries. Of the radionuclides dispersed by the fallout, ^{137}Cs was comparatively easy to measure and of radiological significance (IAEA, 2006), especially considering its long radiological half-life (Figure S.2).

A ^{137}Cs soil deposition greater or equal to 37 kBq m^{-2} qualifies the area as officially contaminated according to UNSCEAR (2000).[3] Belarus, Russia, and Ukraine were the most severely impacted countries; according to the data in European Commission (1998), they received 30 percent, 23 percent, and 18 percent of the estimated ^{137}Cs deposition from the nuclear accident, respectively. However, many other European countries, including Finland, Sweden, Romania, Germany, and Austria, experienced high levels of ^{137}Cs concentration.

The health consequences of the Chernobyl accident have been widely discussed in the medical literature, and the accumulation of knowledge about the long-term health effects of the accident is an ongoing process (UNSCEAR, 1998, 2000, 2008). Many studies have concentrated on the health implications for the populations that lived close to the site of the accident in Belarus, Russia, and Ukraine (Bogdanova *et al.*, 2006; Brown, 2011). A report by the European Commission (1998) suggests that the accident may have caused an increase in the incidence of thyroid cancer cases in the European countries that were hit by the radioactive fallout. Unlike ^{137}Cs, which is characterised by a half-life of thirty years, Iodine isotopes like ^{131}I have a short half-life

[3]This level corresponded to a yearly radioactivity absorption of 1 mSv during the first year after the accident, that is, the yearly limit of radioactivity absorption prescribed in the US and Canada, and about ten times the deposition from global fallout.

of eight days, but they have been shown to be an important factor in explaining the incidence of thyroid neoplasm in people who were directly exposed to the explosion or who were living in heavily contaminated regions in the days immediately following the disaster.

However, an unanimous agreement over the broad health consequences for the populations in areas contaminated by the Caesium fallout has not been found yet. One immediate reason for the lack of consensus could be due the long latency periods needed to detect the effects. Baverstock and Williams (2006) notice how research on the topic has focused primarily on the effects of iodine exposure, neglecting the potential effects of solid cancers and non-cancer health effects that could appear even decades after the explosion, as happened in Japan after the atomic bombs were dropped on Hiroshima and Nagasaki. Besides the immediate exposure to the radioactive plume and the inhalation of the related radionuclides, the two main channels of contamination for people who were living in the areas impacted by the fallout could be the continuous radiation exposure from radionuclides deposited in the soil and ingestion of contaminated food.

The need to study Chernobyl-related health outcomes long after the explosion depends on the characteristics of the illnesses under scrutiny: if the effect over the population of Belarus, Russia, and Ukraine was a clear increase in thyroid neoplasms and leukaemia, effects on other types of solid cancers may manifest over the longer term.

Cardis *et al.* (2006) estimate an increase in neoplasms in Europe that may be attributable to radiation exposure after Chernobyl, although the predicted increase is very small at the time of the study and subject to substantial uncertainty, especially considering the limited knowledge of the dose-response relationship when the doses of radiation are very low, like in most European countries after Chernobyl. The assumption behind these predictions are that radiations can affect individuals' health even at very low doses through continuous absorption from radionuclides deposited in the soil and ingestion of contaminated foods. The authors emphasize that, because of long latency periods, we may observe an increase in all cancer cases long after the disaster, with only 14 percent of the total excess cases predicted to 2065 occurring in the first 20 years after the disaster. Jaworowski (2010) criticises the use of this linear-no-threshold approach to estimate the effect of absorbed radiation on health, claiming that no increase in neoplasms took place after the disaster. Cardis and Hatch (2011) provide a review of the evidence on the health consequences of the Chernobyl accident with a particular focus on the most affected countries, i.e. Belarus, Russia and Ukraine, calling for further investigation of the long-term effects on the involved populations. Similar conclusions can be found in Moysich *et al.* (2002).

Tondel *et al.* (2004, 2006) find evidence in favour of an increase in the incidence of neoplasms in Sweden based on the recorded ^{137}Cs fallout intensity. Using data up to 1996 and comparing eight Swedish counties, some severely impacted by the fallout and some not, Tondel *et al.* (2004) find an excess relative risk of total neoplasm incidence of 0.11 per 100 kBq/m^2. Tondel *et al.* (2006) expands the study to 1999 and confirms the correlation between the total incidence rate of neoplasms and the amount of radioactive fallout. Both studies account for possible confounding effects, such as age, population density, and some proxies for overall incidence of neoplasms. In addition, Wu *et al.* (2015) show that ionizing radiations are among the environmental extrinsic factors that constitute a major determinant of the probability of developing neoplasms since they cause DNA damage.

Summarising all of these findings, we conclude that a body of evidence is emerging that suggests significant increases in neoplasms and secondary effects not only in Belarus, Russia, and Ukraine, but also in other European countries that were reached by the radioactive plume. The intensity of these effects is still debated and a consensus has not yet been reached. Our aim is to contribute to this debate by examining the aggregate evidence on health patterns across European regions thirty years after the Chernobyl accident. To our knowledge, this is the first attempt to investigate the relationship between the Chernobyl fallout and health patterns using aggregate data collected in those regions that were not immediately adjacent to Chernobyl.

Our data on the concentration of ^{137}Cs on European soil is gathered from the information provided by the Atlas of Caesium Deposition on Europe after the Chernobyl Accident, published by the European Commission. From this data we construct a set of dummy variables that indicate the intensity of the fallout for each European region in our sample. The first dummy (D_{F1}) indicates fallout deposition of 2-10 kBq/m^2, the second dummy (D_{F2}) is 10-40 kBq/m^2, and the third (D_{F3}) is greater than 40 kBq/m^2. However, some areas have only spotty ^{137}Cs concentrations greater than 40 kBq/m^2, while other areas have been widely affected. For this reason we use a fourth dummy, (D_{F4}), to distinguish the regions that recorded a ^{137}Caesium soil deposition greater than 40 kBq/m^2 in more than 50 percent of their territories (Table S.1). Our sample consists of those European regions for which homogeneous information on the incidence of neoplasms is available from Eurostat (see section 1.3 below).

Our estimated model is equal to:

$$Health_j = \alpha_0 + \alpha_1 D_{F1j} + \alpha_2 D_{F2j} + \alpha_3 D_{F3j} + \alpha_4 D_{F4j} + \alpha_5 X_j + \varepsilon_i \tag{1.1}$$

where we include the set of dummies that correspond to the different intensity levels of the fallout and X_j is a vector of controls for each region j, including GDP per capita, population density, and the proportion of residents aged over sixty, in our baseline specification.

The random nature of the Caesium deposition after the accident created the conditions of a natural experiment, i.e. the fallout deposition resembles the experimenter's random treatment allocation. In addition, the literature suggests that most European citizens did not engage in any particular protective action after the disaster and, if present, the countermeasures were only temporary, resulting in an homogeneous long-term behavioural response of the affected and non-affected areas (Peters *et al.*, 1990; Renn, 1990; Tønnessen *et al.*, 2002; Berger, 2010). As a result, our dummy variables of interest are uncorrelated with the stochastic component ε_i of model (1.1) and the estimated coefficients may be given a causal interpretation. Nevertheless, especially considering the small number of observations in our sample, we cannot exclude that some unobserved factors may correlate with the fallout dummies. Therefore, in what follows we provide a battery of robustness checks to exclude that our findings are spurious or determined by chance.

1.3 The Data

In addition to the data on the radioactive fallout in Europe, our analysis is based on regional-level health data from Eurostat (Table S.2). Since neoplasms are the most frequent form of illness associated with exposure to radioactivity, we focus on the total number of hospital discharges after treatment of neoplasms observed in a large number of European regions characterized by a certain degree of homogeneity in cancer-related treatment and diagnosis practices. The regions belong to thirteen European countries – Austria, the Czech Republic, Germany, Spain, Portugal, France, Estonia, Denmark, Netherlands, Ireland, Latvia, Lithuania, and Luxembourg – for a total of eighty regions. The pool of regions is a balanced mix of areas with varying degrees of fallout intensity.

Our measure of health is objective, rather than self-reported, and it is aggregated at the regional level. By adopting an aggregate measure of health at the regional level, we can provide a comparatively precise match between the fallout and health outcomes that would be difficult to achieve using individual level data. Indeed, not all of the inhabitants in the regions were exposed to the fallout in the same way. However, these differences are likely to cancel out when we consider regional averages. The measures are standardised as percentages of the resident population and averaged over the period 2000-2013 in order to eliminate short-term nuisance. Regional data are aggregated at the NUTS[4] 2 level whenever possible.[5]

We also observe regional GDP per capita, population density, and the proportion of residents aged over sixty, all of which can affect health patterns in general and the neoplasms' incidence in particular at the regional level. Other controls used for robustness include the regions' distance from Chernobyl, longitude, life expectancy measured at the national level in 1985, i.e. before the nuclear disaster, proportion of wooded areas in the region, the tendency toward hospitalization, the number of physicians or doctors, and the number of beds in hospitals at the regional level, and health care expenditure by financing agent and by function at the national level.

The geographical representation of the dummies created from the data on the radioactive fallout's dispersion is displayed in Figure 1.1.

[4]Nomenclature of Units for Territorial Statistics

[5]See supplementary section 1.5 for further details on data construction.

1.4 Empirical Findings

1.4.1 Baseline Model

Table 1.1 reports the estimated regressions. Our estimates indicate that the radioactive fallout is positively and significantly associated with the incidence of neoplasms and that the incidence increases with the intensity of the fallout.

The baseline model in column (1) indicates that the regions where the ^{137}Cs soil concentration was 2-10 Kbq m^{-2} saw an increase in hospital discharges after treatment for neoplasms of around 0.6 percentage points compared to regions with no fallout. The effect associated with a ^{137}Cs soil concentration of 10-40 Kbq m^{-2} is around 0.95 percentage points.

The areas most affected by the fallout, those captured by the dummies D_{F3} and D_{F4}, experience much higher levels of hospital discharges after treatment for neoplasms, with point estimates around 1.4 and 2.2 percentage points, respectively. These coefficients do not necessarily measure the increase in the incidence of neoplasms among resident populations in absolute terms since they refer to hospital discharges, and one patient may be associated with more than one hospitalization during the course of the disease. However, the effect seems large considering that hospital discharges after treatment for neoplasms on average are equal to around 1.7 percent of the resident population. Similar findings are obtained using alternative specifications of the fallout dummies based on the extension of the regional area exposed to the fallout (Table S.4).

Our estimated effects are close to the crude neoplasm-incidence ratios in Tondel *et al.* (2004, 2006), although the findings should be compared with care, given the different methodology, the different outcome measures used, and the different time spans of the analysis. GDP per capita, population density and the proportion of residents age 60 or more are all positively associated with the incidence of neoplasms, as expected.

The assessment of the actual long term effects of the Chernobyl nuclear disaster on deaths by neoplasm is affected by the increasing survival rates from neoplasms in recent years. Several studies have highlighted a positive trend in 1, 5 and 10 years survival rates after a neoplasm diagnosis in Europe (Allemani *et al.*, 2015; Quaresma *et al.*, 2015). Our model cannot find any significant effect of the fallout on deaths by neoplasms.[6] However, we checked the correlation between deaths and hospital discharges by neoplasms over the 2000-2010 time span, finding a positive correlation that tends to increase the larger is the time lag between the two measures (Table S.5). Deaths are generally positively correlated with hospital discharges. The correlation is equal to 0.19 when comparing contemporaneous measures of deaths and discharges, while it amounts to 0.27 when comparing measures observed 8 years apart, indicating that death patterns are much more correlated to past levels than to contemporaneous levels of hospitalization. This may indicate that the effect of the fallout on deaths may show in the data in future analysis, assuming a reliable measure of deaths by neoplasms will

[6] Not reported, available upon request.

be available.

1.4.2 Robustness Checks

Additional Regional Controls

Our findings reveal a strong association of the actual radionuclide soil concentration with the incidence of neoplasms, measured by hospitalization. Still there are a number of issues that deserve attention. Figure 1.1 shows that the geographical distribution of the regions with no fallout concentrates in those areas that were more distant from Chernobyl (Portugal, Spain and the western French regions). Despite the randomness of the geographical dispersion of the fallout, the concentration of the no fallout areas in the west of Europe may still constitute a problem for our estimates if those regions have unobservable characteristics that correlate with health patterns. Therefore, we re-estimate our model to determine whether our findings disappear when we include additional controls, such as a measure of regional distance from Chernobyl, longitude, life expectancy measured at the national level in 1985 before the nuclear disaster, and a measure of anthropization, i.e. the proportion of wooded areas in the region. Our results are robust to the inclusion of all these additional controls, as displayed in the remaining columns of Table 1.1. Not surprisingly, the incidence of neoplasms is negatively associated with the distance from Chernobyl, with life expectancy in 1985 and with the percentage of woods in the region, and positively associated with longitude.

Additional Health-Related Controls

As a further robustness check, we include health-related controls measured at the regional level (Table S.6). Some could argue that the higher number of hospital discharges in some regions could not be due to the exogenous fallout but to a greater tendency toward hospitalization in general or a more diffused presence of hospitals in the region. We determine whether such is the case by controlling for several variables: the standardised number of hospital discharges from medical observation, the standardised number of doctors, and the standardised number of beds in hospitals. The inclusion of these variables does not affect our findings. In some cases the point estimates are slightly smaller (e.g. when we control for available bed in hospitals in column 3), but the effect of fallout on neoplasms is always positive and statistically significant and always increases with the intensity of the fallout.

Another dimension that could affect our estimates is the internal allocation of health care expenditure. The incidence of hospitalizations and, more generally, the procedures by which neoplasm treatments are administered to the patients could be affected by health-care policies at the national level. We control for, respectively, financing agents of total health care expenditure as share of GDP, and for the specific type of health care provision per inhabitant (Tables S.7 and S.8). Our results are robust to the inclusion of all of these controls, therefore excluding the possibility that the findings are due to the characteristics of health care expenditure at the national level.

Sensitivity to Country Exclusion

Our findings are also robust to the exclusion of any country in the sample, as displayed in Table 1.2, as in all cases the effect of the fallout is positive and increasing with the intensity of the fallout. Some of the dummies are associated to a slightly smaller point estimate when we exclude Spain, which is not surprising considering that most of the regions with no fallout are in that country. Spain is, with Portugal, the only country in the sample that was not affected by the fallout at all, and its regions make up a large share of the zero-fallout areas. Despite ending up with much lower variability in the data when we eliminate Spain, all fallout dummies are still statistically significant with an effect that still increases with the intensity of the fallout.

Another possible factor that could affect our estimations is the geographical location of the regions with the highest and the lowest levels of fallout intensity. We test whether the inclusion of specific group of countries is the main driver of our findings. The areas that received the highest levels of contamination are located in Austria and Czech Republic, while the least contaminated ones are in Portugal and Spain. In the final columns of Table 1.2 we repeat the analysis after excluding Austria and Czech Republic (column 14), Spain and Portugal (column 15) and lastly excluding all the four countries together, Austria, Czech Republic, Portugal and Spain (column 16). The positive and increasing pattern of neoplasm incidence with the fallout intensity is confirmed even excluding "extreme" countries.

Panel Data Specification

We also check whether our findings survive a panel specification. Our baseline model exploits the cross-sectional variability in the nuclear fallout to estimate its effects on health patterns. For this reason, we prefer to use regional averages in hospitalization over the 2000-2013 time span. However, Table S.9 shows that our results are confirmed when we exploit the panel structure of the data. Given that the after Chernobyl fallout dummies are time invariant, we adopt a random effects specification that supports all our main findings.

Placebo Test: Effect on Unrelated Illnesses

We also check whether the fallout affected hospital discharges related to other forms of illness that are clearly not related to the harmful effect of radioactivity. Table 1.3 shows that the effect of the fallout is not significant when we consider other causes of hospitalization, such as tuberculosis, alcoholic liver diseases, pregnancy and child birth, and poisoning. We also find that the effect of the fallout is positive and significant for any type of malignant neoplasm, although the intensity varies according to the type (Table S.10).

Placebo Test: Randomly Assigned Fallout Dummies

In another robustness test, we check for the likelihood that our findings are produced by chance, a necessary test given the relatively small number of regions in our sample. We perform a placebo test, where our fallout dummies are substituted with a set of randomly assigned placebo dummies that respect the proportions of the fallout intensity areas in the baseline fallout specification.[7] Our findings are summarized in Table S.11. After 1000 replications, in not even one case are all dummies' coefficients positive, statistically significant, and increasing with the intensity of the fallout. In none of the replications are all four dummies positive and significant. The percentages for three, two and only one dummy being positive and significant are 0.3, 2.7, and 19.2 percent, respectively. The frequencies are even lower when considering positive and significant dummies increasing with the intensity of the fallout. In other words, our placebo test shows that our empirical findings are unlikely to have been determined by chance.

1.4.3 Economic Implications of the Chernobyl Nuclear Disaster

Finally, we provide an approximate estimate of the increase in annual health-care expenditure induced by the Chernobyl nuclear disaster based on the implications of our baseline estimates. Using Eurostat data on health expenditure by country, we calculate what share of the 2000-2012 annual curative care expenditure may be due to the increase in hospital discharges attributable to the fallout.[8] Our findings reported in Table 1.4 suggest that the increase in curative expenditure is substantial. Around 4.4% to 4.9% of the average curative care expenditure in Austria and Czech Republic could be imputed to the consequences of the fallout. Germany and France, that received lower levels of radiations, may have spent, respectively, 3.8% and 1.9% of their total curative care expenditure because of the excess number of hospitalizations due to the fallout.

1.5 Conclusions

This study provides one of the first investigations of the long-term health consequences of the Chernobyl nuclear disaster in the European regions that were not immediately adjacent to Chernobyl. Our research design exploits the random nature of the soil deposition of ^{137}Caesium to investigate the association with hospitalizations due to neoplasms almost thirty years later.

Our findings indicate that the radioactive fallout from the Chernobyl accident is positively associated with the neoplasm-related hospitalization rate, with larger effects in regions where the radioactivity was more intense. This association does not depend on the characteristics of the regions in our sample, such as GDP per

[7]See the details in supplementary section 1.5 and the complete set of results from the simulations in Table S.12.

[8]The detailed procedure and the complete set of estimates are described in the supplementary section 1.5.

capita, population age and density, the amount of wooded areas in the region, the distance from the epicentre of the nuclear disaster, life expectancy before the explosion, the diffusion of doctors and hospitals in the area, or health-care policies at the national level. In addition, it is not driven by any specific country in the sample or by unobserved regional characteristics modelled using random effects. Our placebo regressions show that our findings are unlikely to be determined by chance, and we do not detect any effect on the incidence of other health conditions that are clearly not related to radiation exposure.

Finally, we show how such an increase in hospital discharges is associated with a substantial increase in curative care expenditure in affected countries.

Our evidence calls for further research to replicate and validate our findings using a similar methodology on larger datasets collected at the national level. Considering the long latency periods required to detect the effects of radioactivity on health, future research should also focus on those affected areas that were not immediately adjacent to the disaster area.

Bibliography

Allemani, C., Weir, H. K., Carreira, H., Harewood, R., Spika, D., Wang, X.-S., Bannon, F., Ahn, J. V., Johnson, C. J., Bonaventure, A. *et al.* (2015). Global surveillance of cancer survival 1995–2009: analysis of individual data for 25 676 887 patients from 279 population-based registries in 67 countries (concord-2). *The Lancet*, **385** (9972), 977–1010. 1.4.1

Baverstock, K. and Williams, D. (2006). The Chernobyl Accident 20 Years On: An Assessment of the Health Consequences and the International Response. *Environmental Health Perspectives*, **114** (9), 1312–1317. 1.2

Berger, E. M. (2010). The Chernobyl Disaster, Concern about the Environment, and Life Satisfaction. *Kyklos*, **63** (1), 1–8. 1.2

Bogdanova, T. I., Zurnadzhy, L. Y., Greenebaum, E., McConnell, R. J., Robbins, J., Epstein, O. V., Olijnyk, V. A., Hatch, M., Zablotska, L. B. and Tronko, M. D. (2006). A cohort study of thyroid cancer and other thyroid diseases after the chornobyl accident. *Cancer*, **107**. 1.2

Brown, V. J. (2011). Thyroid cancer after chornobyl: Increased risk persists two decades after radioiodine exposure. *Environmental Health Perspectives*, **119** (7). 1.2

Cardis, E. and Hatch, M. (2011). The Chernobyl accident-an epidemiological perspective. *Clinical Oncology*, **23** (4), 251–60. 1.2

—, Krewski, D., Boniol, M., Drozdovitch, V., Darby, S. C., Gilbert, E. S., Akiba, S., Benichou, J., Ferlay, J., Gandini, S., Hill, C., Howe, G., Kesminiene, A., Moser, M., Sanchez, M., Storm, H., Voisin, L. and Boyle, P. (2006). Estimates of the cancer burden in Europe from radioactive fallout from the Chernobyl accident. *International Journal of Cancer*, **119** (6), 1224–35. 1.2

European Commission (1998). *Atlas of Caesium Deposition on Europe After the Chernobyl Accident*. Luxembourg: Office for Official Publications of the European Communities. 1.2

IAEA (2006). *Environmental consequences of the Chernobyl accident and their remediation: twenty years of experience. Report of the chernobyl forum expert group 'environment': STI/PUB/1239, 2006, International Atomic Energy Agency, Vienna, Austria ISBN: 92-0-114705-8,*. Tech. Rep. 4, International Atomic Energy Agency (IAEA), Vienna. 1.2

Jaworowski, Z. (2010). Observations on the Chernobyl Disaster and LNT. *Dose-Response*, **8** (2), 148–71. 1.2

Luengo-Fernandez, R., Leal, J., Gray, A. and Sullivan, R. (2013). Economic burden of cancer across the European Union: a population-based cost analysis. *The Lancet Oncology*, **14** (14), 1165–74. 1.5

MOYSICH, K. B., MENEZES, R. J. and MICHALEK, A. M. (2002). Chernobyl-related ionising radiation exposure and cancer risk: an epidemiological review. *The Lancet Oncology*, **3** (May), 269–279. 1.2

PETERS, H. P., ALBRECHT, G., HENNEN, L. and STEGELMANN, H. U. (1990). Chernobyl and the nuclear power issue in West German public opinion. *Journal of Environmental Psychology*, **10**, 121–134. 1.2

QUARESMA, M., COLEMAN, M. P. and RACHET, B. (2015). 40-year trends in an index of survival for all cancers combined and survival adjusted for age and sex for each cancer in england and wales, 1971–2011: a population-based study. *The Lancet*, **385** (9974), 1206–1218. 1.4.1

RENN, O. (1990). Public responses to the chernobyl accident. *Journal of Environmental Psychology*, **10**, 151–167. 1.2

TONDEL, M., HJALMARSSON, P., HARDELL, L., CARLSSON, G. and AXELSON, O. (2004). Increase of regional total cancer incidence in north Sweden due to the Chernobyl accident? *Journal of epidemiology and community health*, **58** (12), 1011–6. 1.2, 1.4.1

—, LINDGREN, . A. P., HJALMARSSON, P., HARDELL, L. and PERSSON, B. (2006). Increased Incidence of Malignancies in Sweden After the Chernobyl Accident–A Promoting Effect? *Americal Journal of Industrial Medicine*, **168**, 159–168. 1.2, 1.4.1

TØNNESSEN, A., BERTIL, M. and WEISÆ TH, L. (2002). Silent Disaster: A European Perspective on Threat Perception From Chernobyl Far Field Fallout. *Journal of Traumatic Stress*, **15** (6), 453–459. 1.2

UNSCEAR (1998). *Report to the General Assembly, with Scientific Annexes*. New York: United Nations. 1.1, 1.2

UNSCEAR (2000). *Effects of Atomic Radiation, Report to the General Assembly, Annex J, Exposures and Effects of the Chernobyl Accident*. New York: United Nations. 1.1, 1.2

UNSCEAR (2008). *Sources and Effects of Ionizing Radiation, Report to the General Assembly, Annex D, Health Effects Due to Radiation from the Chernobyl Accident*. New York: United Nations. 1.1, 1.2

WU, S., POWERS, S., ZHU, W. and HANNUN, Y. A. (2015). Substantial contribution of extrinsic risk factors to cancer development. *Nature*, pp. 1–15. 1.2

Fig. 1.1 – *Fallout dummy specification*

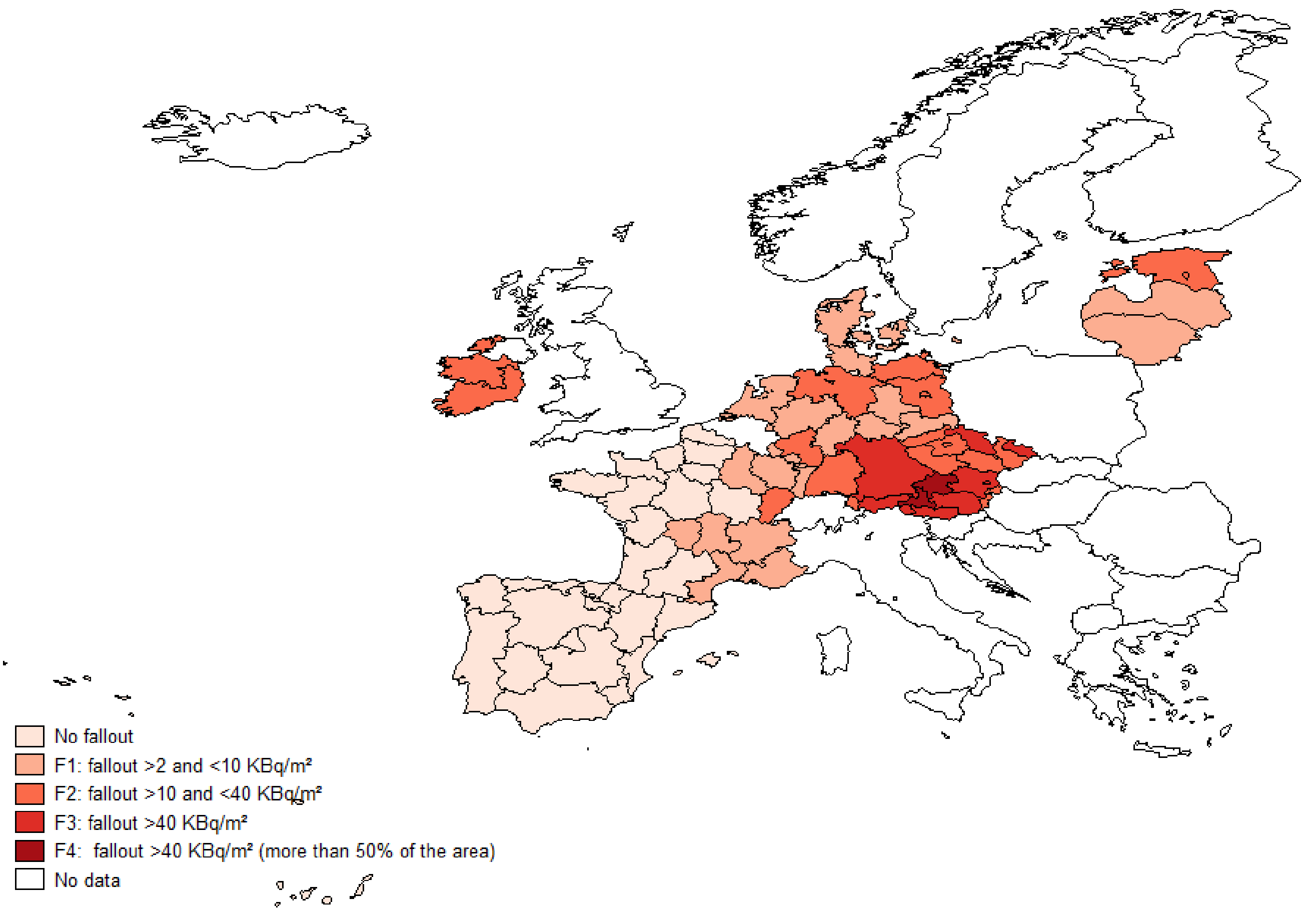


Table 1.1 – Fallout effect on hospital discharges, with additional controls

Dependent variable: hospital discharges by neoplasms	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D_{F1}	0.645***	0.293*	0.299**	0.472***	0.662***	0.310**	0.319**	0.409***
	(0.127)	(0.156)	(0.139)	(0.123)	(0.126)	(0.149)	(0.138)	(0.153)
D_{F2}	0.950***	0.522***	0.561***	0.644***	1.038***	0.485***	0.528***	0.632***
	(0.123)	(0.153)	(0.117)	(0.170)	(0.119)	(0.158)	(0.147)	(0.190)
D_{F3}	1.369***	0.840***	0.826***	1.063***	1.453***	0.815***	0.813***	1.012***
	(0.221)	(0.285)	(0.251)	(0.254)	(0.232)	(0.282)	(0.260)	(0.302)
D_{F4}	2.245***	1.703***	1.662***	1.950***	2.294***	1.677***	1.650***	1.853***
	(0.086)	(0.183)	(0.159)	(0.144)	(0.085)	(0.179)	(0.169)	(0.180)
Wealth	0.003***	0.004***	0.005***	0.005***	0.003**	0.004***	0.005***	0.004**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Population density	0.0004***	0.0003***	0.0003***	0.0004***	0.0004***	0.0003***	0.0003***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	10.975***	9.973***	10.421***	11.677***	10.221***	10.049***	10.453***	9.940***
	(1.875)	(1.693)	(1.682)	(1.787)	(1.862)	(1.664)	(1.696)	(1.689)
Distance		-0.000***				-0.000*		-0.000
		(0.000)				(0.000)		(0.000)
Longitude			0.033***				0.028***	
			(0.008)				(0.010)	
Life expectancy in 1985				-0.112***		-0.033	-0.031	-0.042
				(0.035)		(0.048)	(0.046)	(0.046)
Percentage woods					-0.986***			-0.905**
					(0.360)			(0.353)
Observations	80	80	80	79	78	79	79	77
R^2	0.736	0.779	0.780	0.764	0.759	0.786	0.786	0.796

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2, F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variable expressed in hospital discharges over 100 inhabitants. Baseline controls: wealth, population density and proportion of population aged over 60. Further controls: distance indicates the area's distance from Chernobyl's nuclear power plant (in km), longitude accounts for the area's meridian: positive numbers correspond to meridians east of Greenwich's, negative numbers are located west, life expectancy in 1985 (pre-accident) at country level expressed in years, percentage of woods controls for the proportion of the area covered by woods. Columns 1 represents the baseline specification. Columns 2, 3, 4 and 5 represent the change in the baseline model adding each control separately, columns 6 and 7 present the joint effect of the additional variables.

Table 1.2 – Panel A. Fallout effect on hospital discharges, excluding one country at a time

	Dependent variable: hospital discharges by neoplasms							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Excl. AT	Excl. CZ	Excl. DE	Excl. DK	Excl. EE	Excl. ES	Excl. FR	Excl. IE
D_{F1}	0.647***	0.661***	0.377***	0.656***	0.644***	0.389***	1.068***	0.655***
	(0.127)	(0.128)	(0.111)	(0.131)	(0.127)	(0.118)	(0.149)	(0.129)
D_{F2}	0.893***	0.942***	0.769***	0.951***	0.948***	0.739***	1.144***	1.023***
	(0.120)	(0.163)	(0.142)	(0.124)	(0.128)	(0.135)	(0.130)	(0.126)
D_{F3}	0.984***	1.523***	1.407***	1.368***	1.369***	1.153***	1.526***	1.360***
	(0.087)	(0.283)	(0.259)	(0.220)	(0.221)	(0.237)	(0.234)	(0.216)
D_{F4}		2.268***	2.213***	2.238***	2.245***	2.077***	2.441***	2.199***
		(0.087)	(0.088)	(0.088)	(0.086)	(0.090)	(0.118)	(0.091)
Wealth	0.002**	0.002**	0.002	0.003***	0.003***	0.003**	0.003*	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Population density	0.0004***	0.0004***	0.001***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	11.348***	10.475***	6.175***	10.904***	10.976***	13.566***	12.210***	9.902***
	(1.855)	(1.978)	(1.529)	(1.882)	(1.876)	(2.201)	(2.071)	(1.973)
Observations	71	72	64	79	79	63	59	78
R^2	0.700	0.739	0.783	0.737	0.736	0.688	0.816	0.741

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). All columns are obtained by the same OLS specification, used controls are only the ones reported in the table. Dependent variable expressed in hospital discharges over 100 inhabitants. Country codes: AT Austria, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FR France, IE Ireland, LT Lithuania, LV Latvia, LU Luxemburg, NL Netherlands, PT Portugal.

Table 1.2 – Panel B. Fallout effect on hospital discharges, excluding one country at a time

	Dependent variable: hospital discharges by neoplasms							
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Variables	Excl. LT	Excl. LV	Excl. LU	Excl. NL	Excl. PT	Excl. AT CZ	Excl. ES PT	Excl. AT CZ ES PT
D_{F1}	0.615***	0.618***	0.658***	0.678***	0.647***	0.647***	0.376***	0.349***
	(0.132)	(0.132)	(0.131)	(0.127)	(0.127)	(0.128)	(0.119)	(0.124)
D_{F2}	0.956***	0.955***	0.954***	0.948***	0.953***	0.865***	0.722***	0.606***
	(0.124)	(0.124)	(0.125)	(0.123)	(0.125)	(0.162)	(0.139)	(0.158)
D_{F3}	1.370***	1.370***	1.365***	1.366***	1.371***	0.982***	1.138***	0.690***
	(0.220)	(0.220)	(0.217)	(0.220)	(0.222)	(0.091)	(0.240)	(0.096)
D_{F4}	2.235***	2.235***	2.217***	2.233***	2.247***		2.065***	
	(0.087)	(0.087)	(0.100)	(0.087)	(0.087)		(0.091)	
Wealth	0.003***	0.003***	0.004**	0.003***	0.003***	0.002**	0.003**	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Population density	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	11.241***	11.141***	10.793***	10.610***	10.977***	11.429***	13.550***	14.555***
	(1.868)	(1.870)	(1.947)	(1.860)	(1.876)	(1.962)	(2.198)	(2.402)
Observations	79	79	79	79	79	63	62	45
R^2	0.739	0.739	0.738	0.742	0.734	0.689	0.681	0.657

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). All columns are obtained by the same OLS specification, used controls are only the ones reported in the table. Dependent variable expressed in hospital discharges over 100 inhabitants. Country codes: AT Austria, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FR France, IE Ireland, LT Lithuania, LV Latvia, LU Luxemburg, NL Netherlands, PT Portugal.

Table 1.3 – Fallout effect on hospital discharges by other causes

Dependent variables: hospital discharges by	tubercolosis	alcoholic liver disease	pregnancy childbirth	poisonings by drugs, medicaments and biological substances
	(1)	(2)	(3)	(4)
D_{F1}	0.011	0.005	0.186**	0.034*
	(0.008)	(0.004)	(0.071)	(0.019)
D_{F2}	-0.003	0.008*	0.249**	-0.005
	(0.002)	(0.004)	(0.113)	(0.019)
D_{F3}	0.008**	0.005	0.037	-0.019
	(0.004)	(0.006)	(0.055)	(0.017)
D_{F4}	0.012***	0.001	0.130	-0.029
	(0.005)	(0.005)	(0.085)	(0.020)
Wealth	-0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)
Population density	0.000	0.000003**	0.000	-0.00002***
	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	-0.106	0.165***	-6.342***	-0.248
	(0.074)	(0.062)	(1.567)	(0.265)
Observations	79	80	80	80
R^2	0.204	0.191	0.383	0.092

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variables expressed in hospital discharges over 100 inhabitants. OLS specification with robust standard errors. In column 1 hospital discharges by tubercolosis data are not available for Estonia (EE). In column 2 hospital discharges by alcoholic liver disease are not available for Netherlands (NL) and Portugal (PT).

*Table 1.4 – **Hospitalization costs, expenditure share attributable to Chernobyl***

	Total expense in inpatient curative care	Amount due to Chernobyl using avg hospitalization cost by neoplasm	Share due to Chernobyl
Unit of measure:	*Millions of Euros*	*Millions of Euros*	*Percentage*
AT	€ 8466.89	€ 368.87	4.36%
CZ	€ 25337.10	€ 1241.11	4.90%
DE	€ 63094.33	€ 2364.49	3.75%
DK			
EE	€ 249.14	€ 14.90	5.98%
ES	€ 19874.98		
FR	€ 54641.06	€ 1035.95	1.90%
IE			
LT	€ 921.47	€ 29.15	3.16%
LU	€ 533.47	€ 22.84	4.28%
LV	€ 378.97	€ 13.45	3.55%
NL	€ 16754.10	€ 1267.09	7.56%
PT			
Source:	*Eurostat*	*Computed*	*Computed*

Column 1 presents the average total in-patient curative care expenditure by country (in millions of Euros). Column 2 presents the amount of curative care expenditure of the country due to the excess hospital discharges predicted by our model. Column 3 presents the share of total curative care expenditure (in Column 1) due to Chernobyl-related excess hospital discharges calculated using the figures estimated. Figures in Columns 1 and 2 are annual averages for the period 2000-2013.

Supplementary Material

Further Details on Data Construction

The regional Eurostat health data is provided at the NUTS 2 level for Austria, the Czech Republic, Germany, Spain[9], Ireland and France, while data is available at the NUTS 1 level for the remaining countries. Our hospital discharge measure captures a crude measure of neoplasm incidence in the region since it includes the number of hospital discharges after a minimum of one night (or more than 24 hours) in the hospital for treatment of neoplasms. It follows that only those who do not require specific hospital treatment or those who are affected by the illness but who have not been diagnosed are excluded.[10] The relative wealth of the region is measured as the regional GDP per capita with respect to the European Union's average, meaning that a value greater of inferior to 100 indicates that the area's is, respectively, richer or poorer than the European average. Population density is measured as the ratio of total population per hectare. The proportion of people aged over sixty is calculated as the ratio between regional population aged over sixty over total population.

Further Details on the Placebo Test

We perform a placebo test, where our fallout dummies are substituted with a set of randomly assigned placebo dummies that respect the proportions of the baseline fallout specification. We set the placebo to thirty-one areas with no fallout, twenty-three areas with F1 fallout <10 kBq/m^2, seventeen areas with F2 fallout <40 kBq/m^2, seven areas with F3 fallout >40 kBq/m^2, and two areas with F4 fallout >40 kBq/m^2 (with more than 50 percent of regional area affected).

An Estimate of the Excess Curative Care Costs Implied by Our Model

Using Eurostat data on health care expenditure by function[11] we first estimated the average day cost of an hospitalization for curative care in each country, following a procedure similar to the one used by Luengo-Fernandez *et al.* (2013). The expenditure data, i.e. total million of Euros spent in curative care for in-patients, was divided by the total number of curative care bed days. The total number of curative care bed days was provided directly by Eurostat. However, the data were not available for all regions/years. In

[9]The data for Spain does not include data from ES63 (Ceuta) or ES64 (Melilla).

[10]By construction, the variable captures each hospitalization, even if it refers to a single patient's being hospitalized more than once. In other words, it is a measure that gives more weight to serious forms of neoplasms that require more times in the hospital. We check whether the hospitalization rate is affected by the characteristics of the healthcare system at the regional and national level in our robustness tests.

[11]Eurostat(2015). Expenditure of selected health care functions by financing agents in health care.

those cases however the dataset had information on bed days classified by ICD10[12] illnesses categories. We therefore summed all hospital days across the ICD10 illness categories to obtain an accurate estimate of total curative care bed days in the country.

The estimated cost of each hospital discharge by neoplasm is the result of the multiplication of the average day cost of an hospitalization by curative care times the average length of stay (in days) of an in-patient classified for neoplasm, provided by Eurostat. Unfortunately, no expenditure data can be obtained specifically for neoplasm treatments. For this reason, assuming that the treatment of neoplasms is on average more costly than the average curative care treatment, our estimates should be considered a lower bound of the actual neoplasm-related costs. Results from the procedure are shown in Table S.13.

Once the average cost of each hospitalization is calculated, we can use it to measure the increase in total costs associated to the excess hospital discharges by neoplasms predicted by our model. Through this procedure we were able to estimate what part of the 2000-2013 curative care expenditure is actually attributable to the excess hospital discharges by neoplams due to radioactive exposure, according to our estimates.

Supplementary Figures and Tables

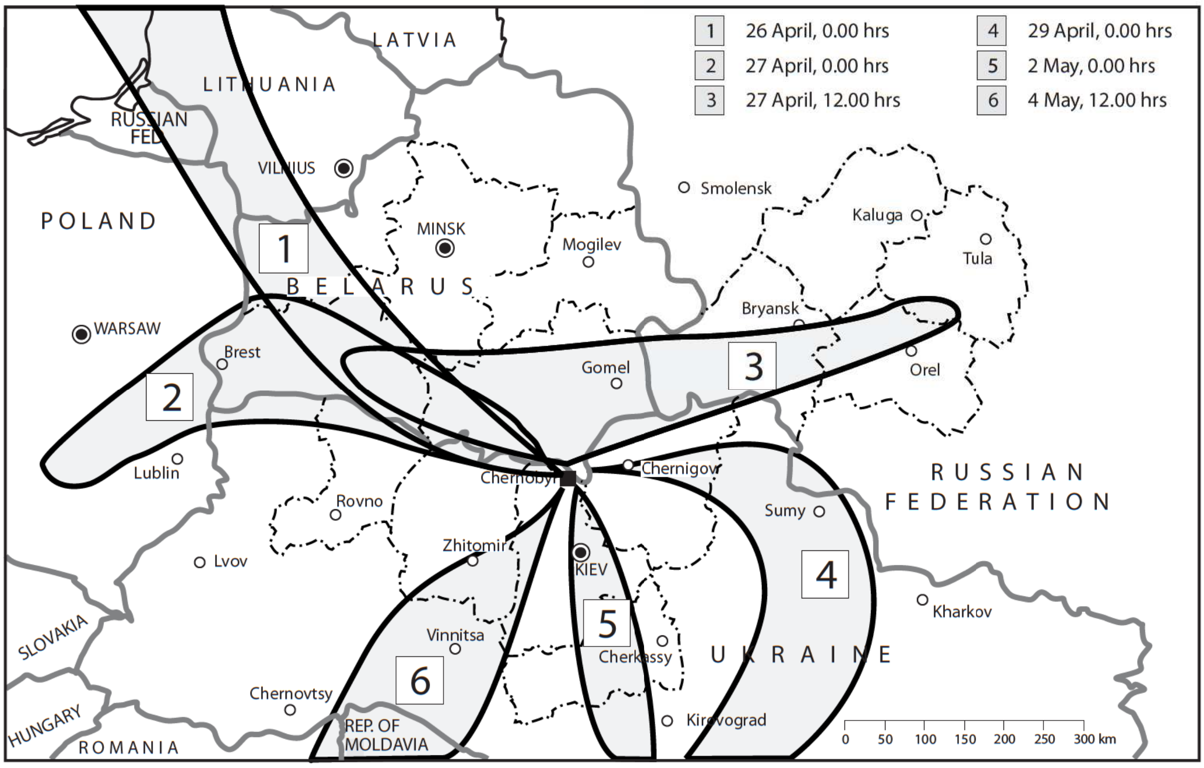
Table S.1 – *Fallout dummy specification*

^{137}Cs concentration (Kbq m^{-2})	Dummy variable	Number of obs.
$<$ 2	-	31
$>$ 2 and $<$ 10	D_{F1}	23
$>$ 10 and $<$ 40	D_{F2}	17
$>$ 40	D_{F3}	7
$>>$ 40	D_{F4}	2

Fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2,F3 Fallout >40 kBq/m^2 , F4 fallout >40 kBq/m^2 in more than 50% of the area. No region in the dataset records a fallout intensity greater than 185 kBq/m^2.

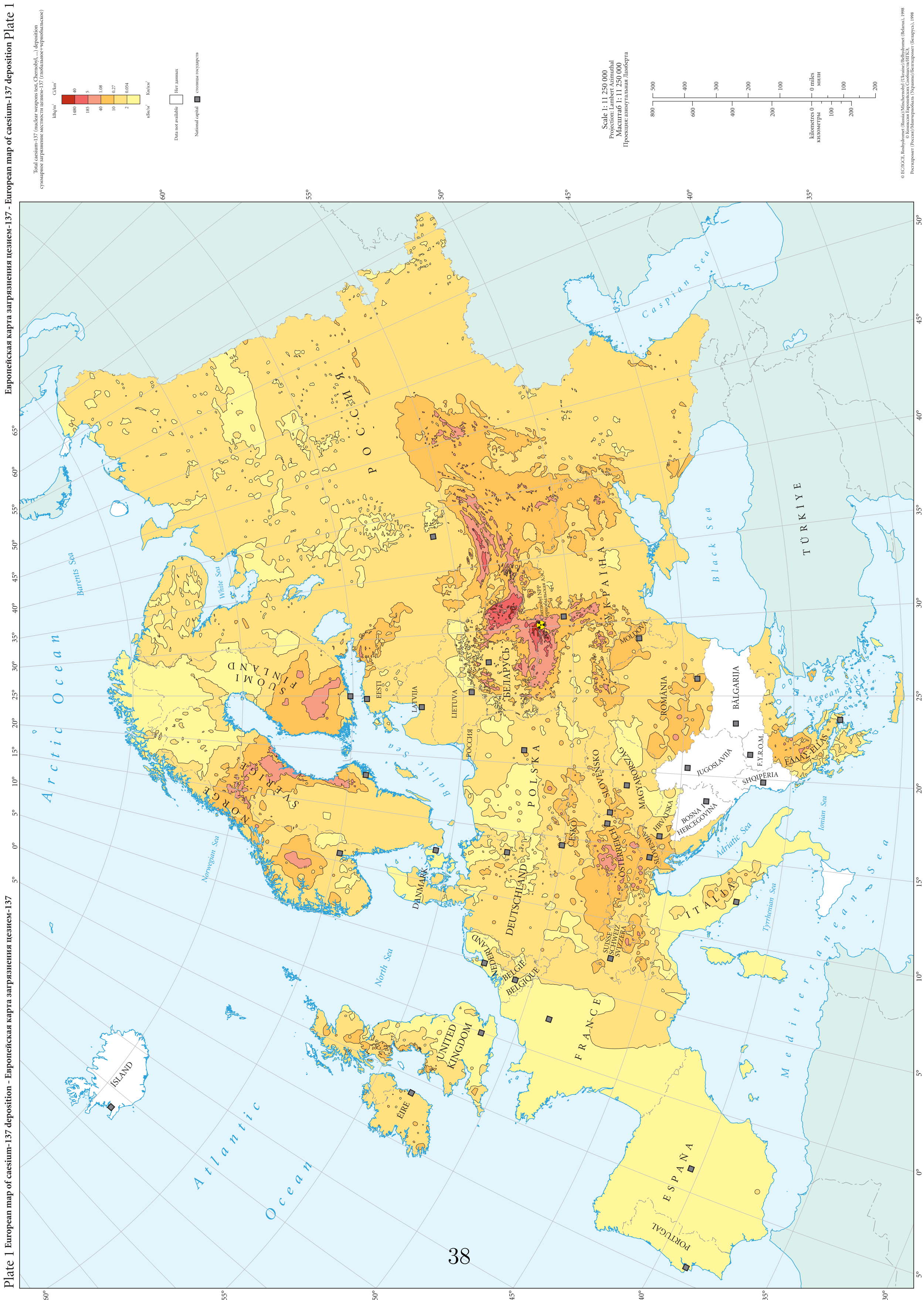
[12]International Statistical Classification of Diseases and Related Health Problems 10th Revision

Fig. S.1 *– Formation of plumes by meteorological conditions for instantaneous releases on the dates and at the times (UTC) indicated.*



Source: UNSCEAR, 2008. United Nations Scientific Committee on the Sources and Effects of Ionizing Radiation, 2008 Report to the General Assembly, with scientific annexes. Annexes D, United Nations, New York.

Fig. S.2 *– Surface Ground Deposition of Caesium-137 Released in Europe After the Chernobyl Accident.*



Source: European Commission (1998). Atlas of Caesium Deposition on Europe After the Chernobyl Accident. Luxembourg: Office for Official Publications of the European Communities.

Table S.2 – Description of main variables

Variable	Description
Fallout Dataset: own elaboration Time range: - Dimension: dummy	From the Atlas of Caesium Deposition on Europe After the Chernobyl Accident by the European Commission (1998) fallout dummies were assigned at Nuts 2 level for Austria, the Czech Republic, Germany, Ireland, Spain and France, and at Nuts 1 level for Denmark,Estonia, Latvia, Lithuania, Luxemburg, Netherlands and Portugal. Each dummy corresponds to the highest concentration of ^{137}Cs expressed in Kbq m^{-2}. Assigned thresholds follow the division presented in the map: D_{F1} concentration >2 and <10 Kbq m^{-2}, D_{F2} concentration >10 and < 40 Kbq m^{-2}, D_{F3} concentration >40 Kbq m^{-2}, D_{F4} concentration >40 Kbq m^{-2} in more than 50% of the area.
Hospital discharges Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	A hospital discharge is considered as the formal release of a patient from a hospital after a procedure or course of treatment. Discharges occur when the patient leaves because of finalisation of treatment, signs out against medical advice,transfers to another health care institution or because of death. Discharges refer to in-patients: an in-patient is a patient who is formally admitted to an institution for treatment and/or care and stays for a minimum of one night or more than 24 hours in the hospital or other institution providing in-patient care (descriptions from Eurostat). Yearly observations lack for the following countries: DK: 2010-2013; EE: 2000-2002, 2012 and 2013; LT: 2000, 2012 and 2013; LU: 2012, 2013; LV: 2000-2003 and 2012,2013; NL: 2000,2001 and 2013; PT: 2000-2004 and 2011-2013.
Baseline controls	
Wealth Dataset: Eurostat Time range: 2000-2013 Dimension: percentage points	Year's corresponding GDP per capita measured as Euros per inhabitant in percentage of the European Union average. A value of 100 corresponds to EU's average. Values higher or lower than 100 indicate respectively that the area's GDP per capita is greater of lower than the European average. Data are not available for the year 2009 in all German regions.
Population density Dataset: Eurostat (elaboration) Time range: 2000-2013 Dimension: raw number	Own elaboration from total population data and total area (ha) statistics, both from Eurostat database. The variable is calculated as year's population over area's surface. It expresses the concentration of individuals standardized by the region or State area expansion.
Proportion population aged over 60 Dataset: Eurostat (elaboration) Time range: 2000-2013 Dimension: percentage points	Own elaboration from population aged over sixty and total area's population data, both from Eurostat database. The variables is calculated as the ratio between popoulation aged over sixty and total population.
Additional controls	
Distance Dataset: own elaboration Time range: - Dimension: kilometers	The variable expresses the region's distance from Chernobyl's nuclear power plant in kilometers, calculated from the region's geographical center. Datas have been elaborated through Google Earth software[a].
Longitude Dataset: own elaboration Time range: - Dimension: decimal degrees	The variable expresses associated region's or country's longitude. Areas east of Greenwich take positive longitude values, areas west of Greenwich are associated to negative longitude values. Informations extracted from http://www.distancesfrom.com/
Life expectancy in 1985 Dataset: World Bank Time range: 1985 Dimension: years	Life expectancy at birth in 1985 (pre-Chernobyl's accident) at country level. It indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life (description from World Bank).
Wooded areas Dataset: Eurostat (elaboration) Time range: 2000-2013 Dimension: percentage points	Own elaboration from wooded areas (in hares) and total territory's extension (in hares) variables, both from Eurostat database. The variables is calculated as the ratio between year's hares occupated by wooded areas and the terriotory's corresponding extension in hares. It expresses the percentage of total area extension covered by woods.
Doctors Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	Physicians or doctors available in the year for providing health care services in the area, regardless of the sector of employment (description from Eurostat).
Available beds in hospital Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	Total available beds in hospitals in the area, variable from Eurostat.
Non curative beds Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	Total available beds in hospitals not classified as for curative care, variable from Eurostat.
Health care expenditure by financing agent Dataset: Eurostat Time range: 2003-2013 Dimension: share of GDP	Health care expenditure divided by financing agents. Categories taken from Eurostat division following the International Classification for the Health Accounts (ICHA).
Health care expenditure by function Dataset: Eurostat Time range: 2003-2013 Dimension: expenditure per inhabitant	Health care expenditure divided by function, i.e. the purpose of the expense. Categories taken from Eurostat division following the International Classification for the Health Accounts (ICHA). .

[a]Google Earth (Version 7.1.2.2041) [Software]. Mountain View, CA: Google Inc. (2013). Available from http://www.google.com/earth/

Table S.3 *– Summary Statistics*

Variable	Obs	Mean	Std.Dev.	Min	Max
Hospital discharges for neoplasms (%)	80	1.650	.815	.565	3.677
Controls					
Wealth	80	104.519	42.288	31.143	287.357
Population Density	80	323.701	727.007	25.067	4202.283
Proportion 60+	80	.228	.030	.151	.290

Table S.4 *– First Stage and alternative fallout specifications*

Dependent variable: hospital discharges by neoplasms over 100 inhabitants			
	(1)	(2)	(3)
Fallout specification method:	Any spot	>30% of soil surface	>50% of soil surface
D_{F1}	0.645***	0.766***	0.738***
	(0.127)	(0.098)	(0.110)
D_{F2}	0.950***	1.276***	1.350***
	(0.123)	(0.194)	(0.209)
D_{F3}	1.369***	2.261***	2.134***
	(0.221)	(0.081)	(0.073)
D_{F4}	2.245***		
	(0.086)		
Wealth	0.003***	0.002**	0.003***
	(0.001)	(0.001)	(0.001)
Population density	0.0004***	0.0004***	0.0003***
	(0.000)	(0.000)	(0.000)
Proportion 60+	10.975***	9.916***	10.877***
	(1.875)	(1.817)	(2.113)
Observations	80	80	80
R^2	0.736	0.723	0.683

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). First stage specification methods according to fallout intensity zones. In column 1 areas have been associated to the highest level of fallout present on their surface, regardless of the dimension (baseline). Columns 2 and 3 associate the area to the highest fallout level detected on their surface only if the dimension of the zone is greater or equal to, respectively, 30% and 50%.

Table S.5 – Pairwise correlations, deaths and hospitalizations by neoplasms

Hospital discharges by neoplasms at time:	Deaths by Neoplasms	Obs
t	0.1940***	864
t - 1	0.2016***	784
t - 2	0.2177***	704
t - 3	0.2280***	624
t - 4	0.2389***	544
t - 5	0.2511***	464
t - 6	0.2594***	384
t - 7	0.2665***	305
t - 8	0.2733***	227
t - 9	0.2739*	150
t - 10	0.2733	74

Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The values are the results of the pairwise correlations between deaths by neoplasms and contemporaneous and lagged hospitalizations by neoplasms. Results are obtained using the sample of the baseline analysis. Data cover the time range 2000 - 2010.

Table S.6 – Fallout effect on hospital discharges, including medical presence controls

Dependent variable: hospital discharges by neoplasms	(1)	(2)	(3)	(4)	(5)	(6)	(7)
D_{F1}	0.648***	0.612***	0.245*	0.510***	0.629***	0.228	0.549***
	(0.132)	(0.146)	(0.125)	(0.148)	(0.154)	(0.139)	(0.174)
D_{F2}	0.949***	1.059***	0.565***	0.897***	1.067***	0.569***	0.990***
	(0.129)	(0.135)	(0.119)	(0.127)	(0.137)	(0.170)	(0.143)
D_{F3}	1.371***	1.341***	0.923***	1.336***	1.347***	0.828***	1.298***
	(0.223)	(0.201)	(0.218)	(0.228)	(0.204)	(0.211)	(0.220)
D_{F4}	2.245***	2.084***	1.660***	2.182***	2.080***	1.539***	2.070***
	(0.087)	(0.121)	(0.136)	(0.100)	(0.120)	(0.190)	(0.131)
Wealth	0.003***	0.006***	0.003**	0.004**	0.006***	0.003	0.005**
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Population density	0.0004***	0.0003***	0.0004***	0.0004***	0.0003***	0.0003***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	10.962***	9.778***	6.952***	10.548***	9.652***	5.864***	9.047***
	(1.893)	(2.024)	(1.463)	(1.853)	(2.061)	(1.752)	(2.075)
Discharges by medical obs	-0.085				-0.300	0.547	-0.057
	(0.275)				(0.322)	(0.334)	(0.415)
Doctors		0.231			0.208	1.100	0.579
		(0.896)			(0.903)	(0.817)	(0.946)
Available beds in hospitals			1.520***			1.602***	
			(0.218)			(0.274)	
Non curative beds				0.686			0.631
				(0.477)			(0.551)
Observations	79	74	76	76	74	74	74
R^2	0.736	0.756	0.821	0.755	0.757	0.827	0.764

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2, F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variable expressed in hospital discharges over 100 inhabitants. Discharges by medical observation data are not available for Estonia (EE). Doctors data are not available for Ireland (IE01 and IE02). Analyses represent the same OLS specification adding to the baseline controls separate medical presence variables (columns 1, 2, 3 and 4) and their joint effect (columns 5, 6 and 7). Discharges by medical observation and evaluation for suspected diseases and conditions, number of doctors, available hospital beds and non curative hospital beds are all standardized by 100 inhabitants. Non curative beds are all hopital beds not cathegorized for curative care means.

Table S.7 – Fallout effect on hospital discharges, controlling for health care expenditure by financing agent

Dependent variable: hospital discharges by neoplasms	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D_{F1}	0.649***	1.177***	0.696***	1.188***	0.686***	1.130***	0.745***	0.726***
	(0.132)	(0.145)	(0.125)	(0.148)	(0.126)	(0.138)	(0.133)	(0.125)
D_{F2}	1.050***	1.159***	0.976***	1.163***	0.958***	1.054***	1.154***	1.110***
	(0.129)	(0.136)	(0.141)	(0.138)	(0.132)	(0.157)	(0.159)	(0.162)
D_{F3}	1.367***	1.132***	0.995***	1.131***	0.976***	1.019***	1.429***	1.412***
	(0.208)	(0.093)	(0.097)	(0.093)	(0.090)	(0.133)	(0.211)	(0.225)
D_{F4}	2.183***						2.165***	2.184***
	(0.082)						(0.080)	(0.091)
Wealth	0.002**	0.002	0.003**	0.003	0.003**	0.001	0.003***	0.004***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Population density	0.0004***	0.0003**	0.0004***	0.0003**	0.0004***	0.0003**	0.0004***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	8.658***	10.844***	9.977***	10.665***	10.030***	10.628***	7.968***	9.071***
	(2.045)	(2.043)	(1.900)	(2.037)	(1.937)	(2.059)	(2.015)	(1.958)
All financing agents	0.066*							
	(0.035)							
Private social insurance		-0.759						
		(1.630)						
Private household out-of-pocket expenditure			0.029					
			(0.097)					
Private social insurance/ Total				-11.284				
				(18.253)				
Private household out-of-pocket expenditure/ Total					-0.169			
					(0.788)			
All the rest/ Total						1.271		
						(0.984)		
Private sector							0.221**	
							(0.099)	
Private sector/ Total								1.354
								(1.039)
Observations	78	47	68	47	68	47	77	77
R^2	0.750	0.853	0.711	0.854	0.711	0.854	0.761	0.752

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2, F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variable expressed in hospital discharges over 100 inhabitants. Baseline controls: wealth, population density and proportion of population aged over 60. All health care expenditure variables are expressed as share of total GDP. OLS specification with robust standard errors.

Table S.8 – Fallout effect on hospital discharges, controlling for health care expenditure by function

Dependent variable: hospital discharges by neoplasms	(1)	(2)	(3)	(4)	(5)	(6)
D_{F1}	0.656***	0.636***	0.691***	0.660***	1.060***	0.576***
	(0.138)	(0.138)	(0.124)	(0.131)	(0.148)	(0.101)
D_{F2}	1.035***	1.014***	0.962***	1.030***	1.204***	0.706***
	(0.126)	(0.121)	(0.132)	(0.129)	(0.129)	(0.144)
D_{F3}	1.337***	1.306***	1.260***	1.356***	1.558***	0.689***
	(0.203)	(0.199)	(0.220)	(0.214)	(0.242)	(0.126)
D_{F4}	2.154***	2.110***	2.062***	2.194***	2.467***	
	(0.096)	(0.107)	(0.130)	(0.096)	(0.160)	
Wealth	0.002	0.002	0.004***	0.003	0.003	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Population density	0.0004***	0.0004***	0.0004***	0.0004***	0.0003***	0.0003*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	9.030***	9.210***	9.183***	9.591***	9.027***	5.141***
	(2.028)	(2.026)	(1.914)	(1.946)	(2.240)	(1.733)
Services of curative care	0.000					
	(0.000)					
In-patient curativive care		0.000				
		(0.000)				
Day cases of curative care			-0.001			
			(0.001)			
Out-patient curative care				0.000		
				(0.000)		
Services of curative care					0.004	
					(0.004)	
Prevention of non-communicable diseases						0.019***
						(0.005)
Observations	76	76	76	77	56	67
R^2	0.745	0.747	0.754	0.740	0.823	0.793

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2, F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variable expressed in hospital discharges over 100 inhabitants. Baseline controls: wealth, population density and proportion of population aged over 60. All health care expenditure variables are expressed in per capita terms.OLS specification with robust standard errors.

Table S.9 – Fallout effect on hospital discharges, random effects estimation

Dependent variable: hospital discharges by neoplasms				
Model:	*RE*	*RE*	*RE*	*Hausman-Taylor*
	(1)	(2)	(3)	(4)
D_{F1}	0.989***	0.988***	0.770***	0.708***
	(0.183)	(0.185)	(0.153)	(0.186)
D_{F2}	0.821***	0.820***	0.801***	0.773***
	(0.174)	(0.175)	(0.152)	(0.194)
D_{F3}	1.261***	1.262***	1.278***	1.290***
	(0.242)	(0.244)	(0.229)	(0.269)
D_{F4}	2.130***	2.131***	2.139***	2.098***
	(0.069)	(0.070)	(0.104)	(0.470)
Observations	1089	1089	1021	1021
N. Groups	80	80	80	80
TIME		✓	✓	✓
BASELINE CONTROLS			✓	✓

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variables expressed in hospital discharges over 100 inhabitants. Columns 1, 2 and 3 are obtained by a random effects specification with robust standard errors. Column 4 is obtained by a Hausman-Taylor specification. The time checkmark indicates the inclusion of time dummies in the regression. The baseline controls checkmark indicates the inclusion of the controls in the baseline specification: wealth, population density and proportion of population aged over 60 controls. In columns 3 and 4 wealth data are not available for Germany in 2009.

Table S.10 – Fallout effect on hospital discharges by neoplasms

Dependent variables: hospital discharges by type of neoplasm

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Type	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	In situ	In situ	Benign
Description	colon, rectosigmoid junction and other	trachea, bronchus and lung	skin	breast	uterus	ovary	prostate	bladder	other neoplasms	in situ neoplasms	ncertain or unknown behaviour	colon, rectum, and other
D_{F1}	0.077***	0.077***	0.021***	0.070***	0.022***	0.022***	0.032***	0.018***	0.203***	0.003	0.004	0.068***
	(0.016)	(0.016)	(0.007)	(0.014)	(0.005)	(0.006)	(0.009)	(0.006)	(0.045)	(0.002)	(0.009)	(0.018)
D_{F2}	0.125***	0.104***	0.039***	0.092***	0.029***	0.028***	0.048***	0.032***	0.309***	0.001	0.001	0.102***
	(0.015)	(0.017)	(0.008)	(0.018)	(0.004)	(0.003)	(0.008)	(0.006)	(0.042)	(0.002)	(0.008)	(0.021)
D_{F3}	0.171***	0.147***	0.066***	0.114***	0.040***	0.052***	0.047***	0.043***	0.459***	0.006	0.000	0.185***
	(0.016)	(0.028)	(0.011)	(0.029)	(0.006)	(0.011)	(0.009)	(0.011)	(0.088)	(0.005)	(0.008)	(0.040)
D_{F4}	0.214***	0.204***	0.140***	0.204***	0.071***	0.101***	0.100***	0.033***	0.833***	0.020***	0.013	0.274***
	(0.025)	(0.026)	(0.030)	(0.013)	(0.008)	(0.008)	(0.020)	(0.006)	(0.031)	(0.005)	(0.010)	(0.018)
Wealth	0.000	0.0003***	0.0001*	0.0005***	-0.000	0.000	0.0003***	0.000	0.002***	0.00009**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.00003**	0.00004***	0.00002***	0.00004**	0.00001***	0.00001***	0.000	0.00002***	0.0002***	0.000	-0.000	0.00005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	1.221***	1.027***	0.470***	1.027***	0.130**	0.142**	0.662***	0.477***	3.993***	0.160***	0.127	1.239***
	(0.224)	(0.236)	(0.095)	(0.223)	(0.051)	(0.058)	(0.111)	(0.084)	(0.658)	(0.027)	(0.105)	(0.286)
Observations	79	79	79	79	79	79	79	79	79	79	79	79
R^2	0.670	0.637	0.659	0.629	0.661	0.684	0.583	0.570	0.744	0.510	0.043	0.629

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variables expressed in hospital discharges over 100 inhabitants. Results are obtained by OLS specification with robust standard errors. All hospital discharges data by type of neoplasm are not available for Estonia (EE).

Table S.11 – Simulated fallout, summary of results

Number of significant coefficients	Frequency	Frequency (absolute)
No coefficient significant	40.7%	40.7%
One coefficient	46.7%	
	Positive	19.2%
	Negative	27.5%
Two coefficients	10.6%	
	Both positive	2.7%
	Of which:	
	- Increasing with fallout and consecutive	0.8%
	- Increasing with fallout, not consecutive	1.6%
	Both negative	5.0%
	Opposite signs	2.9%
Three coefficients	2.0%	
	No positive, three negative	0.5%
	One positive, two negative	0.6%
	Two positive, one negative	0.6%
	Three positive, no negative	0.3%
	Of which:	
	- Increasing with fallout and consecutive	0.1%
	- Increasing with fallout, not consecutive	0.2%
Four coefficients	0%	
	All positive	0%
	All negative	0%
	Opposite signs	0%
Total		**100%**

Results from 1000 simulations. A random fallout dummy assignment was performed respecting the proportions of the baseline fallout specification: 31 areas with no fallout, 23 areas belonging to F1 fallout >2 kBq/m^2 and <10 kBq/m^2, 17 areas to F2 fallout >10 kBq/m^2 <40 kBq/m^2, 7 areas to F3 fallout >40 kBq/m^2 , and 2 areas to F4 fallout >40 kBq/m^2 (more than 50%). Simulations made according to the first stage of the two stages least squares baseline specification using wealth, population density and proporion of population aged over sixty. Reported frequencies picture how many times the specific fallout combination was significant.

Table S.12 – Simulated fallout, extended results

Number of coefficients	Sign	Variable	Frequency
No Coefficient			40.7%
One coefficient	Positive	F1	1.6%
		F2	1.6%
		F3	2.9%
		F4	13.1%
	Negative	F1	1.8%
		F2	2.5%
		F3	4.4%
		F4	18.8%
Two coefficients	All positive	F1 + F2	0.4%
		F1 + F3	0.3%
		F1 + F4	0.7%
		F2 + F3	0.1%
		F2 + F4	0.6%
		F3 + F4	0.6%
	All negative	F1 + F2	0.7%
		F1 + F3	0.2%
		F1 + F4	0.7%
		F2 + F3	0.3%
		F2 + F4	1.0%
		F3 + F4	2.1%
	Opposite signs	F1 negative + F3 positive	0.1%
		F1 negative + F4 positive	0.1%
		F1 positive + F3 negative	0.2%
		F1 positive + F4 negative	0.6%
		F2 negative + F4 positive	0.3%
		F2 positive + F3 negative	0.1%
		F2 positive + F4 negative	0.3%
		F3 negative + F4 positive	0.5%
		F3 positive + F4 negative	0.7%
Three coefficients	All positive	F1 + F2 + F3	0.1%
		F1 + F3 + F4	0.1%
		F2 + F3 + F4	0.1%
	All negative	F1 + F2 + F4	0.3%
		F1 + F3 + F4	0.1%
		F2 + F3 + F4	0.1%
	Different signs	F1, F2 negative + F4 positive	0.1%
		F2, F3 negative + F4 positive	0.2%
		F2, F4 negative + F1 positive	0.1%
		F2, F4 negative + F3 positive	0.2%
		F1, F2 positive + F4 negative	0.2%
		F1, F3 positive + F4 negative	0.1%
		F2, F3 positive + F4 negative	0.3%
Four coefficients	All negative		0.0%
	All positive		0.0%
	Different signs		0.0%

Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 and <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 fallout >40 kBq/m^2 (more than 50%). Results from 1000 simulations. Random fallout dummy assignment respecting the proportions of the original fallout area division: 31 areas with no fallout, 23 areas belonging to F1, 17 areas to F2, 7 areas to F3, and 2 areas to F4. Simulations made using the first stage baseline specification of the two-stages least squares model employing wealth, population density and proportion fo populaiton aged over sixty. Reported frequencies picture how many times the dummy combination was significant.

Table S.13 – Hospitalization costs, average cost

Country	(1) Total expense in inpatient curative care	(2) Bed days of inpatients	(3) Daily cost of a hospitalization	(4) Length of stay by neoplams	(5) Average cost of a hospitalization by neoplasms
Unit of measure	*Millions of Euros*	*Days*	*Euros*	*Days*	*Euros*
AT	€ 8466.89	20076674	€ 421.81	7.76	€ 3274.37
CZ	€ 25337.10	22706184	€ 1127.57	10.00	€ 11278.75
DE	€ 63094.33	186476240	€ 338.48	10.03	€ 3393.72
DK	€ -	5001282.5	€ -	6.84	€ -
EE	€ 249.14	1503536.6	€ 146.41	7.91	€ 1158.24
ES	€ 19874.98	30714612	€ 673.83	9.73	€ 6555.64
FR	€ 54641.06	62730084	€ 872.65	7.88	€ 6878.79
IE			€ -	10.82	€ -
LT	€ 921.47	6433731	€ 144.21	9.59	€ 1383.14
LU	€ 533.47	636924.125	€ 826.85	8.98	€ 7420.96
LV	€ 378.97	3602870	€ 104.86	9.00	€ 943.72
NL	€ 16754.10	11232391	€ 1514.77	7.93	€ 12008.00
PT	€ -	6587893.5	€ -	7.82	€ -
Source:	*Eurostat*	*Eurostat*	*Computed*	*Eurostat*	*Computed*

Column 1 presents total expense in inpatient curative care at national level from Eurostat. Column 2 presents total bed days of hospitalizations for inpatients at national level from Eurostat. Column 3 is computed as the annual ratio between Column 1 and Column 2. Column 4 presents the average length of stay of an hospitalization by neoplasm: original data in Eurostat are at Nuts2 level, the table presents only country-level averages. Column 5 presents the average cost of an hospitalization by neoplasm computed as Column 3 multiplied by Column 4, reporting country-level averages only. All figures are to be intended as annual averages for the period 2000-2013.

Chapter 2

Radioactive Decay, Health and Social Capital: Lessons From The Chernobyl Experiment

Radioactive Decay, Health and Social Capital: Lessons From The Chernobyl Experiment[1]

Francesca Marino

University of Padua

Luca Nunziata[2]

University of Padua

IZA

Abstract

We exploit the exogenous variation in health patterns across European regions that resulted from the Chernobyl nuclear disaster to provide new quasi-experimental evidence on the causal effect of health on social capital. Our instrumental variable estimations show that the radioactive fallout is positively associated with an increase in hospital discharges after treatment for neoplasms almost thirty years later. An increased incidence of neoplasms induced by the radioactive fallout generates a sizeable impoverishment of social capital at nearly all levels, including social interactions, altruism and trust toward institutions and the health care system. Our findings suggest that health care and prevention may have higher returns than previously thought since they may also contribute to a significant increase in social capital.

Keywords: Health, Social Capital, Chernobyl, Radioactive Fallout, Neoplasm.
JEL Classification: I13, O15, Z13.

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[2]Corresponding author. Dept. of Economics, University of Padua, Via del Santo 33, 35121, Padua, Italy, e-mail: *luca.nunziata@unipd.it*, phone: ++39 049 8274288.

2.1 Introduction

Since Coleman (1990) and Putnam *et al.* (1993) introduced the concept of social capital, many studies have investigated its relevance over a broad range of topics. Social capital has been shown to generate beneficial spill-overs of economic relevance, with effects on economic growth (Knack and Keefer, 1997; Zak and Knack, 2001; Knack and Zak, 2003) and political and civic involvement (Knack and Keefer, 1997).

The last decade witnessed a surge of contributions on the relationship between social capital and health. In their commentary, Kawachi *et al.* (2004) highlight the enormous attention that the question has attracted in recent years, pointing out that only ten empirical studies on the topic were available at the time of Macinko and Starfield (2001), while more than fifty papers were published in 2002 alone.

The main insights from the literature are the evidence of a negative correlation between social capital and mortality rates (Kawachi *et al.*, 1997; Wilkinson *et al.*, 1998; Kennedy *et al.*, 1998; Veenstra, 2002; Lochner *et al.*, 2003; Skrabski *et al.*, 2003; Kennelly *et al.*, 2003), psychiatric disorders (Veenstra, 2002), suicide rates (Helliwell, 2007), and self-rated health (Lynch *et al.*, 2001; Subramanian *et al.*, 2001, 2002; Wen *et al.*, 2003). However, only a few studies have recognised that the relationship between social capital and health is characterised by reverse causality, so policy implications derived from simple empirical correlations may be misleading. More recent studies have tried to isolate the causal effect of social capital through an instrumental variable approach, using as instruments regional indicators of employment, geographic latitude and government expenses (Folland, 2007), household structure (Sirven and Debrand, 2008), communities' heterogeneity in terms of education, religion and economic status (d'Hombres *et al.*, 2010), and crime victimization and physicians' density (Rocco *et al.*, 2014). To our knowledge, no attempt has been made to investigate the causal link from health patterns to social capital through a natural experiment. The purpose of this paper is to fill this gap through a novel approach based on the experimental nature of the Chernobyl nuclear disaster. Our analysis sheds new light on the presence of reverse causality between social capital and health and contributes to clarify the broader returns of health care policies.

Our identification strategy exploits the natural experiment that resulted from the Chernobyl nuclear disaster in 1986. The explosion of the Chernobyl nuclear reactor released a large amount of radioactive material into the atmosphere. The continuous release of radioactivity over a ten-day period and the accompanying meteorological conditions resulted in a complex dispersion pattern across Europe. As a result, most European regions were exposed to radioactive fallout in a random fashion.

The health consequences of such exposure are still debated in the medical literature, and the accumulation of knowledge about the long-term health effects of the accident continues to advance today, as reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (UNSCEAR, 1998, 2000, 2008).

Using data provided by the Atlas of Caesium Deposition on Europe after the Chernobyl Accident, published by the European Commission, in Marino and Nunziata (2016) we compare the health consequences of radioactivity about thirty years after the accident in several European regions that were characterised by heterogeneous ^{137}Cesium fallout patterns. We find that the regions that experienced more intense radioactive fallout than others are characterised by a higher incidence of neoplasms today. The effect is large, statistically significant, and increasing with the intensity of the fallout; it does not depend on GDP per capita, population density and age patterns. It is also robust to a number of robustness checks, including controlling for the distance from Chernobyl, life expectancy in 1985, the environmental characteristics of the regions, and the characteristics of the health care sector. A set of placebo tests confirms that our findings are unlikely to result from randomness and that the fallout did not have any effect on diseases that are clearly not related to the harmful effect of radioactivity.

Using these results as a first stage in an instrumental variable model of the effects of health on social capital, we find that the three recognized dimensions of social capital– bonding, bridging and linking – are differently affected by a deterioration of health at the regional level. While the bonding component representing the level of trust toward close people does not seem to be affected, our results display a general deterioration in bridging and linking social capital, i.e., respectively, in the relationships between individuals belonging to different socio-demographic groups, and in the trust and respect between individuals and institutionalised forms of authority in society. Among other effects, a deterioration of health in the community induces a reduction in sociability, a tendency toward selfishness and a decrease in happiness.

This paper is innovative in several ways. First, it provides a new identification strategy with which to assess the causal effect of health on social capital. Second, our analysis indicates that the effects of health on social capital may be important. In other words, the implications of a deterioration of health conditions at the regional level may go beyond the direct effects on afflicted individuals to cause a general community-level change in social capital in the affected areas. This is the result of the sum of a direct incapacitation effect on the ill individuals and an indirect effect on healthy individuals who become more short-sighted and less cooperative. Our findings suggest therefore that health care efforts may have higher returns than previously thought since they may also contribute to a significant increase in social capital. Fourth, our analysis implies that previous estimates of the effect of social capital on health may be biased.

The paper is organised as follows: section 2.2 introduces the literature on health and social capital. Section 2.3 presents our research design and discusses how the Chernobyl nuclear disaster can be considered a natural experiment. Section 2.4 presents the data, and section 2.5 presents our empirical findings. Finally, section 2.6 concludes.

2.2 Health and Social Capital

Following the classification in Szreter and Woolcock (2004), we classify social capital into three types. The first is *bonding* social capital, that is, the relationships of trust and cooperation between individuals who share the same socio-demographic identity and operate within the same network. The second is *bridging* social capital, which refers to the relationships between individuals who belong to different socio-demographic groups but still share similar status and power. The third is *linking* social capital, that is, the trust and respect between individuals and explicit, formal, or institutionalised forms of authority in the society. An important attribute of this classification is that it lies between the micro and macro approaches to social capital; it recognises that individuals benefit from social connections, and it highlights the importance of the relationship between state and society, a necessary dimension of a broader definition of social capital (Kawachi *et al.*, 2004). The contextual and collective dimension of social capital is fundamental to fully analyse the mechanisms that underlie the debated relationship between social capital and health.

An additional consideration regards the distinction between structural and cognitive social capital. While structural social capital is a more objective measure of the density and the extent of associational links, activities, and overall social engagement, cognitive social capital regards personal perceptions of support and the sharing of norms and values, trust, and reciprocity inside a community. Many studies have found a positive link between both structural and cognitive social capital and good health (d'Hombres *et al.*, 2010; Engström *et al.*, 2008; Brown *et al.*, 2006).

Veenstra (2005) recalls two ways through which social capital can affect health: compositionally and contextually. The compositional effect is a direct effect since it recognises that individual health can be a product of people's activities and characteristics that affect social capital inside communities and societies. The contextual effect is an indirect effect through which structural components, such as associational density, participation in voluntary organisations, and political participation, affect individual health.

The reverse effect of a change in health patterns on the structural component of social capital is difficult to predict, although one can expect that a deterioration in health may reduce the cognitive individual component of social capital. Pearce and Davey Smith (2003) admit the possible presence of reverse causality, suggesting that poor health could erode individuals' or communities' social capital. Similar conclusions can be found in Kim *et al.* (2006).

There are several underlying mechanisms through which worsening health conditions at the community level could determine a change in social capital in the same community. The first is a direct incapacitation effect due to the increased difficulty that ill individuals experience in interacting with others, including friends and families. The second is an indirect effect on healthy individuals generated by the consequences of a deterioration of health conditions at the community level.

As regards the first channel, it has been demonstrated that people who suffer from poor health and/or mental status are likely to be subject to a stigma (Fife and Wright, 2000; Wilson and Luker, 2006; Gonzalez and Jacobsen, 2012). The presence of social stigma seems to be stronger in some cases. For example, patients who suffer from lung neoplasms are more likely to be stigmatised because they can easily be blamed for their conditions, whether they were smokers or not (Cataldo *et al.*, 2012), and patients who are affected by treatment-induced alopecia have physical signs of illness that are a constant obstacle to everyday social interactions (Rosman, 2004).

The role of stigma is twofold: it changes others' attitudes toward ill people and restrains ill people in their social interactions. Oh *et al.* (2014) highlight how the stress to which cancer patients are exposed causes stressful interpersonal interactions that affect familial relationships, adding more stress. In this context, emotional distress is likely to be categorised as anxiety or depression (Linden *et al.*, 2012). Broad evidence shows that neoplasm patients have a higher average probability of being depressed than other people do (for a review see Massie, 2004). Adding depression to the personal limitations that follow from the disease may result in further deterioration of social contacts with families and friends.

Being exposed to neoplasms and living with the long-time physical consequences of the condition may then discourage patients from interacting socially with other people. Simmons *et al.* (2007) suggests that living for even a short time with the unequivocal signs of an illness may have permanent consequences on people's ability to engage in social relationships. Mulders *et al.* (2008) suggests that, beyond the immediate concern for the actual and future physical consequences of illness, a possible change in the relationships with family and friends is a big issue for ill people. In all such cases, patients are likely to be characterized by fewer social relationships (Vironen *et al.*, 2006; Sirven and Debrand, 2008) and greater social isolation (Subramanian *et al.*, 2002; Guiso *et al.*, 2007).

In addition to this direct channel through which poor health affects social capital at the individual level, an increase in the incidence of health conditions may indirectly affect social capital at the community level in various ways. First, the exposure to higher risks of contracting potentially deadly diseases may shorten the time horizon of inter-temporal choices of healthy individuals who may then adopt more short-term oriented strategies, resulting in a general decrease in cooperation (Dal Bó, 2005; Cervellati *et al.*, 2014). Secondly, a peer network that is affected by an episode of serious illness may acquire a more pessimistic reading of the human condition and of life and social interactions in general. Mosher and Danoff-Burg (2007) recognise that people who are affected by neoplasms represent clear proof of physical vulnerability, so they may contribute to increase death anxiety among their peers. Hirschberger *et al.* (2005) confirm that the anxiety about death that underlies the interaction with someone with health problems is a powerful emotional factor that may in turn negatively affect individuals' behaviour. On the other hand, some contributions suggest that social capital may increase as an optimal response to social adversities, like in the case of wars (Blattman, 2009; Bellows and Miguel, 2009; Voors *et al.*, 2012).

Our aim is to investigate whether the three different dimensions of social capital – bonding, bridging and linking – that are only weakly inter-related (Poortinga, 2012), react differently to a general corrosion of health inside a community.[3]

The forces at play at the individual level suggest a tendency toward social isolation and a decrease in

[3] Poortinga (2012) shows that despite showing low levels of inter-connection, bonding, bridging, and linking social capital are all positively associated with good community health outcomes, even after controlling for neighbourhood deprivation.

cooperation when health deteriorates at the community level. Ill individuals have limitations in interacting with others because of the perceived social stigma and/or the lack of acceptance of the change in their condition. Healthy individuals are more short-sighted and less cooperative and display a more negative attitude toward life and social interactions after an episode of illness among their peers and/or when they perceive an higher risk of contracting a malignant disease. The net effect on social capital may be determined by the combination of all these factors, and may therefore be larger than the simple incapacitation effect resulting from those individuals directly affected by the disease.

We use the Chernobyl nuclear disaster as an identification device to provide new empirical evidence on the effects of changes in health conditions on social capital at the regional level.

2.3 Research Design: The Chernobyl Nuclear Disaster as a Natural Experiment

2.3.1 The Disaster and the Random Dispersion of the Fallout

The notorious accident at the Chernobyl nuclear power plant happened on 26 April, 1986, during the scheduled shutdown of one of the plant's least powerful reactors. Besides the immediate release of radioactive materials in the proximity of the plant, the disaster resulted in a diffused release of nuclear particles over vast territories for several days (UNSCEAR, 2000).

Various factors contributed to the disposition of radionuclides in the soil, and their joint effect leads us to conclude that this phenomenon may have the characteristics of a natural experiment. Four main mechanisms determined the conditions of the fallout: the release of radioactive materials over a ten-day period; the height dispersion of radionuclides inside the plume, depending on their form and weight; winds blowing in different directions on different days interacting with plume heights (UNSCEAR, 1998), as displayed in Figure 2.1; and the plume's exposure (or not) to rain during its passage over each territory (IAEA, 2006).

FIGURE 2.1 AROUND HERE

The significant differences in disposition of radionuclides in European soil is explained by the presence or absence of precipitation during the passage of the cloud. The composition of the cloud, depending on the chemical forms of the radionuclides and the distance from the explosion, also affected how those elements were deposited on the ground.

When deposition was not caused by rainfall, the radioactivity levels were lower but composed of more radio-iodine isotopes. In the areas where disposition was caused by rain, the fallout composition was similar to that of the originating radioactive cloud (IAEA, 2006). The result was a fragmented deposition of radionuclides over the European soil, as depicted in Figure 2.2, which shows the different concentrations of ^{137}Cs over Europe.

The map in Figure 2.2 is the result of surveys undertaken in May 1986, immediately after the accident, by dose rate meters and airborne gamma spectrometers in order to measure the soil deposition of ^{137}Cs in several European and Asian countries. Of the radionuclides dispersed by the fallout, ^{137}Cs was comparatively easy to measure and of radiological significance (IAEA, 2006), especially considering its long radiological half-life.

A ^{137}Cs soil deposition greater or equal to 37 kBq m^{-2} qualifies the area as officially contamined according to UNSCEAR (2000).[4] Figure 2.2 shows that Belarus, Russia, and Ukraine were the most severely impacted countries; according to the data in European Commission (1998), they received 30 percent, 23 percent, and 18 percent of the estimated ^{137}Cs deposition from the nuclear accident, respectively. However, many other European countries, including Finland, Sweden, Romania, Germany, and Austria, experienced high levels of ^{137}Cs concentration.

The health consequences of the Chernobyl accident have been widely discussed in the medical literature, and the accumulation of knowledge about the long-term health effects of the accident is an ongoing process (UNSCEAR, 1998, 2000, 2008). Many studies have concentrated on the health implications for the populations that lived close to the site of the accident in Belarus, Russia, and Ukraine (Bogdanova *et al.*, 2006; Brown, 2011; Cardis and Hatch, 2011), although more recent studies have discussed how the Chernobyl radioactive fallout effects on various types of solid cancers may manifest over the longer term, with important health consequences also in countries that were not immediately adjacent to the disaster area.

Cardis *et al.* (2006) estimate an increase in neoplasms in Europe that may be attributable to radiation exposure after Chernobyl, although the predicted increase is very small at the time of the study and subject to substantial uncertainty, especially considering the limited knowledge of the dose-response relationship when the doses of radiation are very low, like in most European countries after Chernobyl. The assumption behind these predictions are that radiations can affect individuals' health even at very low doses through continuous absorption from radionuclides deposited in the soil and ingestion of contaminated foods. The authors emphasize that, because of long latency periods, we may observe an increase in all cancer cases long after the disaster, with only 14 percent of the total excess cases predicted to 2065 occurring in the first 20 years after the disaster.

Tondel *et al.* (2004, 2006) find evidence in favour of an increase in the incidence of neoplasms in Sweden based on the recorded ^{137}Cs fallout intensity. Using data up to 1996 and comparing eight Swedish counties, some severely impacted by the fallout and some not, Tondel *et al.* (2004) find an excess relative risk of total neoplasm incidence of 0.11 per 100 kBq/m^2. Tondel *et al.* (2006) expands the study to 1999 and confirms

[4]This level corresponded to a yearly radioactivity absorption of 1 mSv during the first year after the accident, that is, the yearly limit of radioactivity absorption prescribed in the US and Canada, and about ten times the deposition from global fallout. The Becquerel (Bq) is one of the units used to measure radioactivity, with 1 Bq corresponding to the radiation emitted by one atomic disintegration per second. The Sievert (Sv) measures the equivalent dose of radiation expressed in energy (Joule) over mass (kg).

the correlation between the total incidence rate of neoplasms and the amount of radioactive fallout. Both studies account for possible confounding effects, such as age, population density, and some proxies for overall incidence of neoplasms.

Marino and Nunziata (2016) show that the radioactive fallout from the Chernobyl accident is positively associated with the neoplasm-related hospitalization rate, with larger effects in regions where the radioactivity was more intense. This association does not depend on the characteristics of the regions in the sample, such as GDP per capita, population age and density, the amount of wooded areas in the region, the distance from the epicentre of the nuclear disaster, life expectancy before the explosion, the diffusion of doctors and hospitals in the area, or health-care policies at the national level. In addition, it is not driven by any specific country in the sample or by unobserved regional characteristics modelled using random effects. Our placebo regressions show that our findings are unlikely to be determined by chance, and we do not detect any effect on the incidence of other health conditions that are clearly not related to the harmful effect of exposure to radioactivity

The exposure to the nuclear accident and to the consequent fallout has been exploited by other authors to assess its effect on various outcomes.

Danzer and Danzer (2011) analyze Ukranian data and estimate the effect of being exposed to the nuclear disaster on life satisfaction, finding that individuals more exposed to the accident are more likely to show higher depression and trauma rates twenty years later. The study by Lehmann and Wadsworth (2011) shows that Ukranians living in the areas that received the highest levels of radiation have a worse perception of their health status, and they are more likely to have worse labour market outcomes.

For what concerns western European countries, Almond *et al.* (2009) show that prenatal exposure to radioactive fallout by children born in Sweden in 1986 may have impaired their cognitive abilities later in life.[5] Along similar lines, Halla and Zweimüller (2014) examine how parents responded to a human capital shock from exposure to the Chernobyl fallout in Austria.

Summarising all of these findings, we conclude that a body of evidence is emerging from the ongoing debate on the health consequences of the Chernobyl nuclear disaster that suggests significant increases in neoplasms and secondary effects not only in Belarus, Russia, and Ukraine, but also in other European countries that were reached by the radioactive plume.

2.3.2 The Instrumental Variable Model

Based on the evidence provided by Marino and Nunziata (2016), our research design exploits the exogenous variability in general health that resulted from the random dispersion across European regions of radioactive

[5]Similar findings are detected by Black *et al.* (2013) using variation in radioactive exposure throughout Norway resulting from the abundance of nuclear weapon testing in the 1950s and early 1960s.

fallout after the Chernobyl explosion. We adopt an instrumental variable approach in order to estimate the causal effect of health on social capital across those regions.

Our identification strategy is based on the randomly distributed fallout in 1986 as an instrument for health status across European regions thirty years later. The exclusion restrictions at the basis of our identification strategy, i.e. no effect of the cross sectional variation in the fallout on social capital rather than through health, are confirmed by the literature. Most European citizens did not engage in any particular protective action after the disaster and, if present, the countermeasures were only temporary, resulting in an homogeneous long-term behavioural response of the affected and non-affected areas (Peters *et al.*, 1990; Renn, 1990; Tønnessen *et al.*, 2002; Berger, 2010).

In addition, the information on the actual variability in the fallout deposition across European regions was scarce among the public. The first official publication displaying actual maps on the fallout deposition across Europe was published by the European Commission in 1998 (European Commission, 1998), i.e. long after the disaster, and it was meant for an audience of experts. No extensive media coverage followed the publication of the report and the public awareness of the consequences of the Chernobyl nuclear disaster can be safely considered limited in the 2000s. Data from the Eurobarometer[6] collected in 2009 seem to confirm this is the case. When estimating the effect of the fallout on a set of indicators of public awareness of the risks and concerns associated to nuclear power across the European regions in our sample, we could not detect any clear pattern of association between the radioactive fallout soil deposition and individuals' beliefs and attitude toward nuclear power. This seems to exclude any direct effect of the fallout on social capital, confirming the validity of our exclusions restrictions.[7]

Our data on the concentration of ^{137}Cs on European soil is gathered from the information provided by the Atlas of Caesium Deposition on Europe after the Chernobyl Accident, published by the European Commission and depicted in Figure 2.2. From this data and using the thresholds indicated in the map, we construct a set of dummy variables that indicate the intensity of the fallout for each European region.

Table 2.1 displays the definition of our set of fallout dummies. The first dummy (D_{F1}) indicates fallout deposition of 2-10 kBq/m^2, the second dummy (D_{F2}) is 10-40 kBq/m^2, and the third (D_{F3}) is greater than 40 kBq/m^2. However, some areas have only spotty ^{137}Cs concentrations greater than 40 kBq/m^2, while other areas have been widely affected. For this reason we use a fourth dummy, (D_{F4}), to distinguish the regions that recorded a ^{137}Caesium soil deposition greater than 40 kBq/m^2 in more than 50 percent of their territories.

Our sample consists of those European regions for which homogeneous information on the incidence of neoplasms is available from Eurostat (see section 2.4 below).

[6]Eurobarometer 72.2, September-October 2009

[7]More details on these estimates can be found in the Appendix.

Our estimated model is equal to:

$$SocialCapital_j = \beta_0 + \beta_1 Health_j + \beta_2 X_j + \nu_j \tag{2.1}$$

where X_j is a vector of controls for each region j, including GDP per capita, population density, and the proportion of residents aged over sixty, in our baseline specification. In our instrumental variable setting, $Health$ is instrumented using the set of dummies that correspond to the different intensity levels of the Chernobyl fallout, so the first-stage estimation is:

$$Health_j = \alpha_0 + \alpha_1 D_{F1j} + \alpha_2 D_{F2j} + \alpha_3 D_{F3j} + \alpha_4 D_{F4j} + \alpha_5 X_j + \varepsilon_i$$

2.4 The Data

In addition to the data on the radioactive fallout in Europe, our analysis is based on regional-level health data from Eurostat and on individual-level social capital and trust data from the European Social Survey (ESS).

We have information on the total number of hospital discharges after treatment of neoplasms and deaths from neoplasms in a large number of European regions characterized by a certain degree of homogeneity in cancer-related treatment and diagnosis practices. We also observe regional GDP per capita, population density, and the proportion of residents aged over sixty, all of which can affect health in general and neoplasms in particular at the regional level.

Other available controls include the regions' distance from Chernobyl, longitude, life expectancy measured at the national level before the nuclear disaster in 1985, the extent of wooded areas in the region, the tendency toward hospitalization, the number of physicians or doctors, the number of beds in hospitals at the regional level, and health care expenditure by financing agent and by function at the national level.

The ESS, a biennial multi-country survey that has been administered in more than thirty countries to date, focuses especially on attitudes, beliefs, and behaviour. Our analysis considers the implications of health on a set of social capital-related outcomes, including trust in other people, social networks, trust toward the health care system and other institutions, and more general personal values.

Our health and economic measures at the regional level are available for the period between 2000 and 2014. Regional data are aggregated at the NUTS[8] 2 level whenever possible. The regional data consist of standardised averages across the period in order to eliminate short-term nuisances in the data.[9] We performed our second-stage estimates using both NUTS2 regional-level aggregated data and clustered individual-level data collected from the first seven waves of the ESS, that is, covering the period 2002-2014. Our baseline

[8]Nomenclature of Units for Territorial Statistics.

[9]A more detailed description of the geographical level of aggregation is provided in the Appendix.

estimates allow for a lag between our health measures and social capital outcomes. (We estimate other specifications using contemporaneous data only, with no appreciable change in our findings.) A detailed list of data sources and definitions is provided in Table 2.7.3 in the Appendix.

Sample of Countries Once the Eurostat and the ESS data are matched, we have information on thirteen European countries – Austria, the Czech Republic, Germany, Spain, Portugal, France, Estonia, Denmark, Netherlands, Ireland, Latvia, Lithuania, and Luxemburg – for a total of eighty regions. The pool of regions is a balanced mix of areas with varying degrees of fallout intensity. The regional Eurostat health data is provided at the NUTS 2 level for Austria, the Czech Republic, Germany, Spain,[10] Ireland and France, while data is available at the NUTS 1 level for the remaining countries.[11]

Health Our measure of health is objective, rather than self-reported, as has been the case in most of the previous literature on the topic, and it is aggregated at the regional level. This approach has three major advantages. First, we are free from the complications attached to self-reported health measures. For example, even though there is a clear association between self-rated health and mortality, Bailis *et al.* (2003) note that self-rated health may be regulated by factors other than the individual's actual health status, including individual efforts to achieve health-related goals. More importantly, Huisman and Deeg (2010) argue that self-rated health should be interpreted as an indicator of people's health perceptions, rather than as a measure of true health, since the process of self-assessment may be illogically influenced by external and internal factors. Second, by adopting an aggregate measure of health at the regional level, we can provide a comparatively precise match between the fallout and health outcomes that would be difficult to achieve using individual level data. Indeed, not all of the inhabitants in the regions were exposed to the fallout in the same way. However, these differences are likely to cancel out when we consider regional averages. Third, by matching health patterns at the regional level with social capital outcomes at the regional or individual level, we can estimate the general equilibrium impact of health on social capital outcomes, including possible spill-over effects that are more difficult to capture when dealing with individual-level health data.

Our objective health measure at the regional level is the number of hospital discharges after treatment for neoplasms, as neoplasms are the most frequent form of illness associated with exposure to radioactivity (section 2.3.1). This dimension captures a crude measure of neoplasm incidence in the region since it includes the number of hospital discharges after a minimum of one night (or more than 24 hours) in the hospital for treatment of neoplasms. It follows that only those who do not require specific hospital treatment or those who

[10] The data for Spain does not include data from ES63 (Ceuta) or ES64 (Melilla).

[11] Some of the NUTS 1 countries' geographical area and population are close or even match the areas and population intervals usually associated with NUTS 2. According to the NUTS classification, the NUTS 1 level identifies macro-regions with populations of 3-7 million, and the NUTS 2 level identifies regions with populations of .8-3 million. Estonia (population of 1.3 million), Latvia (population of 2 million), and Lithuania (population of 3 million), fit within the NUTS 2 thresholds. Luxembourg (population of .53 million) is below the threshold, and Denmark (5.6 million), the Netherlands (16.8 million) and Portugal (10.5 million) are above the threshold.

are affected by the illness but who have not been diagnosed are excluded.[12] The variable is standardised as percentage of the resident population and averaged over the period 2000-2013 in order to eliminate short-term nuisance.

Fallout and Additional Controls The geographical representation of the dummies created from the data on the radioactive fallout's dispersion presented in section 2.3.2 is displayed in Figure 2.3. Our regressions include a number of controls for confounding factors that may affect the health status of the regions' inhabitants. These controls include the relative wealth of the region, measured as the nominal regional GDP per capita as a percentage of the EU average, such that a value of 100 means that GDP per capita in the region is equal to the EU average. We also control for population density measured as the ratio of total population per hectare, and for age patterns, measured as the proportion of total population aged over sixty.

Other controls used for robustness include the regions' distance from Chernobyl, longitude, life expectancy measured at the national level before the nuclear disaster in 1985, proportion of wooded areas in the region, the tendency toward hospitalization, the number of physicians or doctors, and the number of beds in hospitals at the regional level.[13]

Social Capital We classify our set of social capital outcomes along the three main dimensions of social capital introduced above: bonding social capital, bridging social capital, and linking social capital. The dimensions covered by ESS data regard primarily cognitive measures of social capital, rather than structural measures. From the ESS questionnaire we selected all variables that could be linked to any of the three dimensions of social capital and then we performed a confirmatory factor analysis to see if they could be summed to a final social capital score. The variables that proved not to map together to explain the same underlying dimension are still presented in our results, however they were not used to obtain the score of interest.

Bonding social capital is represented by five variables, the first three account for personal trust toward other people and the perceived levels of fairness and helpfulness, while the others measure social activity with other members of the same social network.

Along with these variable, we check the effect of health on happiness, as happiness may be associated with social activity. Subramanian *et al.* (2005) investigates the link between self-assessed health and happiness, stating that individuals who are unhealthy are likely to be unhappy too, with the correlation holding strong at the community level. Sabatini (2011) investigates the causal relationship between happiness and health,

[12]By construction, the variable captures each hospitalization, even if it refers to a single patient's being hospitalized more than once. In other words, it is a measure that gives more weight to serious forms of neoplasms that require more times in the hospital. In Marino and Nunziata (2016) we show that the evidence on the hospitalization rate is not affected by the characteristics of the healthcare system at the regional and national levels.

[13]In Marino and Nunziata (2016) we also include controls for the health care expenditure structure by financing agent and by function at the national level.

recognising the existence of reverse causality. Our model sheds light on whether a causal channel from health to happiness exists or whether only the reverse is true.

According to Szreter and Woolcock (2004)'s definition, bridging social capital includes all relationships of respect and mutuality between people outside one's personal network. We measure bridging social capital as individuals' general predisposition toward others. The ESS survey asked respondents to state the importance of several values in life; we selected those ones that are most relevant to our purpose: being rich, having equal opportunities in life, the importance of understanding different people, helping people and care for others' well being, and spending free time helping others. All of these variables are available for all ESS waves except for the last one which is provided by a special module of the second wave only. We also test the effect of health on political orientation – that is, left versus right – which should be related to the set of values at the basis of the individual's social capital.

We measured linking social capital as the level of trust toward all possible institutions that were presented in the questionnaire: national parliament, legal system, police, politicians, political parties, the European Parliament and the United Nations.

Finally, we estimate the effect of changes in health patterns at the regional level on trust in the healthcare system, which is the one institution that is directly connected with our explanatory variable. As Gilson(2003,2005) points out, healthcare systems are an essential part of any society, and their role is not limited to the provision of health care. Mechanic and Meyer (2000) highlight an important feature of the patient-doctor relationship: patients tend to evaluate their doctors continually with respect to their expectations, so trust toward doctors can be seen as an iterative process. According to Mechanic and Meyer, patients consider doctors as their agents and expect them to act in their best interest. Calnan and Sanford (2004) provide an empirical measure of the determinants of trust toward the healthcare system and confirm that micro-level determinants like the direct relationship between patients and doctors are the most important factors in explaining the general level of trust and confidence toward the healthcare system.

We seek to understand how an increase in neoplasm-related hospitalizations at the regional level may affect trust toward healthcare providers and the healthcare system. These regressions may also be considered a set of control estimations since we may expect the effect of changes in health patterns on health-related outcomes to be significant, although the direction of the effect is hard to predict.

The ESS questionnaire asked respondents whether they thought doctors and nurses treated everyone equally or gave special advantages to some. The questionnaire measures the general attitude toward healthcare institutions by a series of questions regarding the level of public health in the country, the likeliness that one will not be cured if one becomes ill, the current state of the health service, the efficiency of healthcare provision, and whether it is the government's responsibility to ensure adequate healthcare for ill individuals. All but one of these questions were asked in a special module of the fourth ESS wave only; the question on the state of the health care system was asked in all waves.

The exact questions asked in the survey are listed in Table 2.2. In all cases, we rescaled the variables so that lower values correspond to lower levels of social capital. In order to eliminate any effect of extreme responses, we generated a set of dummies from each original variable. In our baseline estimations, the data are aggregated at the regional level over the time span of our analysis. The thresholds we used to construct the dummy variables can be found in Table 2.2.

After selecting all ESS variables that could be linked to social capital, we divided them in four groups, corresponding to each dimension of social capital we aim to investigate: bonding, bridging and linking, where the latter can be classified as related, in turn, to general institutions and the health care system. We performed a confirmatory factor analysis for the variables in each group to check if and how they map together in the same underlying factor constituting our summary measure for each social capital dimension. This process brought to the exclusion of some variables that were not used to obtain the final score associated to each dimension. However, we present separate results for each social capital variable in the estimation tables.

Table 2.3 present the summary statistics for all of the aggregated variables used in the analysis. The factor analysis behind the construction of the four social capital scores is detailed in Table 2.7.4.

2.5 Empirical Findings

2.5.1 First Stage

Table 2.4 reports the estimated first-stage regression. Our baseline first stage (column 1) shows that the regions where the ^{137}Cs soil concentration was 2-10 Kbq m^{-2} saw an increase in hospital discharges after treatment for neoplasms of around 0.6 percentage points compared to regions with no fallout. The effect associated with a ^{137}Cs soil concentration of 10-40 Kbq m^{-2} is around 0.9 percentage points.

The areas most affected by the fallout, those captured by the dummies D_{F3} and D_{F4}, experience much higher levels of hospital discharges after treatment for neoplasms, with point estimates around 1.4 and 2.2 percentage points, respectively. These coefficients do not necessarily measure the increase in the incidence of neoplasms among resident populations in absolute terms since they refer to hospital discharges, and one patient may be associated with more than one hospitalization during the course of the disease. However, the effect seems large considering that hospital discharges after treatment for neoplasms on average are equal to around 1.7 percent of the resident population, as indicated in the summary statistics in Table 2.3.

Our estimated effects are close to the crude neoplasm-incidence ratios estimated by Tondel *et al.* (2004, 2006) on Swedish data, although the findings should be compared with care, given the different methodologies adopted, the different outcome measures used, and the different time spans of the analysis. We evaluate the incidence of neoplasms almost ten years later than Tondel *et al.* do. Moreover, while Tondel *et al.* use the number of cases of neoplasms as an outcome, we use a hospitalization measure. When the incidence of neoplasms increase, hospital discharges may increase more than proportionally because of the possibility that patients have multiple spells in hospitals.

We find no robust effect of the fallout on the number of deaths that are due to neoplasms (not reported). This result may indicate either that the radioactive fallout caused an increase in neoplasms of minor severity or that it is too soon to record such an effect. As noted by Cardis *et al.* (2006), for many types of neoplasms death may occur a long period after the first diagnosis, especially given the improvements in diagnosis and treatment.

In Marino and Nunziata (2016) we provide an extensive discussion on the robustness of these first stage estimates, showing how the results are robust to the inclusion of additional controls, such as a measure of regional distance from Chernobyl, longitude, life expectancy measured at the national level before the nuclear disaster in 1985, and a measure of anthropization, i.e. the proportion of wooded areas (Table 2.4). In addition, the estimates are not driven by an heterogeneous tendency toward hospitalization in general or a more diffused presence of hospitals in the region, or by differences in the internal allocation of health care expenditure at the national level. The findings are also robust to the exclusion of any country or specific group of countries in the sample. The areas that received the highest levels of contamination are located in Austria and Czech Republic, while the least contaminated ones are in Portugal and Spain. When repeating the analysis excluding "extreme" countries, i.e. Austria and Czech Republic, Spain and Portugal and lastly excluding all the four countries together, Austria, Czech Republic, Portugal and Spain, the results still hold, with a positive and increasing pattern of neoplasm incidence with the fallout intensity. The first stage results still hold in a random effects specification that exploits the panel nature of the data, controlling for time and regional unobserved characteristics and including the baseline set of controls introduced in the current setting.

The effect of the fallout is not significant when the dependent variable consists of measures of other causes of hospitalization that are clearly not related to the harmful effect of radioactivity, such as tuberculosis, alcoholic liver diseases, pregnancy and child birth, and poisoning (Table 2.5). Moreover, the effect of the fallout is positive and significant for any type of malignant neoplasm, although the intensity varies according to the type (Table 2.7.5).

Our set of first-stage findings are unlikely to have been determined by chance: we performed a placebo test where our fallout dummies are substituted with a set of randomly assigned placebo dummies that respect the proportions of the fallout intensity areas in the baseline fallout specification.[14] We simulate 1000 random fallout dispositions and in not even one case are all dummies' coefficients positive, statistically significant, and increasing with the intensity of the fallout like in our findings.

[14] Detailed results can be found in Marino and Nunziata (2016)

2.5.2 Second Stage

Our second-stage estimates are presented in Tables 2.6 and 2.7. Table 2.6 displays the effect of a change in health patterns at the community level on the constructed scores for each social capital dimension. An exogenous worsening of health conditions at the regional level is associated with a decrease in bridging and linking social capital components, where the linking component is considered in relation to, respectively, institutions and the health care sector. Bonding social capital is instead unaffected. An increase in hospital discharges equal to 1 percentage point is estimated to cause a reduction of 2.4 percentage points in bridging social capital, of 4 percentage point in social capital linking to institutions and a reduction of 14 percentage points in social capital linking to the healthcare system.

Table 2.7 presents the same estimates using as outcomes the selected components of the scores used in Table 2.6, and on the variables excluded through the factor analysis detailed in Table 2.7.4. Even though excluded variables have proved not to be explicative for the social capital scores, interpreting such results can still be informative for our analysis.

The general score for bonding social capital indicates a non significant effect of health on this dimension, even if we estimate a significant increase in perceived helpfulness equal to 3.2 percentage points following an increase of hospital discharges by 1 percentage point. Social meetings and social activities are both negatively affected. An increase in hospital discharges equal to 1 percentage point, i.e. the amount associated with fallout of intermediate intensity and representing a significant increase of 77% with respect to the average hospitalization rate for neoplasms in no fallout areas,[15] is estimated to cause a reduction in the frequency of social meetings (several times a month or more) of 5.7 percentage points, a reduction in social activities (same level of social activity as people of same age, or more) of 4.8 percentage points, and a reduction in happiness of 3.6 percentage points. These large effects are the result of a sizeable increase in hospitalizations due to the fallout, and are unlikely to be generated by the incapacitation effect of ill individuals alone, therefore confirming the presence of indirect effects through healthy individuals as suggested by the literature.

We measured the bridging component of social capital through several variables measuring individuals' general attitude toward others. The estimation results on the overall score and the single dimensions highlight a general decrease in bridging social capital following a worsening in health conditions at the regional level. An increase in hospital discharges by neoplasms of 1 percentage point causes a reduction in people's taste for equality of 3.5 percentage points, and in the importance of understanding different people of 2.5 percentage points. The results on the variables excluded from the overall score go in the same direction. We observe a large increase in the incidence of individuals who think that being rich is important (a 11 percentage point increase caused by a unitary increase in hospitalization), and a reduction of people thinking it is important to spend some time to help other of almost 2 percentage points. In addition, the political leaning within the region shifts significantly to the right.

[15] The average hospitalization rates for neoplasms in the sample are around 1% in no fallout areas, 2% in F1 and F2 areas, 2.28% in F3 areas and 3% in F4 areas.

As for the "vertical" trust toward institutions, the linking type of social capital, we find that a decrease in health results in less trust toward most political institutions, sometimes with large effects.

Finally, the effect of increased hospitalizations on trust toward the healthcare sector is negative, significant, and large. More respondents fear that it is more likely that they will not be cured if they become ill (a 25 percentage points effect corresponding to a unitary change in hospitalization), doctors are more likely to be judged as not treating everyone equally (a 12 percentage points effect), more people perceive the state of the country's health services as bad (by 6 percentage points), and the whole system is considered to be less efficient (by 9 percentage points). Again, the excluded variables show a similar path: expectations about the level of public health are lower (by 10 percentage points) and fewer people believe the government should be responsible for healthcare (by 3 percentage points).

Our findings are robust to a number of robustness checks. Almost identical estimates are produced when we estimate our model using individual-level data from the same regions, with clustered standard errors, ending up with 39,050 observations and controlling for individual-level controls like gender, age, education, and whether the respondent feels socially discriminated.[16] Similarly, our estimates are basically unchanged when we calculate our regional averages using data collected between 2002 and 2012 only, i.e. when Eurostat and ESS data overlap.

Furthermore, we perform a series of tests in order to check whether our IV estimations suffer from weak instruments. The F-statistics of excluded instruments in our baseline first stage estimation is equal to 197.78, i.e. relatively safe as regards weak instruments (Bound *et al.*, 1995).

We also performed the tests suggested by Stock and Yogo (2005) for weak instruments. The minimum eigenvalue of our first stage, equal to 29.10, lead us to reject the null of weak instrument both for the relative bias test (5% threshold equal to 16.85) and for the size distortion of the 5% Wald test (10% threshold equal to 24.58). Lastly, we do not obtain any difference in our results repeating the same baseline analysis using Limited Information Maximum Likelihood estimators instead of the two-stages least squares estimates presented so far (see Table 2.7.6 in the appendix).

In summary, our results show a clear negative causal effect from bad health to social capital: a higher number of hospital discharges after treatment for neoplasms in the region impoverishes social capital at the bridging and linking levels, and while the bonding level is unaffected, there is a sizeble reduction in sociability and a general decrease in happiness levels.

[16] Not reported, available upon request.

2.6 Conclusions

This study exploits the exogenous variation in health patterns across European regions that resulted from the Chernobyl nuclear disaster to provide new quasi-experimental evidence on the implications of health on social capital. The radioactive fallout pattern from Chernobyl was the product of many combined atmospheric factors. The composition of winds at different heights blowing in various directions right after the explosion and in the following days led to a heterogeneous diffusion of the nuclear cloud over Europe. The resulting deposition of the radionuclides from the cloud into the soil depended on the plume's composition and the changing meteorological conditions in terms of wind and precipitation.

Our research design exploits the random nature of the disposition of ^{137}Cesium in the soil in Europe. We adopt an instrumental variable approach, where health at the regional level, measured by the number of hospital discharges after treatment for neoplasms, is instrumented using the intensity of the radioactive fallout in each region.

In the second stage of our IV regressions, we estimate the effect of health on the three dimension of social capital: trust and cooperative relationships between members of the same network who perceive each other as similar (bonding social capital), between individuals who do not consider each other similar but who lie on the same level of status and power (bridging social capital), and vertical trust and respect relationships toward explicit, formal or institutionalised forms of authority in the society (linking social capital).

The first stage estimates indicate that the random dispersion of the radioactive fallout from the Chernobyl accident increased the neoplasm-related hospitalization rate with larger effects in regions where the radioactivity was more intense. The robustness of these findings are extensively discussed in Marino and Nunziata (2016) where it is shown that they does not depend on the characteristics of the regions in our sample, such as GDP per capita, population age and density, the amount of wooded areas in the region, the distance from the epicentre of the nuclear disaster, life expectancy before the explosion, or the diffusion of doctors and hospitals in the area.

Our second-stage estimates show that there is an important causal channel from health to social capital. More specifically, a higher number of hospital discharges after treatment for neoplasms in the region impoverishes social capital at the bridging and linking levels, and causes a general decrease in sociability and happiness. We observe lower levels of altruism, happiness, and general trust toward institutions and the healthcare system. In addition, poor community health means individuals are more likely to be selfish and conservative.

The effects are sizeable. An increase in hospital discharges equal to 1 percentage point, i.e. the amount associated with fallout of intermediate intensity and representing a significant increase of 77% with respect to the average hospitalization rate for neoplasms in no fallout areas, is estimated to cause a reduction in the frequency of social meetings (several times a month or more) of 5.7 percentage points, a reduction in social activities (same level of social activity as people of same age, or more) of 4.8 percentage points, and a general tendency toward selfishness.

These findings are unlikely to be generated by the incapacitation effect of ill individuals alone, therefore confirming the presence of indirect effects through healthy individuals as suggested by the literature. They can be interpreted as being the summation of a direct effect of illness on the capacity to engage in social relationships and the result of an indirect effect of how a community respond to illness. On the one hand, ill individuals are limited in their capacity to interact with others, while healthy individuals may have difficulties in dealing with ill people because of contrasting feelings about the illness and the ill. On the other hand, when individuals experience a general deterioration in health in their community or peer networks and therefore perceive higher risks of contracting a malignant disease or experience death anxiety, they may become more short-sighted and less cooperative and adopt a more negative attitude toward life and social interactions in general.

The effects at the community level are coherent with Putnam's theories (Putnam *et al.*, 1993; Putnam, 1995). A reduction in social meetings and social activities erodes the extent and power of social networks that are at the basis of a community's social capital. This can contribute to explain the reduction in altruism and the higher levels of selfishness observed in our findings. These effects extend to the vertical component of social capital, i.e. both political institutions and the health care sector. Finally, our findings confirm the view that previous estimates of the effect of social capital on health are likely to be biased.

From a public health perspective, our analysis indicates that the returns from healthcare spending and prevention are higher than previously thought since they may have important additional effects on social capital at the community level.

Bibliography

ALMOND, D., EDLUND, L. and PALME, M. (2009). Chernobyl's Subclinical Legacy: Prenatal Exposure to Radioactive Fallout and School Outcomes in Sweden. *The Quarterly Journal of Economics*, **124** (4), 1729–1772. 2.3.1

BAILIS, D. S., SEGALL, A. and CHIPPERFIELD, J. G. (2003). Two views of self-rated general health status. *Social science & medicine*, **56** (2), 203–17. 2.4

BELLOWS, J. and MIGUEL, E. (2009). War and local collective action in Sierra Leone. *Journal of Public Economics*, **93** (11-12), 1144–1157. 2.2

BERGER, E. M. (2010). The Chernobyl Disaster, Concern about the Environment, and Life Satisfaction. *Kyklos*, **63** (1), 1–8. 2.3.2

BLACK, S. E., BÜTIKOFER, A., DEVEREUX, P. J. and SALVANES, K. G. (2013). *This Is Only a Test? Long-Run Impacts of Prenatal Exposure to Radioactive Fallout*. NBER Working Papers 18987, National Bureau of Economic Research, Inc. 5

BLATTMAN, C. (2009). From violence to voting: War and political participation in uganda. *American Political Science Review*, **103**, 231–247. 2.2

BOGDANOVA, T. I., ZURNADZHY, L. Y., GREENEBAUM, E., MCCONNELL, R. J., ROBBINS, J., EPSTEIN, O. V., OLIJNYK, V. A., HATCH, M., ZABLOTSKA, L. B. and TRONKO, M. D. (2006). A cohort study of thyroid cancer and other thyroid diseases after the chornobyl accident. *Cancer*, **107**. 2.3.1

BOUND, J., JAEGER, D. and BAKER, R. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association*, **90**, 443–450. 2.5.2

BROWN, T. T., SCHEFFLER, R. M., SEO, S. and REED, M. (2006). The empirical relationship between community social capital and the demand for cigarettes. *Health economics*, **15** (11), 1159–72. 2.2

BROWN, V. J. (2011). Thyroid cancer after chornobyl: Increased risk persists two decades after radioiodine exposure. *Environmental Health Perspectives*, **119** (7). 2.3.1

CALNAN, M. W. and SANFORD, E. (2004). Public trust in health care: the system or the doctor? *Quality and Safety in Health Care*, **13** (2), 92–97. 2.4

CARDIS, E. and HATCH, M. (2011). The Chernobyl accident-an epidemiological perspective. *Clinical Oncology*, **23** (4), 251–60. 2.3.1

—, KREWSKI, D., BONIOL, M., DROZDOVITCH, V., DARBY, S. C., GILBERT, E. S., AKIBA, S., BENICHOU, J., FERLAY, J., GANDINI, S., HILL, C., HOWE, G., KESMINIENE, A., MOSER, M., SANCHEZ, M., STORM, H., Voisin, L. and Boyle, P. (2006). Estimates of the cancer burden in Europe from radioactive fallout from the Chernobyl accident. *International Journal of Cancer*, **119** (6), 1224–35. 2.3.1, 2.5.1

Cataldo, J. K., Jahan, T. M. and Pongquan, V. L. (2012). Lung cancer stigma, depression, and quality of life among ever and never smokers. *European journal of oncology nursing : the official journal of European Oncology Nursing Society*, **16** (3), 264–9. 2.2

Cervellati, M., Sunde, U. and Valmori, S. (2014). Pathogens, Weather Shocks, and Civil Conflicts. *University of Bologna, mimeo.* 2.2

Coleman, J. (1990). *Foundations of social theory*. Cambridge, MA: Harvard University Press. 2.1

Dal Bó, P. (2005). Cooperation under the Shadow of the Future: Experimental Evidence from Infinitely Repeated Games. *American Economic Review*, **95** (5), 1591–1604. 2.2

Danzer, A. M. and Danzer, N. (2011). The Long-Term Effects of the Chernobyl Catastrophe on Subjective Well-Being and Mental Health. *IZA Discussion Paper*, (5906). 2.3.1

d'Hombres, B., Rocco, L., Suhrcke, M. and McKee, M. (2010). Does social capital determine health? Evidence from eight transition countries. *Health Economics*, **19** (1), 56–74. 2.1, 2.2

Engström, K., Mattsson, F., Järleborg, A. and Hallqvist, J. (2008). Contextual social capital as a risk factor for poor self-rated health: a multilevel analysis. *Social science & medicine*, **66** (11), 2268–80. 2.2

European Commission (1998). *Atlas of Caesium Deposition on Europe After the Chernobyl Accident*. Luxembourg: Office for Official Publications of the European Communities. 2.3.1, 2.3.2

Fife, B. L. and Wright, E. R. (2000). The dimensionality of stigma: a comparison of its impact on the self of persons with HIV/AIDS and cancer. *Journal of health and social behavior*, **41** (1), 50–67. 2.2

Folland, S. (2007). Does "community social capital" contribute to population health? *Social science & medicine*, **64** (11), 2342–54. 2.1

Gilson, L. (2003). Trust and the development of health care as a social institution. *Social Science & Medicine*, **56**, 1453–1468. 2.4

— (2005). Editorial: building trust and value in health systems in low- and middle-income countries. *Social Science & Medicine*, **61**, 1381–1384. 2.4

Gonzalez, B. D. and Jacobsen, P. B. (2012). Depression in lung cancer patients: the role of perceived stigma. *Psycho-oncology*, **21** (3), 239–46. 2.2

Guiso, L., Sapienza, P. and Zingales, L. (2007). *Social Capital as Good Culture*. Tech. rep., EUI. 2.2

Halla, M. and Zweimüller, M. (2014). *Parental Response to Early Human Capital Shocks: Evidence from the Chernobyl Accident*. Discussion Paper 7968, IZA. 2.3.1

Helliwell, J. F. (2007). Well-Being and Social Capital: Does Suicide Pose a Puzzle? *Social Indicators Research*, **81** (3), 455–496. 2.1

Hirschberger, G., Florian, V. and Mikulincer, M. (2005). Fear and Compassion: A Terror Management Analysis of Emotional Reactions to Physical Disability. *Rehabilitation Psychology*, **50** (3), 246–257. 2.2

Huisman, M. and Deeg, D. J. H. (2010). A commentary on Marja Jylhä's "What is self-rated health and why does it predict mortality? Towards a unified conceptual model". *Social science & medicine*, **70** (5), 652–4; discussion 655–7. 2.4

IAEA (2006). *Environmental consequences of the Chernobyl accident and their remediation: twenty years of experience. Report of the chernobyl forum expert group 'environment': STI/PUB/1239, 2006, International Atomic Energy Agency, Vienna, Austria ISBN: 92-0-114705-8,*. Tech. Rep. 4, International Atomic Energy Agency (IAEA), Vienna. 2.3.1

Kawachi, I., Kennedy, B. P., Lochner, K. and Prothrow-Stith, D. (1997). Social capital, income inequality and mortality. *American Journal of Public Health*, **87** (9), 1491–1498. 2.1

—, Kim, D., Coutts, A. and Subramanian, S. V. (2004). Commentary: Reconciling the three accounts of social capital. *International Journal of Epidemiology*, **33**, 682–690. 2.1, 2.2

Kennedy, B. P., Kawachi, I. and Brainerd, E. (1998). The Role of Social Capital in the Russian Mortality Crisis. *World Development*, **26** (11), 2029–2043. 2.1

Kennelly, B., O'Shea, E. and Garvey, E. (2003). Social capital, life expectancy and mortality: a cross-national examination. *Social science & medicine*, **56** (12), 2367–77. 2.1

Kim, D., Subramanian, S. V. and Kawachi, I. (2006). Bonding versus bridging social capital and their associations with self rated health : a multilevel analysis of 40 US communities. *Journal of epidemiology and community health*, **60** (2). 2.2

Knack, S. and Keefer, P. (1997). Does social capital have an economic payoff? A cross country investigation. *The Quarterly Journal of Economics*, **November**. 2.1

— and Zak, P. J. (2003). Building trust: public policy, interpersonal trust and economic development. *Supreme Court Economic Review*, **10** (91), 91–107. 2.1

Lehmann, H. and Wadsworth, J. (2011). The impact of Chernobyl on health and labour market performance. *Journal of health economics*, **30** (5), 843–57. 2.3.1

Linden, W., Vodermaier, A., Mackenzie, R. and Greig, D. (2012). Anxiety and depression after cancer diagnosis: prevalence rates by cancer type, gender, and age. *Journal of affective disorders*, **141** (2-3), 343–51. 2.2

Lochner, K. a., Kawachi, I., Brennan, R. T. and Buka, S. L. (2003). Social capital and neighborhood mortality rates in Chicago. *Social science & medicine*, **56** (8), 1797–805. 2.1

Lynch, J., Smith, G. D., Hillemeier, M., Shaw, M., Raghunathan, T. and Kaplan, G. (2001). Income inequality, the psychosocial environment, and health: comparisons of wealthy nations. *Lancet*, **358** (9277), 194–200. 2.1

Macinko, J. and Starfield, B. (2001). The Utility of Social Capital in Research on Health Determinants. *Milbank Quarterly*, **79** (3), 387–427. 2.1

Marino, F. and Nunziata, L. (2016). Long term health consequences and economic costs of the chernobyl radioactive fallout: an exploration of the aggregate data. *University of Padua, mimeo*. 2.1, 2.3.1, 2.3.2, 12, 13, 2.5.1, 14, 2.6

Massie, M. J. (2004). Prevalence of depression in patients with cancer. *Journal of the National Cancer Institute. Monographs*, **10021** (32), 57–71. 2.2

Mechanic, D. and Meyer, S. (2000). Concepts of trust among patients with serious illness. *Social Science & Medicine*, **51**, 657–668. 2.4

Mosher, C. E. and Danoff-Burg, S. (2007). Death anxiety and cancer-related stigma: a terror management analysis. *Death studies*, **31** (10), 885–907. 2.2

Mulders, M., Vingerhoets, A. and Breed, W. (2008). The impact of cancer and chemotherapy: perceptual similarities and differences between cancer patients, nurses and physicians. *European journal of oncology nursing : the official journal of European Oncology Nursing Society*, **12** (2), 97–102. 2.2

Oh, H., Ell, K. and Subica, A. (2014). Depression and family interaction among low-income, predominantly hispanic cancer patients: a longitudinal analysis. *Supportive care in cancer : official journal of the Multinational Association of Supportive Care in Cancer*, **22** (2), 427–34. 2.2

Pearce, N. and Davey Smith, G. (2003). Is Social Capital the Key to Inequalities in Health? *American Journal of Public Health*, **93** (1), 122–129. 2.2

Peters, H. P., Albrecht, G., Hennen, L. and Stegelmann, H. U. (1990). Chernobyl and the nuclear power issue in West German public opinion. *Journal of Environmental Psychology*, **10**, 121–134. 2.3.2

Poortinga, W. (2012). Community resilience and health: the role of bonding, bridging, and linking aspects of social capital. *Health & place*, **18** (2), 286–95. 2.2, 3

Putnam, R. (1995). Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America. *PS: Political Science and Politics*, **28** (4), 664–683. 2.6

Putnam, R. D., Leonardi, R. and Nanetti, R. Y. (1993). *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton University Press. 2.1, 2.6

Renn, O. (1990). Public responses to the chernobyl accident. *Journal of Environmental Psychology*, **10**, 151–167. 2.3.2

Rocco, L., Fumagalli, E. and Suhrcke, M. (2014). From social capital to health - and back. *Health economics*, **23** (5), 586–605. 2.1

Rosman, S. (2004). Cancer and stigma: experience of patients with chemotherapy-induced alopecia. *Patient education and counseling*, **52** (3), 333–9. 2.2

Sabatini, F. (2011). *The relationship between happines and health: evidence from Italy*. Tech. Rep. 30948, MPRA. 2.4

Simmons, K. L., Smith, J. a., Bobb, K.-A. and Liles, L. L. M. (2007). Adjustment to colostomy: stoma acceptance, stoma care self-efficacy and interpersonal relationships. *Journal of advanced nursing*, **60** (6), 627–35. 2.2

Sirven, N. and Debrand, T. (2008). *Promoting Social Participation for Healthy Ageing*. Tech. rep., IRDES Working Paper. 2.1, 2.2

Skrabski, A., Kopp, M. and Kawachi, I. (2003). Social capital in a changing society: cross sectional associations with middle aged female and male mortality rates. *Journal of epidemiology and community health*, **57** (2), 114–9. 2.1

Stock, J. H. and Yogo, M. (2005). Testing for weak instruments in linear IV regressions. In D. W. K. Andrews and J. H. Stock (eds.), *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, Cambridge: Cambridge University Press, pp. 80–108. 2.5.2

Subramanian, S. V., Kawachi, I. and Kennedy, B. P. (2001). Does the state you live in make a difference? Multilevel analysis of self-rated health in the US. *Social science & medicine*, **53** (1), 9–19. 2.1

—, Kim, D. and Kawachi, I. (2005). Covariation in the socioeconomic determinants of self rated health and happiness: a multivariate multilevel analysis of individuals and communities in the USA. *Journal of Epidemiology and Community Health*, **59** (8), 664–669. 2.4

—, Kim, D. J. and Kawachi, I. (2002). Social trust and self-rated health in US communities: a multilevel analysis. *Journal of urban health: bulletin of the New York Academy of Medicine*, **79** (Suppl 1), S21–34. 2.1, 2.2

Szreter, S. and Woolcock, M. (2004). Health by association ? Social capital, social theory, and the political economy of public health. *International Journal of Epidemiology*, **33** (4), 650–667. 2.2, 2.4

Tondel, M., Hjalmarsson, P., Hardell, L., Carlsson, G. and Axelson, O. (2004). Increase of regional total cancer incidence in north Sweden due to the Chernobyl accident? *Journal of epidemiology and community health*, **58** (12), 1011–6. 2.3.1, 2.5.1

—, Lindgren, . A. P., Hjalmarsson, P., Hardell, L. and Persson, B. (2006). Increased Incidence of Malignancies in Sweden After the Chernobyl Accident–A Promoting Effect? *Americal Journal of Industrial Medicine*, **168**, 159–168. 2.3.1, 2.5.1

Tønnessen, A., Bertil, M. and Weisæ th, L. (2002). Silent Disaster: A European Perspective on Threat Perception From Chernobyl Far Field Fallout. *Journal of Traumatic Stress*, **15** (6), 453–459. 2.3.2

UNSCEAR (1998). *Report to the General Assembly, with Scientific Annexes.* New York: United Nations. 2.1, 2.3.1

UNSCEAR (2000). *Effects of Atomic Radiation, Report to the General Assembly, Annex J, Exposures and Effects of the Chernobyl Accident.* New York: United Nations. 2.1, 2.3.1

UNSCEAR (2008). *Sources and Effects of Ionizing Radiation, Report to the General Assembly, Annex D, Health Effects Due to Radiation from the Chernobyl Accident.* New York: United Nations. 2.1, 2.3.1

Veenstra, G. (2002). Social capital and health (plus wealth, income inequality and regional health governance). *Social science & medicine*, **54** (6), 849–68. 2.1

— (2005). Location, location, location: contextual and compositional health effects of social capital in British Columbia, Canada. *Social Science & Medicine*, **60**, 2059–2071. 2.2

Vironen, J. H., Kairaluoma, M., Aalto, A.-M. and Kellokumpu, I. H. (2006). Impact of functional results on quality of life after rectal cancer surgery. *Diseases of the colon and rectum*, **49** (5), 568–78. 2.2

Voors, M. J., Nillesen, E. E. M., Verwimp, P., Bulte, E. H., Lensink, R. and Soest., D. P. V. (2012). Violent Conflict and Behavior: A Field Experiment in Burundi. *American Economic Review*, **102** (2), 941–64. 2.2

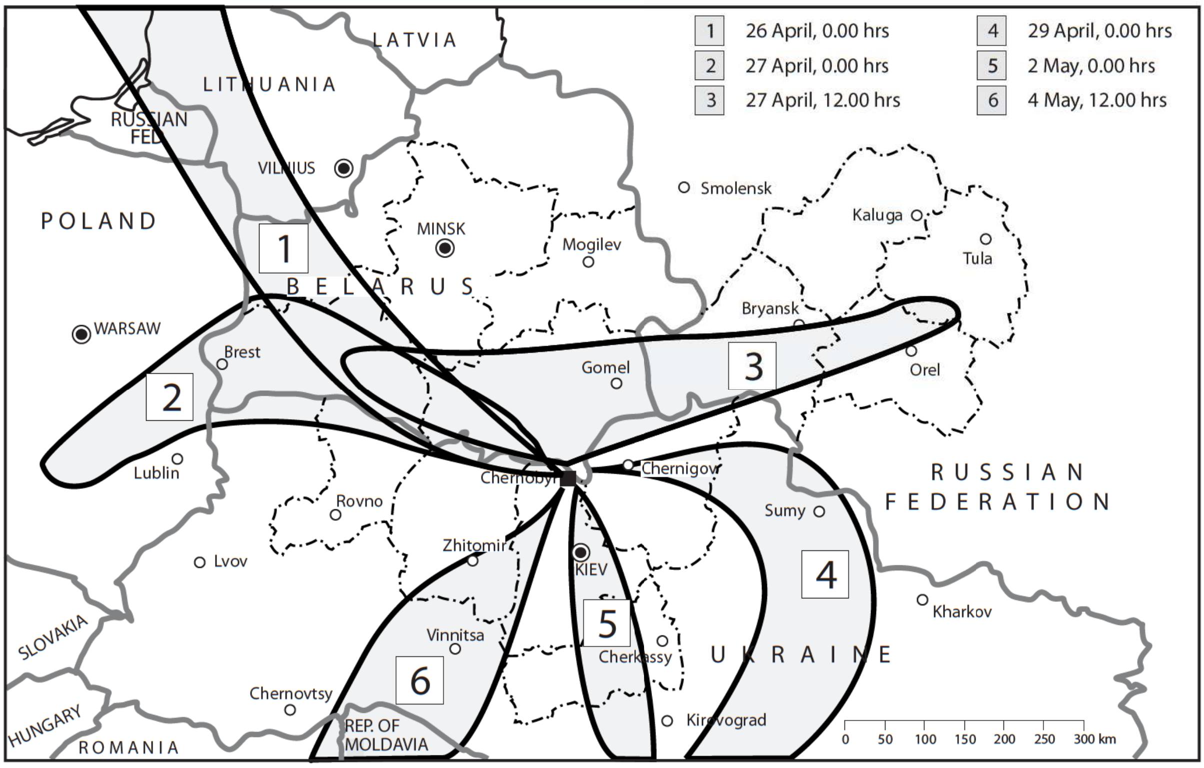
Wen, M., Browning, C. R. and Cagney, K. a. (2003). Poverty, affluence, and income inequality: neighborhood economic structure and its implications for health. *Social science & medicine*, **57** (5), 843–60. 2.1

Wilkinson, R. G., Kawachi, I. and Kennedy, B. P. (1998). Mortality, the social environment, crime and violence. *Sociology of Health and Illness*, **20** (5), 578–597. 2.1

WILSON, K. and LUKER, K. A. (2006). At home in hospital? Interaction and stigma in people affected by cancer. *Social science & medicine*, **62** (7), 1616–27. 2.2

ZAK, P. J. and KNACK, S. (2001). Trust and Growth. *The Economic Journal*, **111** (470), 295–321. 2.1

***Fig. 2.1** – Formation of plumes by meteorological conditions for instantaneous releases on the dates and at the times (UTC) indicated.*



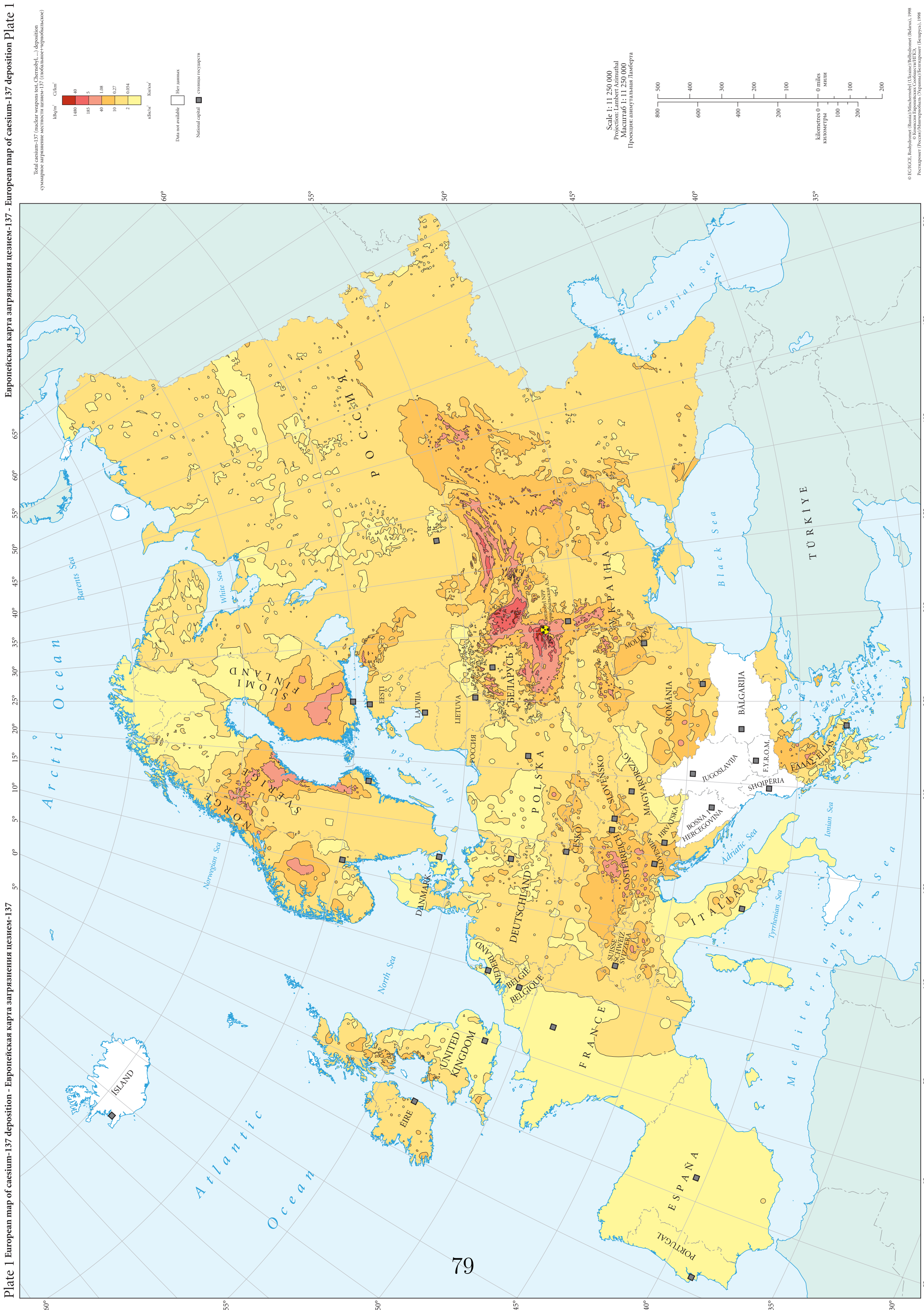
Source: UNSCEAR, 2008. United Nations Scientific Committee on the Sources and Effects of Ionizing Radiation, 2008 Report to the General Assembly, with scientific annexes. Annexes D, United Nations, New York.

***Table 2.1** – Fallout dummy specification*

^{137}Cs concentration (Kbq m^{-2})	Dummy variable	Number of obs.
$<$ 2	-	31
$>$ 2 and $<$ 10	D_{F1}	23
$>$ 10 and $<$ 40	D_{F2}	17
$>$ 40	D_{F3}	7
$>>$ 40	D_{F4}	2

Note : fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2,F3 Fallout >40 kBq/m^2 , F4 fallout >40 kBq/m^2 in more than 50% of the area. No region in the dataset records a fallout intensity greater than 185 kBq/m^2.

Fig. 2.2 *– Surface Ground Deposition of Caesium-137 Released in Europe After the Chernobyl Accident.*



Source: European Commission (1998). Atlas of Caesium Deposition on Europe After the Chernobyl Accident. Luxembourg: Office for Official Publications of the European Communities.

Fig. 2.3 – *Fallout dummy specification*

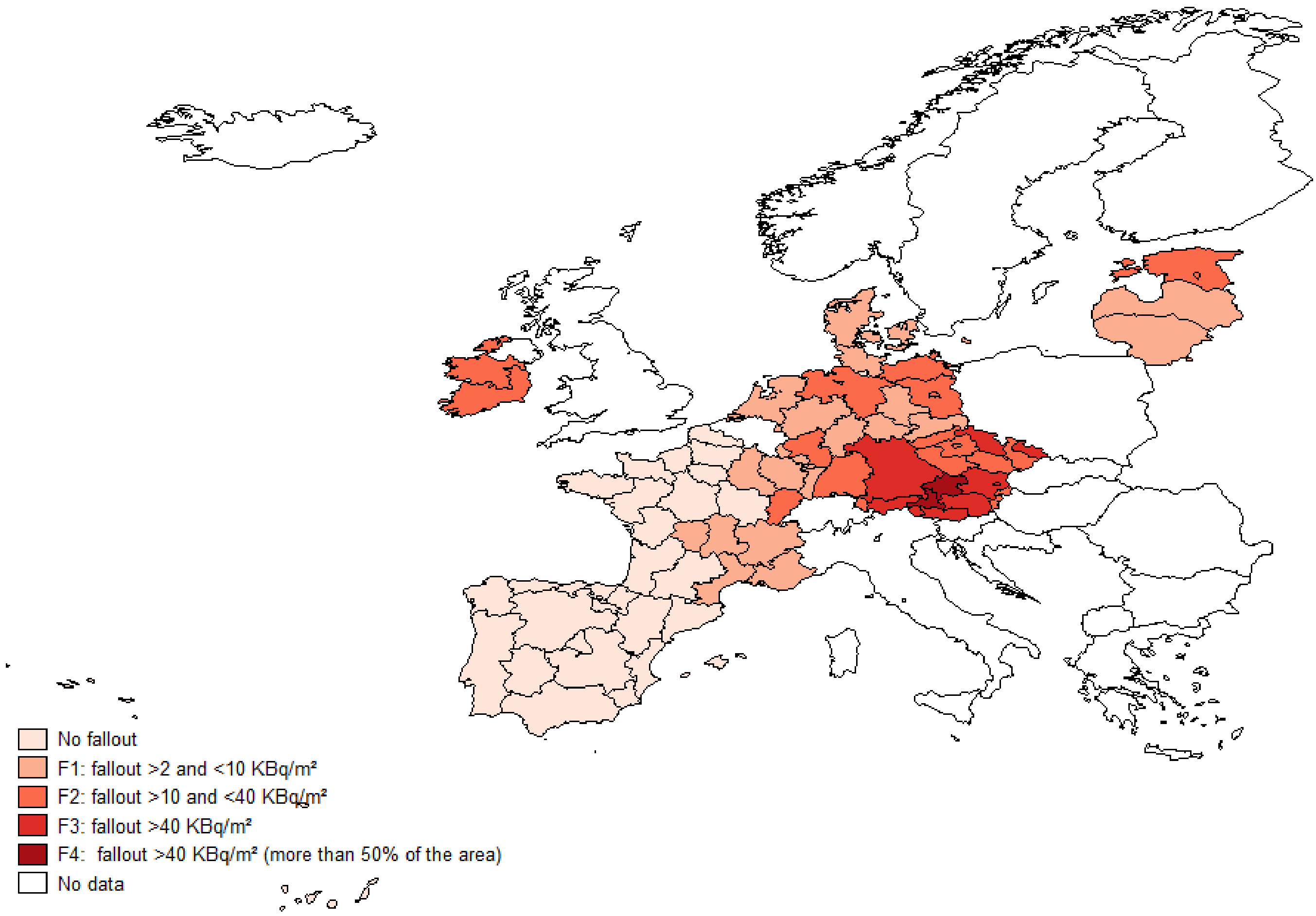


Table 2.2 – Survey Questions

Variable	Question	Scale	N. obs	Mean (SD)	Threshold*	ESS wave
	Bonding Social Capital					
Trust	Generally speaking, would you say that most people can be trusted, or that you can't be too careful?	0 - 10 0 you can't bee too careful 10 most people can be trusted	119731	5.11 (2.39)	5	[1-7]
Perceived fairness	Generally speaking, would you say that most peopletry to take advantage of you, or try to be fair?	0 - 10 0 try to take advantage of you 10 try to be fair	119041	5.78 (2.22)	5	[1-7]
Perceived helpfulness	Generally speaking, would you say that most of the time people try to be helpful or that they are mostly looking out for themselves?	0 - 10 0 look out for themselves 10 try to be helpful	119556	4.96 (2.26)	5	[1-7]
Social meetings	How often do you meet socially with friends, relatives or work colleagues?	1 - 7 1 Never 2 Less than once a month 3 Once a month 4 Several times a month 5 Once a week 6 Several times a week 7 Every day	119776	5.00 (1.56)	4	[1-7]
Social activities	Compared to other people of your age, how often would you say you take part in social activities?	1 - 5 1 Much less than most 2 Less than most 3 About the same 4 More than most 5 Much more than most	117487	2.71 (0.93)	3	[1-7]
	Bridging Social Capital					
Be rich	It is important to her/him to be rich. She/he wants to have a lot of money and expensive things.	1 - 6 1 Very much like me 2 Like me 3 Somewhat like me 4 A little like me 5 Not like me 6 Not like me at all	115549	4.11 (1.30)	4	[1-7]
Have equal opportunities	She/he thinks it is important that every person in the world should be treated equally and have equal opportunities in life.	1 - 6	115438	2.14 (1.07)	4	[1-7]
Understand different people	It is important to her/him to listen to people who are different from her/him. Even when she/he disagrees with them, she/he still wants to understand them	1 - 6	115277	2.43 (1.08)	4	[1-7]
Help and care for others well-being	It's very important to her/him to help the people around her/him. She/he wants to care for their well-being.	1 - 6	115567	2.28 (1.01)	4	[1-7]
Spend time to help others	Citizens should spend at least some of their free time helping others	1 - 5 1 Agree strongly 2 Agree 3 Neither agree nor disagree 4 Disagree 5 Disagree strongly	20719	2.17 (0.80)	4	[2]
	Political Placement					
Left - Right	In politics people sometimes talk of "left" and "right". Where would you place yourself on this scale, where 0 means the left and 10 means the right?	0 - 10 0 Left 10 Right	103062	4.97 (2.09)	5	[1-7]
	Happiness					
Happy	Taking all things together, how happy would you say you are?	0 - 10 0 Extremely unhappy 10 Extremely happy	119580	7.27 (1.92)	5	[1-7]

*the reported value refers to the first number associated to 1 in the dummy variable.

Table 2.2 – Survey Questions (cont.)

Variable	Question	Scale	N. obs	Mean (SD)	Threshold*	ESS wave
	Linking Social Capital					
Trust in institutions						
Country's Parliament	On a score of 0-10, how much you personally trust the Parliament of your country?	0 - 10 0 No trust at all 10 Complete trust	116360	4.44 (2.50)	5	[1-7]
Country's legal system	On a score of 0-10, how much you personally trust the legal system of your country?	0 - 10	116803	5.19 (2.60)	5	[1-7]
Country's police	On a score of 0-10, how much you personally trust the police of your country?	0 - 10	118676	6.10 (2.44)	5	[1-7]
Country's politicians	On a score of 0-10, how much you personally trust the politicians of your country?	0 - 10	117765	3.55 (2.37)	5	[1-7]
Country's political parties	On a score of 0-10, how much you personally trust the political parties of your country?	0 - 10	100462	3.48 (2.35)	5	[1-7]
European Parliament	On a score of 0-10, how much you personally trust the European Parliament?	0 - 10	107230	4.48 (2.41)	5	[1-7]
United Nations	On a score of 0-10, how much you personally trust the United Nations?	0 - 10	106927	5.14 (2.46)	5	[1-7]
Trust in the health care system						
Level of public health	There is some debate nowadays about the cost of providing public health care in you country. Thinking about 10 years from now, which of the statements comes closest to your own opinion?	1 - 3 1 Will not be able to afford present level 2 Afford present level but not increase 3 Will be able to afford to increase	17137	1.84 (0.72)	2	[4]
Not receiving cures	During the next 12 months how likely is it that you will not receive the health care you really need if you become ill?	1 - 4 1 Not at all likely 2 Not very likely 3 Likely 4 Very likely	17679	2.14 (0.93)	3	[4]
Doctors treat equally	During the next 12 months how likely is it that you will not receive the health care you really need if you become ill?	0 - 10 0 Give special advantages to certain people 10 Deal with everyone equally	18182	4.75 (2.85)	5	[4]
State of health services	Please say what you think overall about the state of health services in your country nowadays?	0 - 10 0 Extremely bad 10 Extremely good	118643	5.34 (2.46)	5	[1-7]
Health care, government's responsibility	People have different views on what the responsibilities of governments should or should not be. How much responsibility you think governments should have to ensure adequate health care for the sick?	0 - 10 0 Not governments' responsibility at all 10 Entirely governments' responsibility	18874	8.69 (1.66)	5	[4]
Efficiency of provision	Thinking about the provision of social benefits and services, please tell me how efficient you think the provision of health care in your country is.	0 - 10 0 Extremely inefficient 10 Extremely efficient	18500	5.30 (2.27)	5	[4]

*the reported value refers to the first number associated to 1 in the dummy variable.

Table 2.3 *– Summary Statistics*

Variable	Obs	Mean	Std.Dev.	Min	Max
Hospital discharges by neoplasms (%)	80	1.650	0.815	0.565	3.677
Controls					
Wealth	80	104.519	42.288	31.143	287.357
Population Density	80	323.701	727.007	25.067	4202.283
Proportion 60+	80	0.228	0.030	0.151	0.290
Obtained scores					
BONDING	80	0.645	0.066	0.464	0.881
BRIDGING	80	0.883	0.050	0.667	0.966
LINKING - INSTITUTIONS	80	0.526	0.086	0.291	0.802
LINKING - HEALTH CARE	48	0.667	0.143	0.384	0.940
Bonding Social Capital					
Trust	80	0.602	0.090	0.395	0.890
Perceived fairness	80	0.750	0.064	0.597	0.929
Perceived helpfulness	80	0.581	0.089	0.387	0.823
Social meetings	80	0.839	0.070	0.591	0.922
Social activities	80	0.673	0.083	0.479	0.855
Bridging Social Capital. Important to:					
Be rich	80	0.266	0.119	0.032	0.612
Have equal opportunities	80	0.914	0.038	0.772	0.984
Understand different people	80	0.855	0.063	0.548	0.949
Help and care for others' well being	80	0.877	0.067	0.679	0.973
Spend time to help others	57	0.949	0.0347	0.792	1
Linking Social Capital - Institutions. Trust in:					
Country's Parliament	80	0.514	0.124	0.220	0.803
Country's legal system	80	0.612	0.122	0.355	0.905
Country's police	80	0.765	0.108	0.457	0.942
Country's politicians	80	0.323	0.095	0.166	0.715
Country's political parties	80	0.311	0.101	0.137	0.729
European Parliament	80	0.530	0.087	0.378	0.732
United Nations	80	0.639	0.071	0.490	0.852
Linking Social Capital - Health Care system					
Level of public health	48	0 .633	0.151	0.417	0.957
Not receiving cures	48	0.750	0.233	0.269	1
Doctors treat equally	48	0.482	0.209	0.160	0.875
State of health services	80	0.706	0.130	0.392	0.894
Health care, government's responsibility	48	0.968	0.035	0.875	1
Effiiency of provision	48	0.748	0.133	0.409	0.984
Left-right	80	0.626	0.080	0.412	0.828
Happiness	80	0 .8174	0.063	0.628	0.951

Table 2.4 – Fallout effect on hospital discharges, with additional controls

Dependent variable: hospital discharges by neoplasms	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D_{F1}	0.645***	0.293*	0.299**	0.472***	0.662***	0.310**	0.319**	0.409***
	(0.127)	(0.156)	(0.139)	(0.123)	(0.126)	(0.149)	(0.138)	(0.153)
D_{F2}	0.950***	0.522***	0.561***	0.644***	1.038***	0.485***	0.528***	0.632***
	(0.123)	(0.153)	(0.117)	(0.170)	(0.119)	(0.158)	(0.147)	(0.190)
D_{F3}	1.369***	0.840***	0.826***	1.063***	1.453***	0.815***	0.813***	1.012***
	(0.221)	(0.285)	(0.251)	(0.254)	(0.232)	(0.282)	(0.260)	(0.302)
D_{F4}	2.245***	1.703***	1.662***	1.950***	2.294***	1.677***	1.650***	1.853***
	(0.086)	(0.183)	(0.159)	(0.144)	(0.085)	(0.179)	(0.169)	(0.180)
Wealth	0.003***	0.004***	0.005***	0.005***	0.003**	0.004***	0.005***	0.004**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Population density	0.0004***	0.0003***	0.0003***	0.0004***	0.0004***	0.0003***	0.0003***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	10.975***	9.973***	10.421***	11.677***	10.221***	10.049***	10.453***	9.940***
	(1.875)	(1.693)	(1.682)	(1.787)	(1.862)	(1.664)	(1.696)	(1.689)
Distance		-0.000***				-0.000*		-0.000
		(0.000)				(0.000)		(0.000)
Longitude			0.033***				0.028***	
			(0.008)				(0.010)	
Life expectancy in 1985				-0.112***		-0.033	-0.031	-0.042
				(0.035)		(0.048)	(0.046)	(0.046)
Percentage woods					-0.986***			-0.905**
					(0.360)			(0.353)
Observations	80	80	80	79	78	79	79	77
R^2	0.736	0.779	0.780	0.764	0.759	0.786	0.786	0.796

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2, F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variable expressed in hospital discharges over 100 inhabitants. Baseline controls: wealth, population density and proportion of population aged over 60. Further controls: distance indicates the area's distance from Chernobyl's nuclear power plant (in km), longitude accounts for the area's meridian: positive numbers correspond to meridians east of Greenwich's, negative numbers are located west, life expectancy in 1985 (pre-accident) at country level expressed in years, percentage of woods controls for the proportion of the area covered by woods. Columns 1 represents the baseline specification. Columns 2, 3, 4 and 5 represent the change in the baseline first stage of the two-stages least squares model adding each control separately, columns 6 and 7 present the joint effect of the additional variables.

Table 2.5 – Fallout effect on hospital discharges by other causes

Dependent variables:	hospital discharges by tubercolosis	alcoholic liver disease	pregnancy childbirth	poisonings by drugs, medicaments and biological substances
	(1)	(2)	(3)	(4)
D_{F1}	0.011	0.005	0.186**	0.034*
	(0.008)	(0.004)	(0.071)	(0.019)
D_{F2}	-0.003	0.008*	0.249**	-0.005
	(0.002)	(0.004)	(0.113)	(0.019)
D_{F3}	0.008**	0.005	0.037	-0.019
	(0.004)	(0.006)	(0.055)	(0.017)
D_{F4}	0.012***	0.001	0.130	-0.029
	(0.005)	(0.005)	(0.085)	(0.020)
Wealth	-0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)
Population density	0.000	0.000003**	0.000	-0.00002***
	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	-0.106	0.165***	-6.342***	-0.248
	(0.074)	(0.062)	(1.567)	(0.265)
Observations	79	80	80	80
R^2	0.204	0.191	0.383	0.092

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variables expressed in hospital discharges over 100 inhabitants. OLS specification with robust standard errors. In column 1 hospital discharges by tubercolosis data are not available for Estonia (EE). In column 2 hospital discharges by alcoholic liver disease are not available for Netherlands (NL) and Portugal (PT).

Table 2.6 – Second stage. Estimated coefficients on obtained scores

Social Capital score:	Coefficient	S.E.	R^2
BONDING	0.0022	(0.010)	0.355
BRIDGING	-0.0238***	(0.008)	0.271
LINKING, INSTITUTIONS	-0.0408***	(0.012)	0.445
LINKING, HEALTH CARE	-0.1442***	(0.024)	0.629

Note : Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Second stage results: reported coefficients refer to the effect of hospital discharges by neoplasms (standardized over 100 inhabitants) instrumented with fallout, over the corresponding social capital scores. All coefficients are obtained by two-stages least squares model. Baseline controls used in the analysis: wealth, population density and proportion of population aged over 60. Social Capital scores are standardized over a 0-1 continuum.

Table 2.7 – Second stage. Estimated coefficients

Bonding Social Capital

Variable	Coefficient	S.E.	R^2
BONDING SCORE	**0.0022**	**(0.010)**	**0.355**
Components:			
- Trust	-0.0126	(0.015)	0.229
- Perceived fairness	-0.0144	(0.009)	0.371
- Perceived helpfulness	0.0318**	(0.014)	0.281
Other related variables:			
Social meetings	-0.0570***	(0.012)	0.472
Social activities	-0.0478***	(0.015)	0.171
Happiness	-0.0360***	(0.009)	0.402

Bridging Social Capital

Variable	Coefficient	S.E.	R^2
BRIDGING SCORE	**-0.0238*** **	**(0.008)**	**0.271**
Components. Important to:			
- Have equal opportunities	-0.0349***	(0.005)	0.377
- Understand different people	-0.0240***	(0.009)	0.292
- Help and care for others' well being	-0.0172	(0.012)	0.166
Other related variables:			
Be rich	0.1083***	(0.017)	0.356
Spend time to help others	-0.0183***	(0.005)	0.084
Left-Right	0.0431***	(0.016)	0.186

Note : Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Second stage results: reported coefficients refer to the effect of hospital discharges by neoplasms (standardized over 100 inhabitants) instrumented with fallout, over the corresponding social capital variable. All coefficients are obtained by two-stages least squares model. Baseline controls used in the analysis: wealth, population density and proportion of population aged over 60. Variables listed as score components are the ones resulted relevant through a common factor analysis. Variables thought relevant for the corresponding social capital area that have proven not to map in the factor analysis are listed in the "other related variables" list. Social Capital scores and individual variables are expressed over a 0-1 continuum. The average hospitalization rates for neoplasms in the sample are around 1% in no fallout areas, 2% in F1 and F2 areas, 2.28% in F3 areas and 3% in F4 areas.

Table 2.7 – Second stage. Estimated coefficients

Linking Social Capital - Institutions

Variable	Coefficient	S.E.	R^2
LINKING, INSTITUTIONS SCORE	**-0.0408*****	**(0.012)**	**0.445**
Components. Trust in:			
- Country's Parliament	-0.0577***	(0.020)	0.427
- Country's legal system	0.0201	(0.016)	0.557
- Country's police	-0.0403***	(0.015)	0.465
- Country's politicians	-0.0018	(0.014)	0.344
- Country's political parties	-0.0063	(0.014)	0.361
- European Parliament	-0.0756***	(0.012)	0.431
- United Nations	-0.0651***	(0.011)	0.398

Linking Social Capital - Health Care System

Variable	Coefficient	S.E.	R^2
LINKING, HEALTH CARE SCORE	**-0.1442*****	**(0.024)**	**0.629**
Components:			
- Not receiving cures*	-0.2514***	(0.030)	0.625
- Doctors treat equally	-0.1227***	(0.037)	0.493
- State of health services	-0.0586**	(0.026)	0.186
- Efficiency of provision	-0.0913***	(0.029)	0.307
Other related variables:			
Level of public health	-0.1013***	(0.025)	0.447
Health care, government's responsibility	-0.0340***	(0.004)	0.599

Note : Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Second stage results: reported coefficients refer to the effect of hospital discharges by neoplasms (standardized over 100 inhabitants) instrumented with fallout, over the corresponding social capital variable. All coefficients are obtained by two-stages least squares model. Baseline controls used in the analysis: wealth, population density and proportion of population aged over 60. Variables listed as score components are the ones resulted relevant through a common factor analysis. Variables thought relevant for the corresponding social capital area that have proven not to map in the factor analysis are listed in the "other related variables" list. Social Capital scores and individual variables are expressed over a 0-1 continuum. *Not receiving cures variables was reversed to construct the final score, in this case negative values determine a greater probability not to receive the adequate cures if the individual becomes ill in the next future. The average hospitalization rates for neoplasms in the sample are around 1% in no fallout areas, 2% in F1 and F2 areas, 2.28% in F3 areas and 3% in F4 areas.

2.7 Appendix

Testing the Exclusion Restrictions: an Estimate of the Direct Effect of the Fallout on Public Opinion on Nuclear Power

Using data from Eurobarometer[17] collected in 2009, we check whether the public opinion on nuclear energy was affected by the intensity in the fallout generated by the Chernobyl disaster. This is an indirect test of the exclusion restrictions at the basis of our instrumental variable setting that assumes that the fallout only affected social capital through the induced variation in health patterns. In other words, we assume no direct effect of the fallout on social capital though behavioural responses triggered by the public awareness of the dangers associated to nuclear energy.

We selected a set of questions asked in 2009 to assess individuals' perception and opinion about nuclear energy across the regions in our sample. The list of questions and their codification can be found in Table 2.7.1. We selected four variables, measuring whether nuclear energy is associated to thoughts of concern, if respondents think to be well informed about the safety of nuclear power plants, if nuclear power plants are considered risky, and lastly if nuclear risks are considered exaggerated if compared to other safety risks in everyday life. We constructed a set of dichotomous indicators of public opinion on nuclear energy and then we created regional scores following the same geographical detail as in our main analysis.[18]

We estimate the same model as our baseline, using the indicators of public opinion on nuclear energy as dependent variables to check whether the latter is differently affected by the regional fallout deposition. Table 2.7.2 shows that there is no clear pattern of correlation between the ^{137}Cs soil deposition and individuals' beliefs and attitude toward nuclear power. This in turn seems to exclude any direct effect on social capital that could question our identification strategy.

[17] Eurobarometer 72.2, September-October 2009

[18] Differently the original sample, we could not match our data with the Eurobarometer data on Irish regions. We had therefore to exclude Ireland from this analysis.

Table 2.7.1 – General public opinion on nuclear power

Variable	Eurobarometer Question	Codification		N. Obs	Mean (s.e.)	Threshold
Concern	When you think about nuclear power, what first comes to mind?	The benefits of nuclear power as an energy source outweigh the risks it poses	1	11445	0.56 (0.50)	1, 3 recoded as 0 2 recoded as 1
		The risks of nuclear power as an energy source outweigh its benefits	2			
		Neither (spontaneous)	3			
Well Informed	How informed do you think you are about the safety of nuclear power plants?	Very well informed Fairly well informed Not very well informed Not at all informed	1 2 3 4	12055	0.24 (0.42)	1, 2 recoded as 1 3, 4 recoded as 0
Risky	To what extent do you think that the nuclear power plant(s) in your country represent(s) a risk to you and your family?	A big risk Some risk Not much of a risk No risk at all Not applicable in the country	1 2 3 4 5	10315	0.58 (0.49)	1,2 recoded as 1 3, 4, 5 recoded as 0
Relative Risk	Nuclear incidents sometimes raise major concerns in the media and the public. In your opinion, compared to other safety risks in our lives, would you say that nuclear risks are	Strongly exaggerated Somewhat exaggerated Somewhat underestimated Strongly underestimated Nuclear risks are perceived correctly (spontaneous)	1 2 3 4 5	10425	0.55 (0.50)	1,2 recoded as 0 3, 4 recoded as 1 5 not considered

Note: Survey questions from Eurobarometer 72.2, September-October 2009 from respondents residing in the European regions considered in our baseline setting. Data for Irish regions are missing.

Table 2.7.2 – Fallout effect on public opinion on nuclear power

Dependent variables: Opinions about nuclear power				
	Concern (1)	Well informed (2)	Risky (3)	Relative risk (4)
D_{F1}	-0.029	0.113***	-0.088**	0.023
	(0.035)	(0.026)	(0.044)	(0.048)
D_{F2}	-0.088*	0.127***	-0.190***	-0.095**
	(0.050)	(0.028)	(0.050)	(0.043)
D_{F3}	-0.020	0.066*	-0.039	0.033
	(0.064)	(0.036)	(0.060)	(0.061)
D_{F4}	0.072	0.096	0.092	0.044
	(0.121)	(0.100)	(0.112)	(0.099)
Wealth	0.000	0.00005***	-0.000	-0.000
	(0.000)	(0.00002)	(0.000)	(0.000)
Population density	0.000	0.00003**	0.000	0.000
	(0.000)	(0.00002)	(0.000)	(0.000)
Proportion 60+	-0.281	0.006	0.414	-0.394
	(0.614)	(0.332)	(0.789)	(0.766)
Constant	0.663***	0.117	0.626***	0.711***
	(0.140)	(0.071)	(0.179)	(0.158)
Observations	78	78	78	78
R^2	0.069	0.354	0.206	0.098

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). OLS specification with robust standard errors. Data missing for Ireland.

Table 2.7.3 – Description of main variables

Variable	Description
Fallout Dataset: own elaboration Time range: - Dimension: dummy	From the Atlas of Caesium Deposition on Europe After the Chernobyl Accident by the European Commission (1998) fallout dummies were assigned at Nuts 2 level for Austria, the Czech Republic, Germany, Ireland, Spain and France, and at Nuts 1 level for Denmark,Estonia, Latvia, Lithuania, Luxemburg, Netherlands and Portugal. Each dummy corresponds to the highest concentration of ^{137}Cs expressed in Kbq m^{-2}. Assigned thresholds follow the division presented in the map: D_{F1} concentration >2 and <10 Kbq m^{-2}, D_{F2} concentration >10 and < 40 Kbq m^{-2}, D_{F3} concentration >40 Kbq m^{-2}, D_{F4} concentration >40 Kbq m^{-2} in more than 50% of the area.
Hospital discharges Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	A hospital discharge is considered as the formal release of a patient from a hospital after a procedure or course of treatment. Discharges occur when the patient leaves because of finalisation of treatment, signs out against medical advice,transfers to another health care institution or because of death. Discharges refer to in-patients: an in-patient is a patient who is formally admitted to an institution for treatment and/or care and stays for a minimum of one night or more than 24 hours in the hospital or other institution providing in-patient care (descriptions from Eurostat). Yearly observations lack for the following countries: DK: 2010-2013; EE: 2000-2002, 2012 and 2013; LT: 2000, 2012 and 2013; LU: 2012, 2013; LV: 2000-2003 and 2012,2013; NL: 2000,2001 and 2013; PT: 2000-2004 and 2011-2013.
Baseline controls **Wealth** Dataset: Eurostat Time range: 2000-2013 Dimension: percentage points	Year's corresponding GDP per capita measured as Euros per inhabitant in percentage of the European Union average. A value of 100 corresponds to EU's average. Values higher or lower than 100 indicate respectively that the area's GDP per capita is greater of lower than the European average. Data are not available for the year 2009 in all German regions.
Population density Dataset: Eurostat (elaboration) Time range: 2000-2013 Dimension: raw number	Own elaboration from total population data and total area (ha) statistics, both from Eurostat database. The variable is calculated as year's population over area's surface. It expresses the concentration of individuals standardized by the region or State area expansion.
Proportion population aged over 60 Dataset: Eurostat (elaboration) Time range: 2000-2013 Dimension: percentage points	Own elaboration from population aged over sixty and total area's population data, both from Eurostat database. The variables is calculated as the ratio between popoulation aged over sixty and total population.
Additional controls **Distance** Dataset: own elaboration Time range: - Dimension: kilometers	The variable expresses the region's distance from Chernobyl's nuclear power plant in kilometers, calculated from the region's geographical center. Datas have been elaborated through Google Earth software[a].
Longitude Dataset: own elaboration Time range: - Dimension: decimal degrees	The variable expresses associated region's or country's longitude. Areas east of Greenwich take positive longitude values, areas west of Greenwich are associated to negative longitude values. Informations extracted from http://www.distancesfrom.com/
Life expectancy in 1985 Dataset: World Bank Time range: 1985 Dimension: years	Life expectancy at birth in 1985 (pre-Chernobyl's accident) at country level. It indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life (description from World Bank).
Wooded areas Dataset: Eurostat (elaboration) Time range: 2000-2013 Dimension: percentage points	Own elaboration from wooded areas (in hares) and total territory's extension (in hares) variables, both from Eurostat database. The variables is calculated as the ratio between year's hares occupated by wooded areas and the terriotory's corresponding extension in hares. It expresses the percentage of total area extension covered by woods.
Doctors Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	Physicians or doctors available in the year for providing health care services in the area, regardless of the sector of employment (description from Eurostat).
Available beds in hospital Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	Total available beds in hospitals in the area, variable from Eurostat.
Non curative beds Dataset: Eurostat Time range: 2000-2013 Dimension: standardized over 100 inhabitants	Total available beds in hospitals not classified as for curative care, variable from Eurostat.
Health care expenditure by financing agent Dataset: Eurostat Time range: 2003-2013 Dimension: share of GDP	Health care expenditure divided by financing agents. Categories taken from Eurostat division following the International Classification for the Health Accounts (ICHA).
Health care expenditure by function Dataset: Eurostat Time range: 2003-2013 Dimension: expenditure per inhabitant	Health care expenditure divided by function, i.e. the purpose of the expense. Categories taken from Eurostat division following the International Classification for the Health Accounts (ICHA). .

[a]Google Earth (Version 7.1.2.2041) [Software]. Mountain View, CA: Google Inc. (2013). Available from http://www.google.com/earth/

Table 2.7.4 – Social Capital categories, factor loadings

Bonding Social Capital

Variable	Factor loading
Trust	0.5883
Perceived fariness	0.5846
Perceived helpfulness	0.5221
Social meetings	-
Social activities	-
Retained items	3
Cronbach's alpha	0.6504

Bridging Social Capital

Variable	Factor loading
Be rich	-
Have equal opportunities	0.3917
Understand different people	0.4502
Help and care for others' well being	0.4751
Spend time to help others	-
Retained items	3
Cronbach's alpha	0.5021

Linking Social Capital - Institutions Trust in:

Variable	Factor loading
Country's Parliament	0.6972
Country's legal system	0.6132
Country's police	0.4987
Country's politicians	0.7817
Country's political parties	0.7708
European Parliament	0.6452
United Nations	0.5986
Retained items	7
Cronbach's alpha	0.8372

Linking Social Capital - Health Care system

Variable	Factor loading
Level of public health	-
Not receiving cures	0.3424
Doctors treat equally	0.4264
State of health services	0.6085
Health care, government's responsibility	-
Efficiency of provision	0.6028
Retained items	4
Cronbach's alpha	0.6053

Reported results of confirmatory factor analysis are lead on each group separately. In each group items loades on only one factor (eigenvalue>1 for Bonding, Linking - Institutions and Linking - Health Care sector Social Capital components, while eigenvalue>.6 for Bridging Social Capital). In order to be included in the category the imposed loading threshold was 0.3.

Table 2.7.5 – Fallout effect on hospital discharges by neoplasms

Dependent variables: hospital discharges by type of neoplasm

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Type	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	Malignant	In situ	In situ	Benign
Description	colon, rectosigmoid junction and other	trachea, bronchus and lung	skin	breast	uterus	ovary	prostate	bladder	other neoplasms	in situ neoplasms	ncertain or unknown behaviour	colon, rectum, and other
D_{F1}	0.077***	0.077***	0.021***	0.070***	0.022***	0.022***	0.032***	0.018***	0.203***	0.003	0.004	0.068***
	(0.016)	(0.016)	(0.007)	(0.014)	(0.005)	(0.006)	(0.009)	(0.006)	(0.045)	(0.002)	(0.009)	(0.018)
D_{F2}	0.125***	0.104***	0.039***	0.092***	0.029***	0.028***	0.048***	0.032***	0.309***	0.001	0.001	0.102***
	(0.015)	(0.017)	(0.008)	(0.018)	(0.004)	(0.003)	(0.008)	(0.006)	(0.042)	(0.002)	(0.008)	(0.021)
D_{F3}	0.171***	0.147***	0.066***	0.114***	0.040***	0.052***	0.047***	0.043***	0.459***	0.006	0.000	0.185***
	(0.016)	(0.028)	(0.011)	(0.029)	(0.006)	(0.011)	(0.009)	(0.011)	(0.088)	(0.005)	(0.008)	(0.040)
D_{F4}	0.214***	0.204***	0.140***	0.204***	0.071***	0.101***	0.100***	0.033***	0.833***	0.020***	0.013	0.274***
	(0.025)	(0.026)	(0.030)	(0.013)	(0.008)	(0.008)	(0.020)	(0.006)	(0.031)	(0.005)	(0.010)	(0.018)
Wealth	0.000	0.0003***	0.0001*	0.0005***	-0.000	0.000	0.0003***	0.000	0.002***	0.00009**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.00003**	0.00004***	0.00002***	0.00004**	0.00001***	0.00001***	0.000	0.00002***	0.0002***	0.000	-0.000	0.00005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Proportion 60+	1.221***	1.027***	0.470***	1.027***	0.130**	0.142**	0.662***	0.477***	3.993***	0.160***	0.127	1.239***
	(0.224)	(0.236)	(0.095)	(0.223)	(0.051)	(0.058)	(0.111)	(0.084)	(0.658)	(0.027)	(0.105)	(0.286)
Observations	79	79	79	79	79	79	79	79	79	79	79	79
R^2	0.670	0.637	0.659	0.629	0.661	0.684	0.583	0.570	0.744	0.510	0.043	0.629

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Baseline fallout dummy specification: F1 Fallout >2 kBq/m^2 <10 kBq/m^2, F2 Fallout >10 kBq/m^2 and <40 kBq/m^2, F3 Fallout >40 kBq/m^2 , F4 Fallout >40 kBq/m^2 (more than 50%). Dependent variables expressed in hospital discharges over 100 inhabitants. Results are obtained by OLS specification with robust standard errors. All hospital discharges data by type of neoplasm are not available for Estonia (EE).

Table 2.7.6 – Second stage. Estimated coefficients using 2SLS and LIML analyses

Bonding Social Capital

	2SLS			**LIML**		
Variable	Coefficient	S.E.	R^2	Coefficient	S.E.	R^2
BONDING SCORE	**0.0022**	**(0.010)**	**0.355**	**0.0025**	**(0.010)**	**0.354**
Components:						
- Trust	-0.0126	(0.015)	0.229	-0.0121	(0.015)	0.228
- Perceived fairness	-0.0144	(0.009)	0.371	-0.0146	(0.010)	0.370
- Perceived helpfulness	0.0318**	(0.014)	0.281	0.0320**	(0.014)	0.281
Other related variables:						
Social meetings	-0.0570***	(0.012)	0.472	-0.0604***	(0.015)	0.465
Social activities	-0.0478***	(0.015)	0.171	-0.0484***	(0.015)	0.170
Happy	-0.0360***	(0.009)	0.402	-0.0365***	(0.010)	0.401

Bridging Social Capital

	2SLS			**LIML**		
Variable	Coefficient	S.E.	R^2	Coefficient	S.E.	R^2
BRIDGING SCORE	**-0.0238*** **	**(0.008)**	**0.271**	**-0.0240*** **	**(0.008)**	**0.271**
Components. Important to:						
- Have equal opportunities	-0.0349***	(0.005)	0.377	-0.0359***	(0.006)	0.374
- Understand different people	-0.0240***	(0.009)	0.292	-0.0241***	(0.009)	0.292
- Help and care for others' well being	-0.0172	(0.012)	0.166	-0.0174	(0.012)	0.166
Other related variables:						
Be rich	0.1083***	(0.017)	0.356	0.1105***	(0.018)	0.352
Spend time to help others	-0.0183***	(0.005)	0.084	-0.0186***	(0.005)	0.081
Left-Right	0.0431***	(0.016)	0.186	0.0465***	(0.017)	0.172

Note : Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Second stage results: reported coefficients refer to the effect of hospital discharges by neoplasms (standardized over 100 inhabitants) instrumented with fallout, over the corresponding social capital variable. All coefficients are obtained by two-stages least squares model. Baseline controls used in the analysis: wealth, population density and proportion of population aged over 60. Variables listed as score components are the ones resulted relevant through a common factor analysis. Variables thought relevant for the corresponding social capital area that have proven not to map in the factor analysis are listed in the "other related variables" list. Social Capital scores and individual variables are expressed over a 0-1 continuum. The average hospitalization rates for neoplasms in the sample are around 1% in no fallout areas, 2% in F1 and F2 areas, 2.28% in F3 areas and 3% in F4 areas.

Table 2.7.6** – **Second stage. Estimated coefficients using 2SLS and LIML analyses

Linking Social Capital - Institutions

	2SLS			LIML		
Variable	Coefficient	S.E.	R^2	Coefficient	S.E.	R^2
LINKING, INSTITUTIONS SCORE	**-0.0408*****	**(0.012)**	**0.445**	**-0.0408*****	**(0.012)**	**0.445**
Components. Trust in:						
- Country's Parliament	-0.0577***	(0.020)	0.427	-0.0577***	(0.021)	0.427
- Country's legal system	0.0201	(0.016)	0.557	0.0201	(0.016)	0.557
- Country's police	-0.0403***	(0.015)	0.465	-0.0405***	(0.015)	0.465
- Country's politicians	-0.0018	(0.014)	0.344	-0.0005	(0.015)	0.342
- Country's political parties	-0.0063	(0.014)	0.361	-0.0055	(0.014)	0.360
- European Parliament	-0.0756***	(0.012)	0.431	-0.0757***	(0.012)	0.431
- United Nations	-0.0651***	(0.011)	0.398	-0.0660***	(0.012)	0.397

Linking Social Capital - Health Care System

	2SLS			LIML		
Variable	Coefficient	S.E.	R^2	Coefficient	S.E.	R^2
LINKING, HEALTH CARE SCORE	**-0.1442*****	**(0.024)**	**0.629**	**-0.1458*****	**(0.026)**	**0.628**
Components:						
- Not receiving cures*	-0.2514***	(0.030)	0.625	-0.2602***	(0.033)	0.619
- Doctors treat equally	-0.1227***	(0.037)	0.493	-0.1206***	(0.038)	0.492
- State of health services	-0.0586**	(0.026)	0.186	-0.0594*	(0.030)	0.185
- Efficiency of provision	-0.0913***	(0.029)	0.307	-0.0942***	(0.032)	0.305
Other related variables:						
Level of public health	-0.1013***	(0.025)	0.447	-0.1025***	(0.026)	0.446
Health care, government's responsibility	-0.0340***	(0.004)	0.599	-0.0357***	(0.005)	0.591

Note : Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Second stage results: reported coefficients refer to the effect of hospital discharges by neoplasms (standardized over 100 inhabitants) instrumented with fallout, over the corresponding social capital variable. All coefficients are obtained by two-stages least squares model. Baseline controls used in the analysis: wealth, population density and proportion of population aged over 60. Variables listed as score components are the ones resulted relevant through a common factor analysis. Variables thought relevant for the corresponding social capital area that have proven not to map in the factor analysis are listed in the "other related variables" list. Social Capital scores and individual variables are expressed over a 0-1 continuum. *Not receiving cures variables was reversed to construct the final score, in this case negative values determine a greater probability not to receive the adequate cures if the individual becomes ill in the next future. The average hospitalization rates for neoplasms in the sample are around 1% in no fallout areas, 2% in F1 and F2 areas, 2.28% in F3 areas and 3% in F4 areas.

Chapter 3

Living with an Ill Sibling: Cognitive and Noncognitive Skills of the Healthy Child

Living with an ill sibling: cognitive and noncognitive skills of the healthy child. [1]

Francesca Marino [2]

University of Padua

Abstract

The aim of this study is to identify changes in cognitive and noncognitive skills among children and early adolescents due to having an ill sibling. Using data from the second wave of the Child Development Supplement (CDS) in the Panel of Income Study Dynamics (PSID), this investigation adopts a Propensity Score Matching approach to compare families where one of the siblings is affected by a physical or mental illness with families where all the children are healthy. Results of the current study highlight a change in noncognitive skills among children living with an ill sibling, while cognitive skills are not affected. By analyzing noncognitive skills in light of the Big Five Personality traits, results shows that living with an ill sibling has a beneficial effect on children's Openness to Experience, Consciensciousness and Extraversion. The analysis identifies children's differences at the gender and birth order levels: living with an ill sibling seems to cause an increase in Openness to Experience among girls and an increase in Conscientiousness among boys while the increase in Extraversion observed in the overall sample may be actually due to the older children subsample. This evidence highlights how children react differently to the same phenomenon according to gender and age differences, and this appears to be useful especially in a prospective point of view, since according to literature such changes may be reflected in future socioeconomic and labour market outcomes.
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[2] Dept. of Economics, University of Padua, Via del Santo 33, 35121, Padua, Italy, e-mail: *francesca.marino@studenti.unipd.it*, *andeor@msn.com*

3.1 Introduction

Economic literature has provided several pieces of evidence on the relationship between cognitive and non cognitive skills, and how their interplay is able to affect a great variety of labour and socioeconomic outcomes in adult age, such as years of education, school grades, employment, wages, health status, teenage pregnancies, crimes, longevity etc. (Cawley *et al.*, 2001; Heckman *et al.*, 2006; Borghans *et al.*, 2008).

In the setting of the current investigation I aim at providing an exploration of which dimensions of cognitive and noncognitive skills may be affected by the presence of an ill sibling in the family. Even though the mechanisms affecting cognitive and noncognitive outcomes may be several, the current study is focused at proving if and what cognitive skills and personality traits are affected by particular household conditions. The emerging pattern may help consolidating or reconsidering actual theories about children's skills formation and provide useful information for policy interventions.

Besides the contextual effect on children's outcomes that represents an interesting phenomenon per se, it is useful to assess any change in children's skills especially in a prospective point of view, since those skills could be predictive of several labour and socioeconomic outcomes later in life. The effect of cognitive skills on several dimension, especially on wage and employment status, is wide and has reached an overall broad consensus (Cawley *et al.*, 1998, 2001).

The importance of studying the relevance of noncognitive skills is twofold. On the one hand cognitive skills influence both cognitive skills assessments, e.g. through motivation or anxiety, and cognitive skills acquirement, meaning that individuals with higher levels of some noncognitive skills are more motivated in acquiring knowledge and show higher levels of cognitive skills (for a review see Almlund *et al.*, 2011). On the other hand some personality traits may directly determine positive socioeconomic and labour market outcomes. In recent years several studies have analysed the link between personality traits and labour market outcomes. Jacob (2002) points out that women's greater non cognitive skills and higher college premiums account for the most part of the gender gap in higher education attendance. Non cognitive skills are a major determinant of higher education attendance, either because low non cognitive abilities lead to decrease the likelihood of graduating from high school, and by increasing the non pecuniary, or "psychic", costs of enrolling to college. Lindqvist and Westman (2011) link noncognitive abilities to unemployment probability. Men with low noncognitive abilities are more likely to become unemployed than men with high noncognitive abilities. Once unemployed, cognitive abilities are neutral to unemployment duration, however men with high levels of noncognitive abilities experience shorter unemployment spells.

The setting of this study takes into consideration a particular households' condition that may affect children's development. The aim of the investigation is to identify changes in cognitive and noncognitive skills among children and early adolescents due to having an ill sibling. The presence of an ill child, and more specifically a chronically ill child in the family, may determine a modification in households' dynamics, everyday life arrangements and familiar roles which are able to affect a child's development. Actually, several mechanisms could be at play when considering the effect that having an ill sibling could exert on the healthy one, and results from literature appear mixed. Medical literature seems to focus on a direct modification of noncognitive skills due to living with an ill sibling. However, results focus both on positive and negative modifications of children's personality and do not provide clear and unanimous conclusions. Children with an ill sibling could represent either a group at risk of social and behavioural problems (Hannah and Midlarsky, 1985; McKeever, 1983) or they might present some skills that can be predictive of positive future achievements in schooling and in the labour market. On the other side, following economic literature, we can hypothesise that families respond to the presence of an ill child revising their resource allocation among the offspring. If quality time and financial resources allocated to each child are responsive to children's ability, parents should decide to invest more in the more able child and to compensate economically the gap with the less able child later in life (Becker, 1991; Becker and Lewis, 1973; Becker and Tomes, 1976). In this study I will not take into account parents' different decision on time and resource allocation which may stem from having an ill child, however it is an important underlying factor that must be taken into account in interpreting possible outcomes.

A possible modification of cognitive skills and personality traits among children with an ill sibling may deliver useful insights on how adverse familiar conditions affect children in the household, and how children react to being exposed to adversities. For example, Heckman *et al.* (2013) prove that the main reason behind the success of the Perry preschool program was the capability of affecting personality traits. Children participating to the program experienced a positive modification in terms of social competency, planning, and organization, that brought them beneficial effects on criminal, labour market, and health behaviour outcomes later in life. Similarly, children living with an ill sibling may be affected in terms of cognitive, and more interestingly in terms of noncognitive skills, and may show positive socioeconomic and labour market outcomes later in life.

In the setting of the current paper I use the presence of an ill sibling inside the household to compare healthy children with an ill sibling to healthy children with healthy siblings. The results can be interpreted as causal if the treatment, having an ill sibling, is randomly distributed among children in the sample. In order to provide reliable estimates I employ Matching techniques to meet the unconfoundedness and common support overlap assumption, so that after proper controls the assignment to the treatment can be considered random. For this reason I do not consider any form of illness, but only those that qualify for Special Education assignment.

Results of the current study highlight a change in noncognitive skills among children living with an ill sibling, while cognitive skills are not affected. Respect to medical literature already mentioned, by analyzing noncognitive skills in light of the Big Five Personality traits explained below, this study shows that living with an ill sibling has a beneficial effect on children's noncognitive outcomes. Given the empirical metodology used, this effect can be interpreted as causal, meaning that various inputs children are exposed to when living with an ill sibling cause a modification of their personality.

This evidence also calls for the need of future investigations of how some particular household conditions are able to affect children's outcomes, may that be the direct effect of living with a sibling with recurrent problems in everyday life or may the effect be mediated by different parental inputs received inside the household. Moreover, different noncognitive skills may be predictive of future labour market and socioeconomic outcomes that this children will show in the future.

The paper is organised as follows: section 3.2 examines the main insights on the conditions of healthy children living with an ill sibling, and possible causes of modification patterns in cognitive and noncognitive skills. Section 3.3 describes the data and the empirical stretegy used in the current analysis, section 3.4 presents the empirical results of the paper. Finally, section 3.5 concludes.

3.2 Siblings of Ill Children

3.2.1 Living with an Ill Sibling

The aim of this study is to provide an examination of the extent to which several cognitive and noncognitive outcomes during childhood and early adolescence can be influenced by living with an ill sibling. For this reason the following section focuses on the possible mechanisms in families with an ill child that could cause a modification in children's skills.

Considering both medical/ psychological literature and economic literature, there can be two pathways through which the presence of an ill child in the household may affect on the healthy one: an indirect and a direct channel. Medical and psychological literature seem to suggest a direct channel: children experience mainly a modification in noncognitive skills as a direct psychological reaction to having a different sibling. Results from literature are quite heterogeneous, depending on the physical proximity among the offspring, the type of illness (Williams, 1997), and its severity (Hastings, 2003; Sharpe and Rossiter, 2002). In the study by Alderfer *et al.* (2010), sibling of children with cancer are more likely to present negative feelings like sadness, fear and worries. They also highlight that these children might have cognitive problems such as difficulties concentrating in school, in memory and in learning processes. Goudie *et al.* (2013) assess an increase in interpersonal and behavioural problems, negative feelings and school problems among children living with a disabled sibling. At the same time other studies identify healthy siblings to be more independent, mature and responsible (Wilkins and Woodgate, 2005). In the review by Knecht *et al.* (2015) it emerges that well siblings of children affected by chronic illnesses are pushed by their familiar experience to be more communicative and cooperative, thus making them be more sensitive in terms of empathy, compassion and patience. Positive behavioural modifications are found also in (Nielsen *et al.*, 2012).

Results from this literature are hard to interpret because of the small sample sizes, the heterogeneity of illness considered, the frequent lack of a proper control group and the empirical methodologies. However, a modification of non cognitive skills may be merely boosted by the child's everyday life conditions: simply by living with a sibling that constantly needs help, or lags behind, may push the children to be more sensitive to others' struggles and increase their social competences.

The indirect channel, interpreted from classical economic literature, focuses on changes in households' conditions due to the presence of an ill child that affect the healthy ones. Having an ill child in the household may influence both parental time allocation and parenting style, which are recognised as keyfactors in shaping personality traits (Almlund *et al.*, 2011; Fiorini and Keane, 2014). According to Becker (1991); Becker and Lewis (1973); Becker and Tomes (1976), parents should optimally decide to allocate resources according to children's ability levels. This mechanism results in an unequal allocation of parental investments anytime children differ in their initial ability level, like in the case of the current analysis. On the other side empirical evidence has proven that parents actually tend to be more inequality avert in time allocation decisions. Price (2008) shows that the equality preference of parents brings them to spend the same amount of time with each child, and to decrease it as children grow up, resulting in less total time spent with the younger child. The effect on noncognitive skills may also be due to a different parenting style that parents could adopt responding to the presence of an ill child among their offspring. Parenting style, especially a certain mixture of warm and authoritative attitude, is an important predictor of children's noncognitive skills (Fiorini and Keane, 2014).

The following sections investigate the evolutionary patterns of cognitive and noncognitive skills: section 3.2.2 focuses on the determinants of cognitive and noncognitive skills among children, introduces the concept of the Big Five and its importance for future outcomes, while section 3.2.3 describes the stability of the Big Five Personality traits during the life course, important to understand the impact of childhood's effects over adult life outcomes.

3.2.2 Cognitive Skills, Non Cognitive and the Big Five

Evolutionary patterns of cognitive and noncognitive skills seem to be different. While cognitive skills are expected to be mouldable only up to a relatively young age, noncognitive skills are considered more malleable and responsive to different stimuli received during the life course. However, personality traits are positively correlated over the life cycle, and both cognitive and noncognitive skills are strongly dependent on early life conditions. Heckman (2008) shows that gaps in cognitive tests score at age 18, relevant in explaining adult outcomes, are present also at age 5. Moreover, behavioural problems measured by the Behavioural Problem Index (BPI) are stable during whole childhood (from age 4 to 12). Almlund *et al.* (2011) identify cognitive skills to become rank stable by the age of 10. On the importance of early life conditions, Neidell (2000) states that parental investments deliver lasting benefits to the child mainly up to the first year of age.

Even though cognitive and noncognitive abilities are influenced by familiar conditions during childhood, literature has proved that those skills show different rates of responsiveness to different stimuli. Empirical evidence shows that the time mothers spend with children, especially at young age, is linked to greater cognitive abilities, while the evidence is weaker or non existent for noncognitive skills (Carneiro and Rodrigues, 2009; Del Bono *et al.*, 2014). While cognitive skills are strongly linked to parental quality time allocation decisions, evidence shows that noncognitive skills are highly sensitive to parenting style (Fiorini and Keane, 2014). It emerges that noncognitive skills seem to be more responsive to the attitude of caregivers respect to cognitive skills. The importance of received stimuli is found also in Behncke (2012), that proved in an experimental context how children that received positive affirmation and motivation by their mathematics teacher had on average higher test scores.

In empirical studies non cognitive skills are frequently measured through the Big Five personality traits construct (Costa and McCrae, 1992). According to the Big Five division, personality can be described into five main categories: Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Emotional Stability. Table 3.1 provides a description of these categories, as well as the associated facets. Economic literature has produced numerous pieces of evidence on how each dimension plays a different role on a broad group on schooling and labour market outcomes. For example, in the work by Nyhus and Pons (2005), emotional stability seems to have a beneficial effect on both women and men's wages. Agreeableness is linked to lower wages for women, while other traits show different patterns with job tenure. Conscientiousness is more rewarded at the beginning of the job, while autonomy is a positive feature for men as tenure increases. Heineck and Anger (2010) find that women benefit from extraversion in terms of hourly wages while males are disadvantaged. Conscientiousness is a positive feature for men , while agreeableness is a negative trait for women and emotional stability seems to have no effect. Mueller and Plug (2006) find that male's wages benefit from antagonism (the opposite of agreeableness), emotional stability and extraversion, while women are more rewarded from conscientiousness and extraversion. Almlund *et al.* (2011) using German data identify conscientiousness and emotional stability to be the most important traits linked to increasing number of school years completed both for boys and girls. Moreover, conscientiousness and extraversion are the personality traits most correlated to course grades (Poropat, 2009). Similar results can be found in Borghans *et al.* (2008).

3.2.3 Big Five Stability over the life course.

As said above, the aim of this analysis relies on the fundamental assumption that modifications in children's cognitive skills and personality traits are predictive for future outcomes, which implies some degree of stability of these skills during the life course. This assumption needs to be deeply investigated. Despite cognitive skills, that have been proved to be responsive to outside stimuli only up to a very young age (Cunha and Heckman, 2008), noncognitive skills are affected by several inputs and experiences during the whole period of development of the child, and maybe also during adulthood. However, even allowing for a certain degree of modification in noncognitive skills during the life course, several studies have succeeded in identifying a predictive pattern of childhood characteristics on future outcomes. Carneiro *et al.* (2007) find that non-cognitive skills at age 11 are an important predictor of staying at school beyond the age of 16, obtaining a degree by age 42, while they do not have an effect on basic literacy and numeracy at adult age.

Although the Big Five personality traits are frequently employed as a proxy for noncognitive skills, usually this measure is not directly applied to children. However, it is possible to relate some personality traits among children and early adolescents in the categories above. Considering the Big Five categories, children seem to differ in fewer traits respect to adults, with the complete differentiation happening later in life (Almlund *et al.*, 2011). Prevoo and ter Weel (2004)) find that some childhood traits linked to conscientiousness at age 16 are positively linked to wages in adult years. More interestingly, personality traits at age 10 are a good predictor of personality traits at age 16 and future labour market and socioeconomic outcomes. Caspi *et al.* (2003) show a deep link between personality traits at age 3 and those at age 26, employing both self-assessed and external assessments of personality traits, and recurring to the Big Five. Lastly, Roberts and DelVecchio (2000) provide evidence in favour of rank-order stability of personality traits over time, from childhood to adult years.

Empirical evidence seems to suggest that noncognitive skills at young age may show a good predictive power of future skills, and their effect should be reflected on several labour and socioeconomic outcomes which have been proven to be affected by personality traits.

In the following analysis I will provide an investigation of some measures of cognitive skills and a recodification of children's personality traits according to the Big Five. Using aggregated measures of children's behavioural problems that are usually provided by the data does not meet the necessity of the current study. Overall behavior may be composed by several dimension that respond differently to outside stimuli. The importance of disaggregating children's behaviour in its compenent is twofold: first of all it delivers a more correct picture of the phenomenon, second it provides more useful information aimed at picturing the future consequences of such changes, and possible areas of intervention if needed.

3.3 Data and Empirical Strategy

PSID and Child Development Supplement This study will use data from the Panel Study of Income Dynamics (PSID)[3]. The dataset has a panel structure beginning in 1968 in the United States. At the beginning it comprised over 18,000 individuals belonging to 5,000 families. Its design allows to follow each individual from the original sample once it detaches from his original family unit, because it becomes an independent unit of analysis. From the general data from PSID this study will use individual level information for the primary adult caregiver of the children under analysis. Children information is obtained from the second wave of the Child Development Supplement (CDS), a special supplement designed to explore various dimensions of children's lives. The first wave (CDSI) was administered in 1997 to collect information for all children aged between 0 and 12. The second wave (CDSII) was collected again in 2002-2003 for all the children in the original questionnaire that remained under 18. I will use exclusively information from CDSII

[3]Panel Study of Income Dynamics, public use dataset. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI 2015.

since the first wave lacks important information on personality traits, while the observations of the third wave collected in 2007 are quite scarce, since a great part of the original sample children has moved out of the panel. This would imply removing not only the children in the original CDS aged over 18, but also their siblings still in the compatible age range, since I am interested in identifying siblings' couples. The CDS collects data only for two children in each family, who where randomly selected in the first wave in case the household included more than two children. The second wave of CDS comprised information on 1856 chidren with a sibling with a completed interview in CDSII (928 couples of siblings).

The sample of the following analyses is composed of all children that took part of the CDSII that have a sibling with a completed interview. This implies that both the child and his/her sibling are in the eligible age range, meaning they all are between 5/6 and 18 years old. Therefore they will exclude all only children, and all children in the eligible age range but with a sibling not in the same age range, or that did not complete the CDSII for some particular reason. Lastly, the sample will also exclude ill siblings' couples, since the aim is to estimate the effect that having an ill sibling exerts on healthy children. In conclusion, analyses will be made considering the following two groups: 150 "healthy" children with an "ill" sibling that represent the treatment group, and 853 "healthy" children with a "healthy" sibling that compose the control group, given the "healthiness" criteria explained below.

Illness The aim of the paper is to compare healthy children that have an ill sibling to children with a healthy sibling. The identification of the source of the illness in this case is crucial. Two elements appear important to describe the illness characteristics that are relevant for the current analysis. First, the illness must be "continuous" in time. Single episodes of illness, e.g. a hospitalization, regardless of the severity, might not enact the modification in parents' and children's attitudes that the study needs to identify. Second, the illness needs to be easily measurable through our data. For this reasons I consider "ill" children as those that have been classified for Special Education needs at least once in their life.

Special education in the USA is provided to needing children under the Individuals with Disabilities Education Act. The procedure requires an initial referral process, that can be started both from the family or from the school. The cases are evaluated from medical and educational specialists through a fair procedure, and if the child is eligible, the cause of his or her disability is categorized in each of the following groups: learning disability, speech or language impairments, other health impairments, mental retardation, emotional disturbance, autism, multiple disabilities, developmental delay, hearing impairment, orthopedic impairment, visual impairment, traumatic brain injury, deaf and blindness. Discretionality is allowed only for children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD) and Pervasive Developmental Disorder (PDD). This process is enacted when the child enters school, even though the majority of these conditions, besides being chronic, may be known to the family long before the official placement in Special Education. However the sample in this study is composed of all children enrolled in schooling, or at least in school years. Since all the requirements for Special Education are provided by the school system at no cost for the family, I assume that all children eligible for Special Education are diagnosed as such. Some children may not be in public education, or may be home schooled, or not using Special Education for some reasons that cannot be accounted for, therefore I require only the diagnosis for Special Education, besides the actual use of it. It has to be noted that all the illness causes are actually chronic conditions, that will last for the entire lifespan of the child, so the situations in which the child is not currently using Special Education do not imply that he recovered. Further information about medical conditions of "ill" children in the sample can be found in the Appendix A.

Cognitive skills Cognitive abilities of children were assessed trough the Woodcock-Johnson Revised (WJ-R) Tests of Achievement. CDSII required children to answer to three standardized protocols: Letter-Word, Passage Comprehension, and Applied Problems tests. The results in the first two protocols were joined to obtain the Broad Reading score, which accounts for a child's overall ability in reading. Results in Applied Problems protocol assess a child's ability in mathematics. CDSII provides information about the stardardized score of the child, which takes into account child's age among all other factors, and the child's ranking position inside his gender's percentile. For more information on the administration of the test and the formation of the final score see Mainieri (2006).

A second measure to assess cognitive abilities is the Wechsler Intelligence Scale for Children (WISC) Digit Span short-term memory. This test measures the ability of the child to remember in a certain sequence several digits. The test is administered in two parts, first requiring the child to recall the digits in forward order, and then in backward order. The maximum score in each subtest is equal to the maximum number of digits to be recalled, since each point corresponded to one digit correctly recalled. For the forward subset, maximum score was equal to 16, while the sample average and standard error are respectively 9.35 and 0.08. The forward test had a maximum value of 14, with sample mean and standard error equal to 5.10 and 0.08. Final score is the sum of the results in the two parts of the test. Obviously, the maximum score was 30, the sample average is equal to 14.46 with standard error equal to 0.14.

Table 3.4 presents summary statistics of the two set of cognitive scores computed on the eligible sample: all children in CDSII with a sibling that completed the same questionnaire and that have never been diagnosed for Special Education needs. Simple mean difference comparison among the group of children with a healthy sibling and the children with an ill sibling does not deliver any statistically significant difference regarding the test scores of the Woodcock-Johnson Tests of Achievement. However it emerges that on average children with an ill sibling seem to score better in the memory test: their average total score is higher by 0.83 points, with the sample average and standard errors described above.

Noncognitive Skills The CDSII does not have a direct assessment on children's noncognitive outcomes following the Big Five personality traits division. Children's personality was assessed using the Behavior Problems Index (BPI) (Peterson and Zill, 1986), and the Positive Behavior Scale (PBS) (Polit, 1998).

BPI is aimed at identifying behavioural problems among children. It comprised thirthy-two question asked to the primary caregiver of the child. Answers had to state if the specific beahviour was "often", "sometimes", or "never" true of the child. To each answer the corresponding item is given a value of three, two and one respectively.

The PBS aims at measuring children's attitude in life in a positive point of view, measuring his/her level of self esteem and social competence among others. As said above, PBS question in the classification by CDSII asked the primary caregiver: "Please tell me how much each statement applies to the child on a scale from 1-5, where one means "not at all like your child," and five means "totally like your child," and two, three and four are "somewhere in between". Respect to the original design by Polit (1998) , CDSII comprises only ten of the original twenty-five questions. Further information for both BPI and PBS can be found in Mainieri (2006). A full description of the questions associated to each item can be found in Table 3.2.

For the scope of the present study, the analysis would lose power if it was restricted only at the evaluation of children's final scores. For this reason I take into account every single component of the BPI and PBS and try to reconsider them in light of the Big Five personality traits. The division in made according to the giudelines in John *et al.* (1994) and in Table 3.1 present in Almlund *et al.* (2011). Reclassified items show a good degree of correspondence with a similar reclassification made by Measelle *et al.* (2005).

First I rescaled PBS items according to the 1-3 scale for BPI's items. That is, values of 1 and 2 were recoded 1, values of 3 were recoded 2, and 4 and 5 were recoded 3. Then after dividing all items according to the Big Five personality categories, I ended up with eight items for Conscientiousness and Extraversion, nine for Agreebleness, sixteen for Emotional Stability, and unfortunately only one for Oppeness to experience. Table 3.2 describes the questions associated to each item and the Big Five category assigned to each. Before constructing the final score I performed a confirmatory factor analysis on each group's items. Results in table 3.3 show that in each category items map together in only one factor, and they all load. Final score was constructed following the BPI's methodology. Values of one were given a score of zero and values of two and three were given a score of two. Then all items' score in each category were summed and the final score was then rescaled on a 0-1 continuum in order to allow better comparisons among groups. Bottom part of Table 3.4 shows sample statistics computed on all healthy children in CDSII that have a sibling with a complete interview comparing the score computed on the Big Five personality traits categories. Sample mean comparison shows no statistical difference among children with a healthy sibling and children with an ill sibling.

Lastly, it has to be noted that the questions of both BPI and PBS were answered by the primary caregiver of the child. The presence of an ill child among the offspring could represent a potential source of bias: parents when assessing children's skills may be pushed to evaluate the healthy child in comparison with the ill sibling. This would determine that the same behaviour is differently evaluated, on average, from parents with an ill child among the offspring than from parents with both healthy children. Psychological literature has focused on the potential bias of parents' child assestment in presence of an ill sibling. Comparing similar measures in parents and child reported assestments of children well being, it seems that parents provide more negative reports than children, either because parents tend to be more sensitive to negative outcomes, or becase children do not perceive the actual entity of the negative effects during childhood (Sharpe and Rossiter, 2002). Similar conclusions are found in Taylor *et al.* (2001). Therefore it seems that the possible presence of a bias in obtained estimates should be negative, leading to underestimate the positive effects, if any, on the treated group and to overestimate the effects on negative outcomes. Researches on healthy siblings of children with physical and mental impairments have highlighted a negative effect on healthy sibling, in most cases measured as an increase in internalizing behavioural problems among these children (Rossiter *et al.*, 2001; Sharpe and Rossiter, 2002). The analysis will provide several checks to assess the presence of a possible bias in parents' reports of children behaviour.

Propensity Score Matching I use Nearest Neighbor matching to compare children on the basis of some common observable characteristics and identify any difference in cognitive and noncognitive outcomes. In this setting the presence of an ill sibling represents the treatment. Given Propensity Score Matching characterstics, obtained estimates are reliable if the setting verifies the uncounfoudedness and common support assumptions (Caliendo and Kopenig, 2008). Unconfoudnedness assumption cannot be directly verified, however using theory I need to be sure that I am controlling for all variables that may affect the treatment and the outcome at the same time. Moreover, given those control, the assignment to the treatment and the control group can be considered purely random.

Morgan *et al.* (2013) show that there are some important predictors of a child's placement into Special Education: gender, ethnicity, family and school-level socio-economic status, parents' marital status, and lastly the age of the mother when she first gave birth. Most of these socioeconomic variables are in turn important in explaining both cognitive and noncognitive outcomes. Studying incidence of disability among children, Boyle *et al.* (2011) confirm the importance of ethnicity and children's age. Considering the characteristics of the illnesses in the current setting, most of them are explained by genetic factors, or conditions during pregnancy, childbirth and early childhood. Therefore by controlling for caregivers' characteristics and some socio-economic proxies, even with the limitations explained below, the birth of an ill child can be considered random. In order to exclude cases in which the illness is due to strong inheritable factors, or by parental behavior, this analysis will exclude ill siblings' couples. In this case, given the probability of having an ill child among the offspring measured through the controls, the actual birth of the ill child can be considered to follow a random assignment mechanism. Based on this evidence, the current setting verifies the unconfoundedness assumption and the estimation can proceed through Propensity Score Matching.

Choosing the right measure to proxy the socio-economic conditions of the household is crucial for the reliability of obtained estimates. For this reason I will use only those variables which are completely unaffected by having an ill child or that have been fixed before the birth of the child. Variables like income or labour market participation may be affected by familiar conditions, like having an ill child, and would represent a great source of bias in the estimates. The variables employed in the analysis are explained in the paragraphs below. Nearest Neighbour Matching computations will be made following the algorithms proposed by Abadie and Imbens (2006). Estimates will be obtained using the Mahalanobis distance matrix, and robust standard errors that allow for the possibility that the variance of the outcome variable may differ across treatment status and other controls, since bootstrapped standard errors proved not to be efficient in this setting (Abadie and Imbens, 2008).

Additional Controls The basic level of comparison among children regards their gender and the grade they are currently enrolled in. Boys and girls may differ a priori on noncognitive traits (Jacob, 2002; Weisberg *et al.*, 2011; Schmitt *et al.*, 2008), that might in turn affect their cognitive skills. Moreover, since some personality traits may evolve over time, I want to compare children enrolled in the same class. Hence, Nearest Neighbour matching will be performed requiring exact matches for gender and grade. Further controls regard ethnicity, the gender of the sibling, whether the child is younger or older than the sibling, the total number of children living in the family unit, primarycaregiver's level of education and primarycaregiver's 5-years age-group. Some may argue that the number of children in the family may be influenced by the presence of an ill child. For this reason further specifications will take into account this possibility and verify the robustness of the results. The complete descriptions of the covariates used can be found in Table 3.5. Lastly, household's income, if the child lives or not with parental figures, and primary caregiver's employment status are also taken into account for further tests, even if with the limitations explained above.

3.4 Empirical Evidence

Summary Statistics For the scope of the current study, and given the exogeneity constraint of the covariates required by matching procedures, the baseline specification of the model is the following. I require exact matching on childrens' grade and gender. The baseline specification will also require bias adjument for the number of children in the family unit and primary caregiver's age group. Adjusting for the bias requires the computation of a linear function of the covariates decided that is used to correct for the bias in the estimates. Even though the covariates that may be source of potential bias are not continuous as in the case by Abadie and Imbens (2011), those variables are not dichotomic. Moreover observing Table 3.6 it seems that the treated (ill sibling) and control (no ill sibling) samples show significant differences for the number of children living in the family unit, which may cause problems to the reliability of obtained estimates. As noted by Abadie and Imbens (2011), results obtained by ordinary matching estimators without bias adjustment may be very sensitive to the number of matches chosen, while correcting for the bias delivers more robust estimates. Moreover, if these covariates prove to balance after the matching procedure, obtained estimates can be considered reliable.

The final model will require the closest match possible for ethnicity, sibling gender, birth order, level of education of the primary caregiver, number of children in the family unit, and primary caregiver's 5-years age group, besides the exact matching criteria already explained. Given postestimation checks, the best model in terms of balancing covariates proved to be the 1:1 Nearest Neighbour matching, i.e. every individual in the sample is compared with one best match given the covariates. Increasing the number of required matches to two delivered the same results, however covariates did not efficiently balance as in the previous case. Finally, requiring four exact matches provided a smaller matched sample and a sensible increase in the bias of the estimates, besides worse covariates' balance already observed in the one to two matching.

Matching Results Results in Tables 3.7 and 3.8 show the estimated average treatment effect of living with an ill sibling with respect to living with a healthy sibling. Results show that any effect of this particular familiar condition on cognitive outcomes must be excluded. The model in Tables 3.7 does not present any difference both in the Woodcock-Johnson Revised Tests of Achievement scores and in the WISC Digit Span short-term memory scores.

A very different pattern is shown by noncognitive skills in Tables 3.8. Matching results highlight that living with an ill sibling seems to cause an increase in three different categories of the Big Five: Openness to Experience[4], Consciensciousness and Extraversion. The increases associated to having an ill sibling are of the size of 2.30 percentage points for Openness to Experience, 2.29 percentage points for Conscientiousness and 1.16 percentage points for Extraversion. No effect is detected on Agreeableness and Openness to Experience.

Even if having an ill sibling is the causal determinant of the observed results, many mechanisms driving this effect cannot be investigated in the current framework. For this reason I decided to check if the overall effect explained above may be differently divided among gender and birth order groups. A careful examination of different effects, if any, may provide useful insights for effective policy designs and for future investigations. Following analyses will be lead on noncognitive outcomes exclusively, since cognitive skills proved not to be affected by the treatment.

Gender Effect In order to investigate the presence of different patterns due to gender characteristics, I performed the same nearest-neighbour analysis separately on the male and female subsamples. Even though for previous results I required exact matches on gender, the observed overall effect is an average of the results between the subsamples. Repeating the estimation separately on the two groups can highligt any gender difference.

Results are shown in Table 3.9. The effect of having an ill sibling seems to differ among boys and girls. It emerges that living with an ill sibling causes an increase in Openness to Experience among girls by 2.65 percentage points. Among boys results highlight an increase in Conscientiousness among by 4.77 percentage points, and an increase in Extraversion by 1.47 percentage points. As verified in the overall results, Agreeableness and Emotional Stability are not affected.

[4]This effect in the overall sample shows a significance level of 10%

Birth Order Effect Since younger or older siblings may react differently to the presence of an ill child in the family, next analyses are performed on these two subsamples. From Table 3.10 it emerges that older siblings are not affected by the presence of an ill child. However, differently from previous results, younger children experience a reduction in Emotional Stability equal to 5.65 percentage points. This evidence seems to suggest that children might actually react differently to the presence of an ill sibling in the household according to their birth order. More specifically, while older children are not affected by causes other than the gender effect already presented, younger childern seem to be disadvantaged in terms of Emotional Stability. Different mechanisms inside the family, also depending by family roles, might be enacted according to the age difference among siblings. Unfortunately with current methodology I cannot directly investigate for the presence of this age gap effect.

Robustness Checks The following analyses are aimed at verifying the reliability of the estimates presented above.

First, I investigate the presence of a potential parents' bias in evaluating children's behavioural outcomes.

Second, I will prove that the Nearest Neighbour model provided a correct balance of the covariates. Control and treated samples after matching should be balanced in order to rely on the estimates provided so far, otherwise unbalanced samples could be a signal for biased estimates.

Third, I will discuss about alternative specifications of the baseline model and the endogenity issue regarding the number of children in the family unit.

Lastly, I will prove the robustness of the findings showing the outcomes of different estimation techniques. Even though Nearest Neighbour matching proved to be the best model in terms of bias and variability of the estimates, it is important to show if other models are able to capture the results shown in the paper. Failure of proving so could mean that the model used may be subject to some undetectable problems that cause it to deliver wrong estimates.

Evaluation Bias As discussed in Section 3.3, parents could differently evaluate the same behaviour in healthy children if they have an ill child among the offspring. Psychological literature analyzing parents' and children's pattern in evaluating behavioural problems has shown that parents tend to provide a more negative assessment of children well being (Taylor *et al.*, 2001; Sharpe and Rossiter, 2002). However, measures obtained through parents and children are not detached: the problem for obtained estimates seems to assess the size of the estimated effect, and not its actual existence. For this reason I propose the following checks: first I show the Behavioural Problem Index and Positive Behavioural Scale scores and subscores to see if the findings are coherent with literature. Then I try to assess the presence of parental misjudgement also on other measures of children's outcomes.

Results in Table 3.11 show that children are not differently judged according to the classical psychological assessment of Behavioural Problem Index and Positive Behavioural Scale. Since part of the literature is focusing on increasing internalizing behavioural problem among healthy children with a chronically ill sibling, evidence in Table 3.11 is suggesting that this is important only among younger siblings. These results show that considering more negative evaluations on children with an ill sibling suggested by previous studies, there is no actual difference considering an appropriate control group. The need to draw robust conclusions using an appropriate control group has been highlighted by several studies and is crucial for the obtained estimates and their reliability (Williams, 1997; Sharpe and Rossiter, 2002). Morover, results either in Table 3.11 and in the baseline analyses in Table 3.8, Table 3.9 and Table 3.10 show different patterns according to children's gender and birth order. Different results found at birth order and gender level are more likely to be due to children's actual differences than to biased parental evaluation mechanisms that apply only at some gender or birth order level.

Additionally, I check parental evaluation bias on other possible measures that could be affected by primarycaregiver's different evaluation of child's capabilities and characteristics. In the survey parents were asked to express the optimal level of education they would like their child to achieve. The questions on the topic were two: the first one was expressed in the following way: "In the best of all worlds, how much schooling would you like the child to complete?". The second one was asked in this terms: "Sometimes children do not get as much education as we would like. How much schooling do you expect that the child will really complete?". The former will be indicated as Preferred Education, the latter as Expected Education. Preferred Education should capture caregivers' expectations on child achievement given their qualities, and should be more biased by positive parental evaluation misjudgements. Expected Education measures the educational level the child will actually complete given some financial or personal constraints. Therefore if parents overvaluate their children, this should affect their Preferred Education, while if their undervaluate them, this should influence the Expected Education. The variables are categorical: they take value 0 for educational levels lower than high school, 1 if equal to high school and at most some post-high school vocational training, 2 if equal to college, and 3 if they include Master's degree or teaching credential program, or an MD, law, PhD, or other doctoral degree. Results in Table 3.12 show that there is no systematic evidence that caregivers evaluate their child able to obtain higher or lower educational achievement. This evidence is partially confirming the absence of parental bias in judging children when there is an ill child among the offspring.

In conclusion, the presence of a possible evaluation bias cannot be directly assessed since the survey lacks behavioural measures assessed by an external figure. Psychological literature has studied that usually parents in these particular conditions tend to provide a more negative estimate of children's behaviour. Results obtained in the main analyses have highlighted a positive effect on children's noncognitive skills. Therefore it might be that parental evaluations suffer from a downward bias, but are not likely to completely misjudge child's behaviour. Additionally, results vary by gender and birth order, which makes the possibility that the results are due to parental bias less probable. The lack of parental bias on other measures, like future educational attainment of the child, seems to exclude that the findings are due to different evaluation parameters among parents with an ill child and parents with all healthy children.

Covariates Balance Table 3.13 reports the results of covariates' balance before and after the matching procedure. Rule of thumb suggests that the standardized difference between treated and control samples after matching should be close to zero, and the variance ratio should be close to one. Obtained results show that nearly all differences and ratios are close to the advised quantities, with some problem given by the number of children in the family unit. However these results provide only raw numbers, without any confidence interval that helps determining any problem, especially in cases of low sample sizes.

For this reason Figure 3.1 shows covariates' Box plots. Covariates Balance before matching may indicate an actual random assignment of the treatment. Overall, control and treated groups reached a good balance. In both Table 3.13 and Figure 3.1 results are omitted for children's grade and gender since the model imposed exact matching, so these variables are perfectly balanced by construction.

Different specifications In order to check the robustness of the results, I repeated the analyses using different specifications of the baseline model. Table 3.14 shows results maintaining the Nearest Neighbour matching changing particular features. Results show that in the overall sample the findings of the baseline model are still confirmed without requiring bias adjustment and by increasing the number of matches to two.

About possible problems given by the endogeneity of the number of children in the family unit, first I repeat the matching without this variable, then I impose exact matching for the number of children in the family unit additional to children's age and grade. The former performs well confirming main results. Problems in the overall sample for Extraversion are not presented repeating same analyses on male sample in Table B.1. Moreover, results on the female sample and by birth order confirm evidence from the baseline specification (Table B.2, Table B.3 and Table B.4). Requiring exact matching for birth order strongly reduces sample size and decreases the quality of obtained matches in terms of other covariates' balance, therefore obtained results are not as reliable as in previous specifications. In this case main findings are not confirmed exclusively for the increase in Extraversion among boys.

Different models If the empirical model is not correctly specified, the results obtained could be sensitive to the matching method employed. Table 3.15 shows the results of the estimated effect on the Big Five dimensions using different estimation techniques. Applying Propensity Score Matching without requiring an exact match does not deliver fully satisfactory results: the model is able to detect only changes in Conscientiousness and Extraversion. This highlights the need to define the right common support before applying this technique: while Nearest Neighbour Matching with exact matches automatically creates its own matched samples, Propensity Score Matching includes the whole sample using also outliers out of the common support region and causes bias in the estimates. Results after performing a caliper matching confirm the importance of determining the correct support for the matching. The rule-of-thumb requires a caliper equal to 20% or 25% of the standard error of the estimated propensity score. Results show that following this rule and requiring a caliper equal to 0.025 brings to confirming overall results in Openness to Experience, Conscientiousness and Extraversion.

Inverse Probability Weighting Regression Adjustment (IPWRA) estimates the average treatment effect in a different way respect to the baseline model, still relying on propensity score estimation. This method has a doubly robust feature: it models separately the propensity score and the outcome, and provided that one of the two is correctly specified, obtained estimates are robust. However plain propensity score matching proved not to perform so efficiently in this context and estimating the outcome suffers from omitted variables problem. Results from IPWRA confirm only evidence on Conscientiousness and Extraversion, with a drop in significancy levels.

Lastly, Table 3.16 shows results of an Ordinary Least Squares (OLS) regression using all the baseline covariates and controls for households' income and primarycaregiver's participation to the labour market. In the first part of Table 3.16 the interaction between the presence of an ill sibling and child's gender shows that girls are basically endowed with higher levels of Conscientiousness, but only boys experience an increase in Conscientiousness and Extraversion because of the presence of an ill sibling. However in the bottom part, the interactions between birth order and the presence of an ill sibling do not deliver satisfactory results. This evidence highlights the possible bias given by unobservables that this analysis cannot account for.

3.5 Conclusions

This study aimed at providing a general description of the effects on cognitive and noncognitive skills that living with an ill sibling may exert on the healthy child. The empirical strategy chosen allows to interpret the results as causal, since applying Nearest Neighbour Matching correctly clears from the possibility of self selection into the treatment.

Observing the effect from a general point of view (Table 3.7), one can assume that living with an ill child has no effect on cognitive skills, and on the contrary it has a positive and significant effect on noncognitive skills (Table 3.8) . By categorizing children's noncognitive skills according to the Big Five Personality traits division by Costa and McCrae (1992), results show a clear increase in Openness to Experience, Conscientiousness and Extraversion, while Agreeablenss and Emotional Stability are unaffected. However, for the scope of the current study it seemed more interesting checking if the overall effect may be decomposed into different gender or birth order effects.

At the gender level a clear path emerged: due to the "treatment" boys experienced an increase in Conscientiousness and Extraversion, while girls experienced an increase in Openness to Experience. At the same time, younger children experience a decrease in Emotional Stability. Therefore even though aggregated results showed an overall positive effect on noncognitive skills, disaggregating by gender and birth order highlighted different patterns.

At the stage of the current analysis one can only speculate on the causes of such differences. Estimates were obtained by requiring exact matches on gender and grade. This decision appeared fundamental in light of the intristic gender differences in noncognitive traits: women are usually endowed with higher levels of Conscientiousness, Extraversion, Agreeableness and lower levels of Emotional Stability (Schmitt *et al.*, 2008). It seems that being exposed to the treatment in this case enriched both genders of the personality traits they lacked: females show higher levels of Openness to Experience, while males have higher levels of Conscientiousness. Interestingly, younger children are the only category that reacts negatively to the presence of an ill sibling.

The reasons behind this effect, and its difference among gender and birth order groups may be several.

First of all, given equal familiar conditions and stimuli, boys and girls may react differently and show unequal modifications of personality traits. Differences in children reaction to the presence of an ill sibling according to their gender has already been observed in psychological literature (Taylor *et al.*, 2001; Nielsen *et al.*, 2012). However the results obtained highlight what aspects of the Big Five are triggered by being exposed to this particular household situation. Evidence on younger children seems to confirm previous findings in medical literature. For example younger siblings of children with autism or other intellectual disabilities usually show greater behavioural problems (Breslau, 1982; McHale *et al.*, 1989; Hastings, 2003).

Another possibility is that parents, of any other caregiver in charge, may be responsible for this difference through a different approach to male and female offspring when facing particular situations in the household. Different parental attitude may results in different noncognitive outcomes, as the linked between the two is identified in Fiorini and Keane (2014). Further investigations are needed to explore familiar reaction to particular household's conditions, like the presence of a chronically ill child in this case.

Moreover, exploring such differences in personality traits can be helpful also in a prospective point of view: according to literature such changes may be reflected in future socioeconomic and labour market outcomes. In the study by Jacob (2002) one of the reasons behind the higher rate in college attendance among girls regards the lower Conscientiousness endowment among boys[5]. Lleras (2008) finds evidence of the direct role of Conscientiousness measured at tenth grade in predicting educational attainments ten years later. Therefore it seems that following these children may detect if higher levels of Conscientiousness may be associated to future schooling outcomes like lower levels of high school dropout, higher enrollment rates in college, grades and college graduation probability. Similarly, it would be interesting to follow the female sample to check if different changes in personality traits are reflected in some specific attainments in schooling and socioeconomic outcomes.

Even though uncertainty remains also in interpreting the results on Extraversion among boys, psychological literature may offer a useful hint. When investigating the ability of children affected by Autism Spectrum Disorders to relate to other people and to interpret others' emotions, intentions and beliefs, O'Brien *et al.* (2011) find that children with a healthy sibling were disadvantaged. According to the authors, the effect is caused by healthy children overcompensating for their ill sibling in social interactions, limiting ill children's possibilities in interacting with the others. This piece of evidence allows for a possible direct causal interpretation: healthy children react to having an ill sibling by showing higher levels of Extraversion.

Finally, the need to disentangle the direct effect of having an ill sibling from the mediated effect, i.e. given by different parental stimuli and attitude, is crucial also for policy implicatios. Given the positive effect that living with an ill sibling has on noncognitive skills, the mechanisms behind may provide useful insights in shaping programmes aimed at increasing noncognitive skills among children. Assessing the presence of a direct effect would mean that children are responsive to others' difficulties, therefore exposing them to particular conditions may shape their personality in a positive manner. On the contrary, the mediated effect would require a deeper understanding of what parental attitudes and what familiar stimuli children receive that are capable of enriching them with higher noncognitive skills. This would call for programmes aimed at informing caregivers about more effective parenting styles.

[5] Jacob (2002) in his work does not talk about Conscientiousness directly, however he proxies noncognitive skills with grades and disciplinary incidents during school years.

Bibliography

Abadie, A. and Imbens, G. W. (2006). Large Sample Properties of Matching Estimators. *Econometrica*, **74** (1), 235–267. 3.3

— and — (2008). On the Failure of the Bootstrap for Matching Estimators. *Econometrica*, **76** (6), 1537–1557. 3.3

— and — (2011). Bias-Corrected Matching Estimators for Average Treatment Effects. *Journal of Business & Economic Statistics*, **29** (1), 1–11. 3.4

Alderfer, M. A., Long, K. A., Lown, E. A., Marsland, A. L., Ostrowski, N. L., Hock, J. M. and Ewing, L. J. (2010). Psychosocial adjustment of siblings of children with cancer : a systematic review. *Psycho-oncology*, **19** (October 2009), 789–805. 3.2.1

Almlund, M., Heckman, J., Duckworth, A. L. and Kautz, T. (2011). Personality Psychology and Economics. pp. 1–254. 3.1, 3.2.1, 3.2.2, 3.2.3, 3.3, 3.1

Becker, G. S. (1991). *A Treatise of the Family*. Cambridge, MA: Harvard University Press. 3.1, 3.2.1

— and Lewis, H. G. (1973). Interaction between Quantity and Quality of Children. *Journal of Political Economy*, **81** (2), S279–S288. 3.1, 3.2.1

— and Tomes, N. (1976). Child Endowments and the Quantity and Quality of Children. *Journal of Political Economy*, **84** (S4), S143. 3.1, 3.2.1

Behncke, S. (2012). How do shocks to non-cognitive skills affect test scores? *Annals of Economics and Statistics/ANNALES D'ÉCONOMIE ET DE STATISTIQUE*, pp. 155–173. 3.2.2

Borghans, L., Duckworth, A. L., Heckman, J. J. and ter Weel, B. (2008). The Economics and Psychology of Personality Traits. *Journal of Human Resources*, **43** (4), 972–1059. 3.1, 3.2.2

Boyle, C. a., Boulet, S., Schieve, L. a., Cohen, R. a., Blumberg, S. J., Yeargin-Allsopp, M., Visser, S. and Kogan, M. D. (2011). Trends in the prevalence of developmental disabilities in US children, 1997-2008. *Pediatrics*, **127** (6), 1034–1042. 3.3

Breslau, N. (1982). Siblings of disabled children: Birth order and age-spacing effects. *Journal of Abnormal Child Psychology*, **10** (1), 85–95. 3.5

Caliendo, M. and Kopenig, S. (2008). Some Practical Guidance for the Implementation of Propensity Score Matching. *Journal of Economic Surveys*, **22** (1), 31–72. 3.3

Carneiro, P., Crawford, C. and Goodman, a. (2007). *The Impact of Early Cognitive and Non-Cognitive Skills on Later Outcomes*. October, Centre for Economics of Education. 3.2.3

— and Rodrigues, M. (2009). Evaluating the Effect of Maternal Time on Child Development Using the Generalized Propensity Score. *Institute for the Study of Labor, 12th IZA European Summer School in Labor Economics*. 3.2.2

Caspi, A., Harrington, H., Milne, B., Amell, J. W., Theodore, R. F. and Moffitt, T. E. (2003). Children's behavioral styles at age 3 are linked to their adult personality traits at age 26. *Journal of personality*, **71** (4), 495–513. 3.2.3

Cawley, J., Heckman, J. and Vytlacil, E. (1998). Cognitive Ability and the Rising Return to Education. *NBER Working Paper Series*, (Working Paper 6388). 3.1

—, — and — (2001). Three observations on wages and measured cognitive ability. *Labour Economics*, **8** (4), 419–442. 3.1

Costa, P. T. and McCrae, R. R. (1992). *Revised Neo Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI)*. Psychological Assesment Resources. 3.2.2, 3.5, 3.1

Cunha, F. and Heckman, J. J. (2008). Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation. *Journal of Human Resources*, **43** (4), 738–782. 3.2.3

Del Bono, E., Francesconi, M., Kelly, I. and Sacker, A. (2014). Early Maternal Time Investment and Early Maternal Time Investment and Early Child Outcomes. *IZA Discussion Paper Series*, (8608). 3.2.2

Fiorini, M. and Keane, M. P. (2014). How the allocation of children's time affects cognitive and noncognitive development. *Journal of Labor Economics*, **32** (4), pp. 787–836. 3.2.1, 3.2.2, 3.5

Goudie, a., Havercamp, S., Jamieson, B. and Sahr, T. (2013). Assessing Functional Impairment in Siblings Living With Children With Disability. *Pediatrics*, **132** (2), e476–e483. 3.2.1

Gough, H. G. and Heilbrun, A. B. (1983). *The adjective check list manual*. Consulting Psychologists Press. 3.1

Hannah, M. E. and Midlarsky, E. (1985). Siblings of the handicapped: A literature review for school psychologists. *School Psychology Review*. 3.1

Hastings, R. P. (2003). Behavioral Adjustment of Siblings of Children with Autism Engaged in Applied Behavior Analysis Early Intervention Programs : The Moderating Role of Social Support. *Journal of Austism and Developmental DIsorders*, **33** (2), 141–150. 3.2.1, 3.5

Heckman, J., Pinto, R. and Savelyev, P. (2013). Understanding the Mechanisms Through Which an Influential Early Childhood Program Boosted Adult Outcomes. *American Economic Review*, **103** (6), 2052–2086. 3.1

Heckman, J. J. (2008). Schools, skills, and synapses. *Economic Inquiry*, **46** (3), 289–324. 3.2.2

—, Stixrud, J. and Urzua, S. (2006). The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior. *National Bureau of Economic Research*, (September 2005). 3.1

Heineck, G. and Anger, S. (2010). The returns to cognitive abilities and personality traits in Germany. *Labour Economics*, **17** (3), 535–546. 3.2.2

Jacob, B. a. (2002). Where the boys aren't: Non-cognitive skills, returns to school and the gender gap in higher education. *Economics of Education Review*, **21** (6), 589–598. 3.1, 3.3, 3.5, 5

John, O. P., Caspi, a., Robins, R. W., Moffitt, T. E. and Stouthamer-Loeber, M. (1994). The "little five": Exploring the nomological network of the five-factor model of personality in adolescent boys. *Child Development*, **65** (1), 160–178. 3.3

— and Srivastava, S. (1999). The big five trait taxonomy: History, measurement, and theoretical perspectives. *Handbook of personality: Theory and research*, **2** (1999), 102–138. 3.1

Knecht, C., Hellmers, C. and Metzing, S. (2015). The Perspective of Siblings of Children With Chronic Illness: A Literature Review. *Journal of pediatric nursing*, **30** (1), 102–116. 3.2.1

Lindqvist, E. and Westman, R. (2011). The Labor Market Returns to Cognitive and Noncognitive Ability: Evidence from the Swedish Enlistment. *American Economic Journal: Applied Economics*, **3**, 101–128. 3.1

Lleras, C. (2008). Do skills and behaviors in high school matter? The contribution of noncognitive factors in explaining differences in educational attainment and earnings. *Social Science Research*, **37** (3), 888–902. 3.5

Mainieri, T. (2006). The panel study of income dynamics child development supplement: User guide for cds-ii. *Ann Arbor, MI: Institute for Social Research, University of Michigan*. 3.3, 3.3, 3.2, 3.5

McHale, S. M., Gamble, W. C. and Pawletko, T. M. (1989). *Sibling Relationships and Adjustment in Children with Disabled and Nondisabled Brothers and Sisters*. Tech. rep., Society for Research in Child Development, Kansas City, MO. 3.5

McKeever, P. (1983). Siblings of Chronically Ill Children : s Literature Review with Implications for Rsearch and Practice. *American Journal of Orthopsychiatry*, **53** (2), 209–218. 3.1

Measelle, J. R., John, O. P., Ablow, J. C., Cowan, P. a. and Cowan, C. P. (2005). Can children provide coherent, stable, and valid self-reports on the big five dimensions? A longitudinal study from ages 5 to 7. *Journal of Personality and Social Psychology*, **89** (1), 90–106. 3.3

Morgan, P. L., Frisco, M., Farkas, G. and Hibel, J. (2013). A Propensity Score Matching Analysis of the Effects of Special Education Services. *Journal of Special Education*, **43** (4), 236–254. 3.3

Mueller, G. and Plug, E. (2006). Estimating the effect of personality on male-female earnings. *Industrial and Labor Relations Review*, **60** (1), 3–22. 3.2.2

Neidell, M. J. (2000). Early Parental Time Investments in Children's Human Capital Development: Effects of Time in the First Year on Cognitive and Non-cognitive Outcomes. Los Angeles: University of California. 3.2.2

Nielsen, K. M., Mandleco, B., Roper, S. O., Cox, A., Dyches, T. and Marshall, E. S. (2012). Parental Perceptions of Sibling Relationships in Families Rearing a Child With a Chronic Condition. *Journal of Pediatric Nursing*, **27** (1), 34–43. 3.2.1, 3.5

Nyhus, E. K. and Pons, E. (2005). The effects of personality on earnings. *Journal of Economic Psychology*, **26** (3 SPEC. ISS.), 363–384. 3.2.2

O'Brien, K., Slaughter, V. and Peterson, C. C. (2011). Sibling influences on theory of mind development for children with ASD. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, **52** (6), 713–719. 3.5

Peterson, J. L. and Zill, N. (1986). Marital Disruption , Parent-Child Relationships , and Behavior Problems in Children. *Journal of Marriage and Family*, **48** (2), 295–307. 3.3

Polit, D. (1998). The positive behavior scale. *Saratoga Springs, NY: Humanalysis*. 3.3

Poropat, A. E. (2009). A Meta-Analysis of the Five-Factor Model of Personality and Academic Performance. *Psychological Bulletin*, **135** (2), 322–338. 3.2.2

Prevoo, T. and ter Weel, B. (2004). The Importance of Early Conscientiousness for Socio-Economic Outcomes. Evidence from the British Cohort Study. *Economic Policy*, (25), 1–46. 3.2.3

Price, J. (2008). Parent-Child Quality Time Does Birth Order Matter? *The Journal of Human Resources*, **43** (1), 240–265. 3.2.1

Roberts, B. W. and DelVecchio, W. F. (2000). The rank-order consistency of personality traits from childhood to old age: a quantitative review of longitudinal studies. *Psychological bulletin*, **126** (1), 3–25. 3.2.3

Rossiter, L., Sharpe, D. and Ph, D. (2001). The Siblings of Individuals with Mental Retardation : A Quantitative Integration of the Literature. *Journal of Child and Family Studies*, **10** (1), 65–84. 3.3

Schmitt, D. P., Realo, A., Voracek, M. and Allik, J. (2008). Why can't a man be more like a woman? Sex differences in big five personality traits across 55 cultures. *Journal of Personality and Social Psychology*, **96** (1), 168–182. 3.3, 3.5

Sharpe, D. and Rossiter, L. (2002). Siblings of children with a chronic illness: a meta-analysis. *Journal of Pediatric Psychology*, **27** (8), 699–710. 3.2.1, 3.3, 3.4

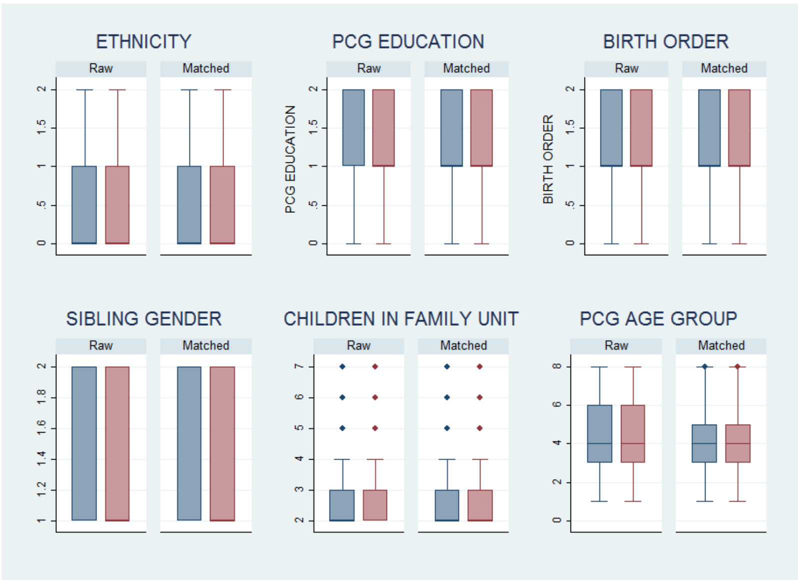
Taylor, Fuggle, P. and Charman, T. (2001). Well Sibling Psychological Adjustment to Chronic Physical Disorder in a Sibling: how Important is Maternal Awareness of their Illness Attitudes and Perceptions? *Journal of child psychology and psychiatry, and allied disciplines*, **42** (7), 953–62. 3.3, 3.4, 3.5

Weisberg, Y. J., De Young, C. G. and Hirsh, J. B. (2011). Gender differences in personality across the ten aspects of the Big Five. *Frontiers in Psychology*, **2** (August), 1–11. 3.3

Wilkins, K. L. and Woodgate, R. L. (2005). A review of qualitative research on the childhood cancer experience from the perspective of siblings: A need to give them a voice. *Journal of Pediatric Oncology Nursing*, **22** (6), 305–19. 3.2.1

Williams, P. D. (1997). Siblings and pediatric chronic illness: a review of the literature. *International journal of nursing studies*, **34** (4), 312–323. 3.2.1, 3.4

Fig. 3.1 – Covariates' Box plots



Note: Covariates' Box plots after baseline Nearest Neighbour Matching. Blue : control sample (healthy children with a healthy sibling). Red: treated sample (healthy children with an ill sibling).

Table 3.1 – Big Five Personality Traits, description and childhood characteristics

Personality Factor	Description	Facets	Childhood Temperament Traits
Openness to Experience	"the tendency to be open to new aethetic, cultural, or intellectual experiences"	Fantasy (imaginative) Aesthetic (artistic) Feelings (excitable) Actions (wide interest) Ideas (curious) Values (unconventional)	Sensory sensitivity Pleasure in low-intensity activities Curiosity
Conscientious-ness	"the tendency to be organized, responsible, and hardworking"	Competence (efficient) Order (organized) Dutifulness (not careless) Acheivement striving (ambitious) Self-discipline (not lazy) Deliberation (not impulsive)	Attention/(lack of) distractibility Effortful control Impulse control/delay of gratification Persistence Activity*
Extraversion	"an orientation of one's interests and energies toward the outer world of people and things rather than the inner world of subjective experience; characterized by positive affect and sociability"	Warmth (friendly) Gregariousness (sociable) Assertiveness (self-confident) Activity (energetic) Excitement seeking (adventurous) Positive emotions (enthusiastic)	Surgency Social dominance Social vitality Sensation seeking Shyness* Activity* Positive emotionality Sociability/affiliation
Agreeableness	"the tendency to act in a cooperative, unselfish manner"	Trust (forgiving) Straight-forwardness (not demanding) Altruism (warm) Compliance (not stubborn) Modesty (not show-off) Tender-mindedness (sympathetic)	Irritability* Aggressiveness Willfulness
Neuroticism/ Emotional Stability	Emotional stability: "predicatibility and consistency in emotional reactions, with absence of rapid mood changes". Neuroticism: chronic level of emotional instability and proness to psychological distress"	Anxiety (worrying) Hostility (irritable) Depression (not content) Self-consciousness (shy) Implusiveness (moody) Vulnerability to stress (not self-confident)	Fearfulness/ behavioral inhibition Shyness* Irritability* Frustration (Lack of) soothability Sadness

Notes: Table taken from Almlund *et al.* (2011) with some modifications, and originally adapted from John and Srivastava (1999). Facets are specified by the NEO-PI-R personality inventory (Costa and McCrae, 1992), trait adjectives in parentheses from the Adjective Check List (Gough and Heilbrun, 1983). *These temperament traits may be related to two Big Five factors.

Table 3.2 – Behavioral Problem Index and Positive Behavioral scale, items and reclassification

Item	Question: For the next set of statements, decide whether they are not true, sometimes true, or often true, of (CHILD)'s behavior. He/She:	Personality trait
Behavioral Problem Index:		
Moodswings	has sudden changes in mood or feeling.	Emotional Stability
No love	feels or complains that no one loves him/her.	Emotional Stability
High Strung	is rather high strung, tense and nervous.	Emotional Stability
Cheats	cheats or tells lies.	Conscientiousness
Fearful	is too fearful or anxious.	Emotional Stability
Argues too much	argues too much.	Emotional Stability
Difficulty concentrating	has difficulty concentrating, cannot pay attention for long.	Conscientiousness
Easily confused	is easily confused, seems to be in a fog.	Conscientiousness
Bullies	bullies or is cruel or mean to others.	Agreebleness
Disobedient	is disobedient.	Conscientiousness
Feels no regret	does not seem to feel sorry after misbehaves.	Agreebleness
Trouble getting along	has trouble getting along with other people (his/her) age.	Extraversion
Impulsive	is impulsive, or acts without thinking.	Conscientiousness
Feels worthless	feels worthless or inferior.	Emotional Stability
Not liked	is not liked by other people (his/her) age.	Extraversion
Has obsessions	has a lot of difficulty getting (his/her) mind off certain thoughts.	Emotional Stability
Overactive	is restless or overly active, cannot sit still.	Emotional Stability
Stubborn	is stubborn, sullen, or irritable.	Agreebleness
Strong tempered	has a very strong temper and loses it easily.	Emotional Stability
Sad	is unhappy, sad or depressed.	Emotional Stability
Withdrown	is withdrown, does not get involved with others.	Extraversion
Destructive	breaks things on purpose or deliberately destroys (his/her) own or another's things.	Agreebleness
Clings to adults	clings to adults.	Emotional Stability
Cries too much	cries too much.	Emotional Stability
Demands attention	demands a lot of attention.	Emotional Stability
Dependent	is too dependent on others.	Emotional Stability
Paranoid	feels others are out to get (him/her).	Emotional Stability
Hangs around trouble	hangs around with kids who get into trouble.	Agreebleness
Secretive	is secretive, keeps things to (himself/herself).	Extraversion
Worries too much	worries too much.	Emotional Stability
Disobedient at school	is disobedient at school.	Agreebleness
Trouble with teachers	has trouble getting along with teachers.	Agreebleness
Positive Behavioral Scale:		
Cheerful	Is cheerful, happy.	Extraversion
Waits turn	Waits (his/her) turn in games and other activities.	Conscientiousness
Careful work	Does neat, careful work.	Conscientiousness
Curious	Is curious and exploring, likes new experiences.	Openness to Experience
Not impulsive	Thinks before (he/she) acts, is not impulsive.	Conscientiousness
Gets along with the others	Gets along well with other people (his/her) age.	Extraversion
Listens	Usually does what you tell (him/her) to do.	Agreebleness
Gets over upset	Can get over being upset quickly.	Agreebleness
Well-liked	Is admired and well-liked by other people (his/her) age.	Extraversion
Self-reliant	Tries to do things for (himself/herself), is self-reliant.	Extraversion

Note: Items and associate questions taken from Mainieri (2006).

Table 3.3 – Big Five Personality Traits categories, factor loadings

Conscientiousness

Variable	Factor loading
Cheats	-0.5398
Difficulty concentrating	-0.6821
Easily confused	-0.5505
Disobedient	-0.5456
Impulsive	-0.6385
Waits turn	0.4903
Careful work	0.4972
Not Impusive	0.6086
Number of items	8
Cronbach's alpha	0.7941
Number of obs	2902

Agreebleness

Variable	Factor loading
Bullies	-0.5791
Feels no regret	-0.5033
Stubborn	-0.5468
Destructive	-0.4748
Hangs around trouble	-0.4849
Disobedient at school	-0.6465
Trouble with teachers	-0.596
Gets over upset	0.3871
Listens	0.5508
Number of items	9
Cronbach's alpha	0,769
Number of obs	2906

Extraversion

Variable	Factor loading
Cheerful	0.502
Gets along with the others	0.7835
Well liked	0.7496
Self reliant	0.3417
Trouble getting along	-0.6769
Not liked	-0.4982
Withdrown	-0.4655
Secretive	-0.3498
Number of items	8
Cronbach's alpha	0.762
Number of obs	2902

Emotional Stability*

Variable	Factor loading
Mood swings	0.5623
No love	0.5724
High strung	0.6096
Feels worthless	0.4967
Has obsessions	0.4938
Overactive	0.5096
Strong tempered	0.6085
Argues too much	0.5291
Sad	0.5763
Clings to adults	0.36
Cries too much	0.4189
Demands attention	0.5802
Dependent	0.5
Paranoid	0.4984
Worries too much	0.5052
Fearful	0.5352
Number of items	16
Cronbach's alpha	0.8531
Number of obs	2907

Note: results of confirmatory factor analysis are lead on each group separately. In each group items loades on only one factor (eigenvalue>1). In order to be included in the category the imposed loading threshold was 0.3. *all items are expressed according to Neuroticism, reversed for scoring.

Table 3.4 – Cognitive and Noncogntive outcomes, sample statistics and t-tests

	Whole sample			No Ill sibling			Ill sibling			
Variable	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Difference
Cognitive Outcomes										
Woodcock-Johnson Tests of Achievement:										
Letter-Word Score	918	501.761	1.230	782	500.919	1.335	136	506.603	3.136	-5.684
Passage Comprehension Score	888	502.011	0.787	756	501.527	0.860	132	504.788	1.923	-3.261
Broad Reading Score	886	503.527	0.912	754	502.964	0.988	132	506.742	2.365	-3.778
Applied Problems Score	916	504.776	0.933	780	504.391	1.011	136	506.985	2.420	-2.594
WISC Digit Span Test:										
Digit Total Score	915	14.456	0.140	780	14.333	0.151	135	15.163	0.367	-0.830 **
Digit Forward Score	915	9.356	0.083	780	9.292	0.090	135	9.726	0.223	-0.434 *
Digit Backward Score	915	5.099	0.079	780	5.041	0.087	135	5.437	0.197	-0.396 *
Noncognitive outcomes										
Openness to Experience	1,003	0.963	0.006	853	0.964	0.006	150	0.960	0.016	0.004
Conscientiousness	1,001	0.938	0.004	851	0.935	0.005	150	0.954	0.009	-0.019
Extraversion	998	0.976	0.003	848	0.976	0.003	150	0.974	0.008	0.002
Agreeableness	1,001	0.960	0.003	851	0.962	0.003	150	0.950	0.009	0.012
Emotional Stability	993	0.942	0.004	843	0.944	0.004	150	0.929	0.011	0.016

Note: "Whole Sample" is composed of all CDSII children with a sibling with a complete interview in CDSII and never diagnosed for Special Education needs. "No Ill Sibling" comprises all healthy children with a sibling that has never been diagnosed for Special Education needs. "Ill Sibling" subsample is composed of all healthy children with a sibling that has been diagnosed for Special Education needs. Last column presents results of a t-test of mean comparison among "No Ill Sibling" and "Ill Sibling" subgroups. *** p<0.01, ** p<0.05, * p<0.1

Table 3.5 – Variables description

Variable	Codification	Survey	Reference year
Child characteristics:			
Ill sibling	1 Sibling evercalssified in need for special education; 0 otherwise	CDSII	2002
Gender	0 Male; 1 Female	PSID Individual-level	-
Ethnicity	0 White; 1 Afro-American; 2 All the rest	CDSI	1997
Grade	1-14 Actual grade in school	CDSII	2002
Birth year	Exact year of birth	PSID Individual-level	2001
Order	0 Twins; 1 Older sibling; 2 Younger sibling	calculated from birth year	-
Family characteristics			
PCG Education	Primary caregiver education level: 0 < high school; 1 high school; 2> high school	PSID Individual-level	2001
PCG Age Group	Primary caregiver five years' age group. Primary caregiver's age calculated as difference between birth year and year of the interview (2002). Five years' age group categorizes as: 1: 21-25 years old; 2: 26-30 years old; 3: 31-35 years old; 4: 36-40 years old; 5:41-45 years old; 6: 46-50 years old; 7: 51-55 years old; 8: 56-60 years old; 9: above 61 years old. Minimum PCG's age is 21.	PSID Individual-level	2001
OCG Education	Secondary caregiver education level: 0 < high school; 1 high school; 2> high school	PSID Individual-level	2001
Children in FU	Number of children living in the family unit	PSID Family-level	2001
Sibling gender	1 Male; 2 Female	PSID Individual-level	-
Living condition variables:			
Mother figure (cathegorical)	1 child living with biological or adoptive mother; 2 living with any other mother figure; 0 otherwise	CDSII (own elaboration)	2002
Father figure (cathegorical)	1 child living with biological or adoptive father; 2 living with any other father figure; 0 otherwise	CDSII (own elaboration)	2002
Possible endogenous controls:			
PCG Employment	1 currently working; 0 otherwise	PSID Individual-level	2001
Income	quartiles of income distribution: 0 first quartile, 1 second quartile, 2 third quartile, 3 fourth quartile	PSID Family-level	2003 (but referred to 2002)
Behavioural Indexes			
BPI - Total	Total Behavioural Problem Index (BPI) score: sum of externalizing internalizing subscores, ranges from 0 to 30. Further information on Mainieri (2006).	CDSII	2002
BPI - Externalizing	Subscore of BPI measuring children's external or aggressive behaviour. Final score range is between 0 and 17	CDSII	2002
BPI - Internalizing	Subscore of BPI measuring children's internal or withdrawn behaviour. The final score is expressed in the range 0-14.	CDSII	2002
PBS - Total	Positive Behavior Scale score aimed at measuring children's positive aspects of life like self-esteem and social competence. Further information on Mainieri (2006). The final score is expressed in a 1-5 continuum.	CDSII	2002

Table 3.6 – Covariates sample statistics and t-tests

	Whole Sample			No Ill Sibling			Ill Sibling			
	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Difference
Gender										
Male	1003	0.477	0.016	853	0.492	0.017	150	0.387	0.040	0.106 **
Female	1003	0.523	0.016	853	0.508	0.017	150	0.613	0.040	-0.106 **
Grade										
1st	1003	0.066	0.008	853	0.072	0.009	150	0.033	0.015	0.038 *
2nd	1003	0.088	0.009	853	0.087	0.010	150	0.093	0.024	-0.007
3rd	1003	0.092	0.009	853	0.094	0.010	150	0.080	0.022	0.014
4th	1003	0.107	0.010	853	0.104	0.010	150	0.120	0.027	-0.016
5th	1003	0.093	0.009	853	0.095	0.010	150	0.080	0.022	0.015
6th	1003	0.111	0.010	853	0.123	0.011	150	0.040	0.016	0.083 ***
7th	1003	0.095	0.009	853	0.095	0.010	150	0.093	0.024	0.002
8th	1003	0.079	0.009	853	0.076	0.009	150	0.093	0.024	-0.017
9th	1003	0.080	0.009	853	0.076	0.009	150	0.100	0.025	-0.024
10th	1003	0.063	0.008	853	0.057	0.008	150	0.093	0.024	-0.036 *
11th	1003	0.054	0.007	853	0.049	0.007	150	0.080	0.022	-0.031
12th	1003	0.034	0.006	853	0.027	0.006	150	0.073	0.021	-0.046 ***
13th	1003	0.041	0.006	853	0.045	0.007	150	0.020	0.011	0.025
Ethnicity										
White	1001	0.549	0.016	853	0.553	0.017	148	0.527	0.041	0.026
Black	1001	0.313	0.015	853	0.313	0.016	148	0.311	0.038	0.002
All the rest	1001	0.138	0.011	853	0.134	0.012	148	0.162	0.030	-0.029
PCG Education										
< high school	954	0.124	0.011	810	0.106	0.011	144	0.222	0.035	-0.116 ***
high school	954	0.384	0.016	810	0.389	0.017	144	0.354	0.040	0.035
> high school	954	0.493	0.016	810	0.505	0.018	144	0.424	0.041	0.081 *
PCG Age Group										
21-25	1003	0.009	0.003	853	0.009	0.003	150	0.007	0.007	0.003
26-30	1003	0.101	0.010	853	0.107	0.011	150	0.067	0.020	0.040
31-35	1003	0.174	0.012	853	0.166	0.013	150	0.220	0.034	-0.054
36-40	1003	0.258	0.014	853	0.259	0.015	150	0.253	0.036	0.006
41-45	1003	0.200	0.013	853	0.203	0.014	150	0.187	0.032	0.016
46-50	1003	0.077	0.008	853	0.077	0.009	150	0.080	0.022	-0.003
51-55	1003	0.021	0.005	853	0.019	0.005	150	0.033	0.015	-0.015
56-60	1003	0.004	0.002	853	0.004	0.002	150	0.007	0.007	-0.003
60+	1003	0.155	0.011	853	0.156	0.012	150	0.147	0.029	0.009
Birth Order										
Twins	1002	0.027	0.005	852	0.028	0.006	150	0.020	0.011	0.008
Older	1002	0.485	0.016	852	0.477	0.017	150	0.533	0.041	-0.057
Younger	1002	0.488	0.016	852	0.495	0.017	150	0.447	0.041	0.049
Sibling Gender										
Male	1003	0.506	0.016	853	0.485	0.017	150	0.627	0.040	-0.141 ***
Female	1003	0.494	0.016	853	0.515	0.017	150	0.373	0.040	0.141 ***
Children in the Family Unit										
Two	1003	0.626	0.015	853	0.658	0.016	150	0.447	0.041	0.211 ***
Three	1003	0.292	0.014	853	0.279	0.015	150	0.367	0.039	-0.088 **
Four	1003	0.057	0.007	853	0.052	0.008	150	0.087	0.023	-0.035 *
Five	1003	0.017	0.004	853	0.007	0.003	150	0.073	0.021	-0.066 ***
Six	1003	0.005	0.002	853	0.002	0.002	150	0.020	0.011	-0.018 ***
Seven	1003	0.002	0.001	853	0.001	0.001	150	0.007	0.007	-0.005
Eight	1003	0.001	0.001	853	0.001	0.001	150	0.000	0.000	0.001

Note: "Whole Sample" is composed of all CDSII children with a sibling with a complete interview in CDSII and never diagnosed for Special Education needs. "No Ill Sibling" comprises all healthy children with a sibling that has never been diagnosed for Special Education needs. "Ill Sibling" subsample is composed of all healthy children with a sibling that has been diagnosed for Special Education needs. Last colum present results of a t-test of mean comparison among "No Ill Sibling" and "Ill Sibling" subgroups. *** p<0.01, ** p<0.05, * p<0.1

Table 3.7 – Cognitive outcomes, results

	(1)	(2)	(3)	(4)
Woodcock-Johnson Tests of Achievement:				
Outcome Variable	**Letter-Word**	**Passage Comprehension**	**Broad Reading**	**Applied Problems**
ATE	2.831	-0.425	0.578	0.107
Std. Err.	(2.579)	(1.644)	(1.917)	(1.771)
Obs. 769	751	750	767	

	(5)	(6)	(7)
WISC Digit Span Test:			
Outcome Variable	**Digit score (total)**	**Digit Forward**	**Digit Backward**
ATE	0.268	0.119	0.148
Std. Err.	(0.394)	(0.282)	(0.210)
Obs.	765	765	765

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unity and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.8 – Noncognitive outcomes, results

	(1)	(2)	(3)	(4)	(5)
Outcome Variable	**Openness to Experience**	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
ATE	0.0230*	0.0229**	0.0116**	-0.00194	-0.0123
Std. Err.	(0.0118)	(0.0102)	(0.00530)	(0.00903)	(0.0115)
Obs.	839	838	834	837	832

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's educational level. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.9 – Noncognitive outcomes, results dividing by gender

Male sample	(1a)	(2a)	(3a)	(4a)	(5a)
	Openness to Experience	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
ATE	0.0218	0.0477***	0.0147**	-0.00935	-0.000534
Std. Err.	(0.0244)	(0.0131)	(0.00627)	(0.0148)	(0.0139)
Obs.	377	377	375	377	374

Female sample	(1b)	(2b)	(3b)	(4b)	(5b)
	Openness to Experience	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
ATE	0.0265***	0.00705	0.00726	-0.000577	-0.0196
Std. Err.	(0.0102)	(0.0151)	(0.00804)	(0.0112)	(0.0179)
Obs.	462	461	459	460	458

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. rows "a"' (1a-5a) and "b" (1b-5b) present the results repeating the analysis respectively on the male and female subsamples. Robust standard errors in parentheses.. *** p<0.01, ** p<0.05, * p<0.1

Table 3.10 – Noncognitive outcomes, results dividing by birth order

Older siblings sample	(1a) **Openness to Experience**	(2a) **Conscientiousness**	(3a) **Extraversion**	(4a) **Agreeableness**	(5a) **Emotional Stability**
ATE	0.0197	0.00330	0.0138	-0.0237	-0.000933
Std. Err.	(0.0416)	(0.0184)	(0.0126)	(0.0190)	(0.0179)
Obs.	261	260	259	260	258

Younger siblings sample	(1b) **Openness to Experience**	(2b) **Conscientiousness**	(3b) **Extraversion**	(4b) **Agreeableness**	(5b) **Emotional Stability**
ATE	0.0238*	0.0270	0.00464	-0.0109	-0.0565**
Std. Err.	(0.0135)	(0.0180)	(0.00779)	(0.0182)	(0.0243)
Obs.	241	241	239	240	240

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. row"a"' (1a-5a) present the results repeating the analysis only on older children. row "b" (1b-5b) presents the anlaysis repeating the same estimations only on the younger siblings sample.Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.11 – BPI and PBS, results on total scores and subscores

	Behavioural Problem Index			**Positive Behavioural Scale**
	Total Score	Externalizing	Internalizing	Total Score
Total Sample	(1)	(2)	(3)	(4)
ATE	0.483	0.137	0.364	0.0384
Std. Err.	(0.656)	(0.410)	(0.337)	(0.0548)
Obs.	827	836	829	839
Male Sample	(5)	(6)	(7)	(8)
ATE	0.217	0.178	0.121	0.118
Std. Err.	(0.987)	(0.671)	(0.447)	(0.0871)
Obs.	373	377	373	377
Female Sample	(9)	(10)	(11)	(12)
ATE	0.297	-0.0357	0.316	-0.00697
Std. Err.	(0.874)	(0.503)	(0.494)	(0.0709)
Obs.	454	459	456	462
Older Children	(13)	(14)	(15)	(16)
ATE	0.398	-0.104	0.475	0.0314
Std. Err.	(1.108)	(0.703)	(0.552)	(0.0877)
Obs.	256	259	257	261
Younger Chidren	(17)	(18)	(19)	(20)
ATE	1.982*	0.967	1.117**	-0.0299
Std. Err.	(1.022)	(0.657)	(0.511)	(0.102)
Obs.	238	240	239	241

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Analyses conducted on the overall sample (1-4), male sample (5-8), female sample (9-12), older children sample (13-14) and younger children sample (17-20). Robust Standard Errores in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.12 – Preferred and Expected Education Results

	Preferred Education	Expected Education
Total Sample	(1)	(2)
ATE	0.0350	0.0532
Std. Err.	(0.0628)	(0.0685)
Obs.	835	832
Male Sample	(3)	(4)
ATE	0.0356	0.0807
Std. Err.	(0.113)	(0.103)
Obs.	376	374
Female Sample	(5)	(6)
ATE	0.0463	0.0509
Std. Err.	(0.0690)	(0.0947)
Obs.	459	458
Older Children	(7)	(8)
ATE	0.0921	0.123
Std. Err.	(0.119)	(0.131)
Obs.	260	258
Younger Children	(9)	(10)
ATE	0.0846	0.0709
Std. Err.	(0.104)	(0.0994)
Obs.	240	238

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Analyses conducted on the overall sample (1-2), male sample (3-4), female sample (5-6), older children sample (7-8) and younger children sample (9-10). Robust Standard Errores in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.13 – Covariates balance after Nearest Neigbour Matching

	Standardized Differences		Variance Ratio	
	(1) Raw	(2) Matched	(3) Raw	(4) Matched
Ethnicity				
Black	0.016	-0.003	1.019	0.998
All the rest	0.120	-0.100	1.278	0.774
PCG Education				
High School	-0.045	0.111	0.983	1.036
> High School	-0.187	-0.127	0.975	0.984
Birth Order				
Older Child	0.099	-0.021	0.995	1.000
Younger Child	-0.074	0.057	0.992	1.005
Sibling Gender				
Female	-0.314	-0.182	0.937	0.969
Children in Family Unit				
3	0.222	0.117	1.192	1.107
4	0.170	-0.123	1.790	0.571
5	0.339	0.140	14.630	4.184
6	0.173	0.074	7.650	2.651
7	0.090	0	5.169	1.000
PCG Age Group				
26-30	-0.125	-0.109	0.703	0.725
31-35	0.140	0.239	1.275	1.423
36-40	-0.043	0.066	0.960	1.065
41-45	-0.023	-0.064	0.973	0.909
46-50	-0.007	-0.038	0.983	0.878
51-55	0.092	-0.027	1.706	0.815
56-60	0.041	0.139	1.728	4.928
60 +	-0.014	-0.206	0.978	0.603

Note: For covariates categorical division see Table 3.5. Columns 1 and 2 present the standardized difference between the control and treated sample respectively before and after the matching. Columns 3 and 4 show the variance ratio between control and treated samples respectively before and after matching. Raw sample includes all eligible observations. Matched sample includes only the observations selected in the Nearest Neighbour Matching.

Table 3.14 – Noncognitive outcomes, alternative nearest neighbor matching

Outcome Variable	**Openness to Experience**	**Conscien- tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
NN 1:1 biasadj	(1a)	(2a)	(3a)	(4a)	(5a)
ATE	0.0230*	0.0229**	0.0116**	-0.00194	-0.0123
Std. Err.	(0.0118)	(0.0102)	(0.00530)	(0.00903)	(0.0115)
Obs.	839	838	834	837	832
NN 1:1	(1b)	(2b)	(3b)	(4b)	(5b)
ATE	0.0238**	0.0242**	0.0108**	-0.000735	-0.00920
Std. Err.	(0.0118)	(0.0102)	(0.00531)	(0.00899)	(0.0115)
Obs.	839	838	834	832	832
NN 1:2	(1c)	(2c)	(3c)	(4c)	(5c)
ATE	0.0251**	0.0229**	0.00972*	-0.00563	-0.00921
Std. Err.	(0.0118)	(0.00956)	(0.00498)	(0.00869)	(0.0113)
Obs.	839	838	834	837	832
without children in family unit					
NN 1:1	(1d)	(2d)	(3d)	(4d)	(5d)
ATE	0.0228**	0.0223**	-0.000460	-0.00782	-0.0194
Std. Err.	(0.0114)	(0.0102)	(0.00840)	(0.0106)	(0.0126)
Obs.	839	838	834	837	832
exact matching children in family unit					
NN 1:1	(1e)	(2e)	(3e)	(4e)	(5e)
ATE	0.0292***	0.0318***	0.00900	0.00295	-0.00449
Std. Err.	(0.00927)	(0.0113)	(0.00705)	(0.0107)	(0.0147)
Obs.	447	446	444	446	444

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Estimations performed on the overall sample. Row "a"' (1a-5a) present the results of the baseline Nearest Neighbour one-to-one matching adjusting for biase given by number of children in family unit and presence of parental figures (already presented). Row "b" (1b-5b) presents the same analysis without adjusting for the bias. Row "c" (1c-5c) shows results of baseline specification requiring two matches for each observation. Row "d" (1d-5d) presents results of the same baseline model excluding the number of children in the family unit control. Row "e" (1e-5e) shows results of baseline specification requiring exact matching also for the number of children in the family unit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.15 – Noncognitive outcomes, different matching techniques

Outcome Variable	**Openness to Experience**	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
NN 1:1 biasadj	(1a)	(2a)	(3a)	(4a)	(5a)
ATE	0.0230*	0.0229**	0.0116**	-0.00194	-0.0123
Std. Err.	(0.0118)	(0.0102)	(0.00530)	(0.00903)	(0.0115)
Obs.	839	838	834	837	832
PSM	(1b)	(2b)	(3b)	(4b)	(5b)
ATE	0.0105	0.0253*	0.0155***	0.0100	0.0111
Std. Err.	(0.0208)	(0.0137)	(0.00423)	(0.00826)	(0.00977)
Obs.	902	799	896	899	887
CALIPER 0.025	(1c)	(2c)	(3c)	(4c)	(5c)
ATE	0.0334***	0.0275**	0.0167***	0.00598	0.0108
Std. Err.	(0.0121)	(0.0128)	(0.00596)	(0.00578)	(0.0106)
Obs.	734	848	914	836	910
IPWRA	(1d)	(2d)	(3d)	(4d)	(5d)
ATE	0.0158	0.0199*	0.0125**	0.00902	-0.0127
Std. Err.	(0.0145)	(0.0119)	(0.00575)	(0.0108)	(0.0151)
Obs.	949	948	944	947	940

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Estimations performed on the overall sample. Row "a"' (1a-5a) present the results of the baseline Nearest Neighbour one-to-one matching adjusting for biase given by number of children in family unit and presence of parental figures (already presented). Row "b" (1b-5b) shows results of propensity score matching using all controls in the baseline specification. Row "c" (1c-5c) presents results using same baseline controls requiring a matching caliper equal to 0.025. Row "d" (1d-5d) shows results using Inverse Probability Weighting Regression Adjustment technique. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.16 – Noncognitive outcomes, OLS results with gender and birth order interactions

Gender interaction

Outcome Variable	**Openness to Experience**	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
	(1)	(2)	(3)	(4)	(5)
0 - Female	0.00140	0.0407***	-0.00101	-0.00255	0.00682
	(0.0138)	(0.0102)	(0.00616)	(0.00705)	(0.00800)
1- Male	-0.00695	0.0577***	0.0223***	-0.00544	0.0173
	(0.0335)	(0.0117)	(0.00773)	(0.0128)	(0.0132)
1 - Female	0.0274	0.0215	-0.00512	-0.0180	-0.0260
	(0.0192)	(0.0147)	(0.0114)	(0.0144)	(0.0182)
Older sibling	-0.0439***	-0.0344*	-0.0225***	-0.00548	-0.0408***
	(0.0149)	(0.0183)	(0.00797)	(0.0196)	(0.0135)
Younger sibling	-0.0260**	-0.0353**	-0.0162**	0.00466	-0.0333***
	(0.0131)	(0.0179)	(0.00702)	(0.0193)	(0.0129)
Female sibling	0.00586	-0.00646	-0.00951*	-0.00475	-0.00605
	(0.0125)	(0.00875)	(0.00564)	(0.00646)	(0.00739)
Observations	949	948	944	947	940
R-squared	0.045	0.084	0.061	0.045	0.079

Birth order interaction

Outcome Variable	**Openness to Experience**	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
	(6)	(7)	(8)	(9)	(10)
0 - Younger	0.0150	-0.00303	0.00518	0.0101	0.0118
	(0.0153)	(0.0110)	(0.00681)	(0.00749)	(0.00923)
1 - Older	0.00341	0.00458	0.00480	-0.0131	0.00228
	(0.0292)	(0.0146)	(0.0134)	(0.0159)	(0.0163)
1 - Younger	0.0379*	0.0185	0.0148	0.00110	-0.0164
	(0.0218)	(0.0148)	(0.0104)	(0.0124)	(0.0179)
Female	0.00700	0.0296***	-0.00504	-0.00372	-0.00123
	(0.0129)	(0.00916)	(0.00580)	(0.00667)	(0.00761)
Female sibling	0.00611	-0.00586	-0.00930	-0.00473	-0.00514
	(0.0129)	(0.00900)	(0.00577)	(0.00657)	(0.00752)
Observations	923	922	918	921	914
R-squared	0.044	0.075	0.058	0.046	0.074

Note: results of Ordinary Least Squares analyses using the following covariates (some omitted in the table): child's gender and grade, child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit, primary caregiver's age group, household's income and primary caregiver's employment status. First table presents results interacting the dummy for the presence of an ill sibling with the gender of the child. Second table presents results interacting the dummy for the presence of an ill sibling with the birth order of the child. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix A

Special Education

As explained in Section 3.3, assignment to Special Education programs requires every child to be categorized in one of the thirteen illness groups required by the law. In the sample I have specific information for the health condition that lead to Special Education only for the children that are currently using it. However a different question asked primary caregivers in CDSII if the child was ever been diagnosed by a medical practitioner of some conditions. This information can be used as a proxy for the cases in which I do not have direct information of what condition determined the diagnosis for Special Education. More specifically, among all children in the sample with a sibling who completed the same questionnaire, 216 are categorized as ill, that is have been diagnosed for Special Education needs at least once in their life. Among this sample 141 children are currently using Special Education at the time of the interview, while 74 are not. Lastly, for 1 observation the sample does not include precise information about the participation to Special Education. Table A.1 shows the illness categorization for Special Education only among children that are currently using it. It emerges that most of these children are affected by some kind of learning disability, 62.42%, by ADHD, almost 18%, or by Developmental Disabilities, 4.26% of the sample.

Observing the illnesses ever diagnosed to children not currently using Special Education in Table A.2 it emerges that for 42% of them I cannot detect any “predictive” diagnosis from the data, but almost 23% has been diagnosed for two or more “predictive” conditions. “Predictive” conditions are the following: Speech Impairment, Hearing Difficulty, Seeing Difficulty, Emotional Disturbance, Developmental Delays and Hyperactivity, denoted with an asterisk in Table A.2. Detailed information about the illnesses diagnosed to these children can be found in the table. According to general statistics[6] in Fall 2002 the disability distribution of the students from six to twenty-one under Individuals with Disabilities Education Act was: Specific Learning Disabilities 48.3%, Speech or Language Impairments 18.7 %, Mental Retardation 9.9%, Serious Emotional Disturbance 8.1%, Other Health Impairments 6.6%, while the rest of all the other disabilities accounted for about 8.4% of the children under Special Education.

[6]Source: U.S. Department of Education, Office of Special Education and Rehabilitative Services, Office of Special Education Programs, 35th Annual Report to Congress on the Implementation of the Individuals with Disabilities Education Act, 2013, Washington, D.C. 2014.

Table A.1 – Categories for Special Education among ill children sample

Child ever diagnosed for Special Education	**Obs.**
No	1,565
Yes	216

Of which:	**Obs.**
Currently in Special Education	141
Not currently in Special Education	74

Diagnosis	**Obs.**	**Share of Children Currently in Special Education**
ADD / ADHD / Hyperactivity	25	17.73%
Emotional/Behavioral Problems	3	2.13%
Learning Disability:		
- Speech and Language	27	19.15%
- Academic Skills	42	29.79%
- General	19	13.48%
Autism	4	2.84%
Developmental Disability / Delay	6	4.26%
Cerebral Palsy	1	0.71%
Epilepsy	1	0.71%
Brain Tumor		-
Hearing / Sight Impaired	5	3,55%
Down Syndrome	2	1.42%
Reason Not Detailed	5	3.55%
Other	1	0.71%

Notes: Sample statistics are presented on all children in CDSII that have a sibling with a completed questionnaire. Shares are computed with respect to 141 ill children ever diagnosed as for Special Education needs and currently enrolled in Special Education. Among 216 children ever diagnosed for Special Education needs, 141 are currently using Special Education, 74 are not currently in Special Education, while for 1 observation the sample does not include precise information about the actual use or not.

Table A.2 – Illness diagnosis among ill children sample and Predictive conditions for Special Education among ill children sample

Child ever diagnosed for Special Education	**Obs.**
No	1,565
Yes	216
Of which:	**Obs.**
Currently in Special Education	141
Not currently in Special Education	74

Diagnosis	**Obs.**	**Share of Children Not Currently in Special Education**
Epilepsy	1	1,35%
Astha medications	2	2,70%
Ear Infection	5	6,76%
Speech Impairment*	6	8,11%
Hearing Difficulty*	1	1,35%
Seeing Difficulty*	4	5,41%
Emotional Disturbance*	2	2,70%
Developmental Delays*	9	12,16%
Hyperactivity*	6	8,11%
Allergies	18	24,32%
Migraine	2	2,70%
Obesity	1	1,35%

N. of Predictive Diseases	**Obs.**	**Share of Children Not Currently in Special Education**
0	31	41,89%
1	26	35,14%
2	12	16,22%
3	1	1,35%
4	3	4,05%
6	1	1,35%

Notes: Sample statistics are presented on all children in CDSII that have a sibling with a completed questionnaire. Shares are computed with respect to 74 ill children ever diagnosed as for Special Education needs but not currently using for Special Education. * indicates “predictive” disorders.

Appendix B

Supplementary tables

Table B.1 – Noncognitive outcomes, different estimation techniques among the male sample

Outcome Variable	**Openness to Experience**	**Conscien- tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
NN 1:1 biasadj	(1a)	(2a)	(3a)	(4a)	(5a)
ATE	0.0218	0.0477***	0.0147**	-0.00935	-0.000534
Std. Err.	(0.0244)	(0.0131)	(0.00627)	(0.0148)	(0.0139)
Obs.	377	377	375	377	374
NN 1:1	(1b)	(2b)	(3b)	(4b)	(5b)
ATE	0.0239	0.0521***	0.0148**	-0.00193	0.00822
Std. Err.	(0.0244)	(0.0131)	(0.00628)	(0.0149)	(0.0140)
Obs.	377	377	375	375	374
NN 1:2	(1c)	(2c)	(3c)	(4c)	(5c)
ATE	0.0185	0.0501***	0.0129*	-0.0133	0.00427
Std. Err.	(0.0231)	(0.0124)	(0.00661)	(0.0145)	(0.0143)
Obs.	377	377	375	377	374
without children in family unit **NN 1:1**	(1d)	(2d)	(3d)	(4d)	(5d)
ATE	0.0200	0.0478***	0.0182***	0.00252	0.00559
Std. Err.	(0.0211)	(0.0131)	(0.00657)	(0.0145)	(0.0144)
Obs.	377	377	375	377	374
exact matching children in family unit **NN 1:1**	(1e)	(2e)	(3e)	(4e)	(5e)
ATE	0.0313*	0.0596***	-0.000676	0.00982	0.0154
Std. Err.	(0.0163)	(0.0159)	(0.00847)	(0.0160)	(0.0204)
Obs.	162	162	161	162	161

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Estimations performed on male subsample. Row "a"' (1a-5a) present the results of the baseline Nearest Neighbour one-to-one matching adjusting for biase given by number of children in family unit and presence of parental figures (already presented). Row "b" (1b-5b) presents the same analysis without adjusting for the bias. Row "c" (1c-5c) shows results of baseline specification requiring two matches for each observation. Row "d" (1d-5d) presents results of the same baseline model excluding the number of children in the family unit control. Row "e" (1e-5e) shows results of baseline specification requiring exact matching also for the number of children in the family unit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table B.2 – Noncognitive outcomes, different estimation techniques among the female sample

Outcome Variable	**Openness to Experience**	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
NN 1:1 biasadj	(1a)	(2a)	(3a)	(4a)	(5a)
ATE	0.0265***	0.00705	0.00726	-0.000577	-0.0196
Std. Err.	(0.0102)	(0.0151)	(0.00804)	(0.0112)	(0.0179)
Obs.	462	461	459	460	458
NN 1:1	(1b)	(2b)	(3b)	(4b)	(5b)
ATE	0.0260**	0.00258	0.00681	0.00195	-0.0230
Std. Err.	(0.0102)	(0.0151)	(0.00803)	(0.0112)	(0.0179)
Obs.	462	461	459	457	458
NN 1:2	(1c)	(2c)	(3c)	(4c)	(5c)
ATE	0.0289***	0.000488	0.00689	-0.00170	-0.0188
Std. Err.	(0.0103)	(0.0141)	(0.00739)	(0.0106)	(0.0168)
Obs.	462	461	459	460	458
without children in family unit					
NN 1:1	(1d)	(2d)	(3d)	(4d)	(5d)
ATE	0.0271**	0.00584	-0.0147	-0.0171	-0.0380*
Std. Err.	(0.0124)	(0.0151)	(0.0135)	(0.0152)	(0.0195)
Obs.	462	461	459	460	458
exact matching children in family unit					
NN 1:1	(1e)	(2e)	(3e)	(4e)	(5e)
ATE	0.0315***	0.0135	0.0134	-0.00163	-0.0114
Std. Err.	(0.0117)	(0.0133)	(0.00883)	(0.0122)	(0.0179)
Obs.	285	284	283	284	283

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Estimations performed on female subsample. Row "a"' (1a-5a) present the results of the baseline Nearest Neighbour one-to-one matching adjusting for biase given by number of children in family unit and presence of parental figures (already presented). Row "b" (1b-5b) presents the same analysis without adjusting for the bias. Row "c" (1c-5c) shows results of baseline specification requiring two matches for each observation. Row "d" (1d-5d) presents results of the same baseline model excluding the number of children in the family unit control. Row "e" (1e-5e) shows results of baseline specification requiring exact matching also for the number of children in the family unit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table B.3 – Noncognitive outcomes, different estimation techniques among older children sample

Outcome Variable	**Openness to Experience**	**Conscien-tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
NN 1:1 biasadj	(1a)	(2a)	(3a)	(4a)	(5a)
ATE	0.0197	0.00330	0.0138	-0.0237	-0.000933
Std. Err.	(0.0416)	(0.0184)	(0.0126)	(0.0190)	(0.0179)
Obs.	261	260	259	260	258
NN 1:1	(1b)	(2b)	(3b)	(4b)	(5b)
ATE	0.00958	0.00433	0.0116	-0.0295	-0.00525
Std. Err.	(0.0417)	(0.0183)	(0.0126)	(0.0191)	(0.0178)
Obs.	261	260	259	258	258
NN 1:2	(1c)	(2c)	(3c)	(4c)	(5c)
ATE	0.0204	0.00748	0.0153	-0.0183	0.000473
Std. Err.	(0.0419)	(0.0163)	(0.0113)	(0.0163)	(0.0157)
Obs.	261	260	259	260	258
without children in family unit					
NN 1:1	(1d)	(2d)	(3d)	(4d)	(5d)
ATE	0.00410	0.00385	-0.00349	-0.0336*	-0.0158
Std. Err.	(0.0316)	(0.0184)	(0.0161)	(0.0200)	(0.0195)
Obs.	261	260	259	260	258
exact matching children in family unit					
NN 1:1	(1e)	(2e)	(3e)	(4e)	(5e)
ATE	0.0209	-0.0102	0.00414	-0.0303	-0.00270
Std. Err.	(0.0162)	(0.0288)	(0.0242)	(0.0351)	(0.0384)
Obs.	95	94	94	94	94

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Estimations performed on older children subsample. Row "a"' (1a-5a) present the results of the baseline Nearest Neighbour one-to-one matching adjusting for biase given by number of children in family unit and presence of parental figures (already presented). Row "b" (1b-5b) presents the same analysis without adjusting for the bias. Row "c" (1c-5c) shows results of baseline specification requiring two matches for each observation. Row "d" (1d-5d) presents results of the same baseline model excluding the number of children in the family unit control. Row "e" (1e-5e) shows results of baseline specification requiring exact matching also for the number of children in the family unit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table B.4 – Noncognitive outcomes, different estimation techniques among younger children sample

Outcome Variable	**Openness to Experience**	**Conscien- tiousness**	**Extraversion**	**Agreeableness**	**Emotional Stability**
NN 1:1 biasadj	(1a)	(2a)	(3a)	(4a)	(5a)
ATE	0.0238*	0.0270	0.00464	-0.0109	-0.0565**
Std. Err.	(0.0135)	(0.0180)	(0.00779)	(0.0182)	(0.0243)
Obs.	241	241	239	240	240
NN 1:1	(1b)	(2b)	(3b)	(4b)	(5b)
ATE	0.0249*	0.0252	0.00462	-0.0109	-0.0592**
Std. Err.	(0.0135)	(0.0181)	(0.00778)	(0.0183)	(0.0245)
Obs.	241	241	239	238	240
NN 1:2	(1c)	(2c)	(3c)	(4c)	(5c)
ATE	0.0211	0.0180	0.00253	-0.0136	-0.0528**
Std. Err.	(0.0148)	(0.0171)	(0.00780)	(0.0179)	(0.0233)
Obs.	241	241	239	240	240
without children in family unit					
NN 1:1	(1d)	(2d)	(3d)	(4d)	(5d)
ATE	0.0252*	0.0248	0.00423	-0.0109	-0.0593**
Std. Err.	(0.0140)	(0.0181)	(0.00931)	(0.0184)	(0.0252)
Obs.	241	241	239	240	240
exact matching children in family unit					
NN 1:1	(1e)	(2e)	(3e)	(4e)	(5e)
ATE	0.0294	0.0339	-0.00741	-0.0280	-0.0427
Std. Err.	(0.0266)	(0.0214)	(0.0151)	(0.0259)	(0.0375)
Obs.	68	68	68	68	68

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade. Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling gender, number of children in the family unit and primary caregiver's age group. Bias adjusted for number of children in family unit and PCG age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Estimations performed on younger children subsample. Row "a"' (1a-5a) present the results of the baseline Nearest Neighbour one-to-one matching adjusting for biase given by number of children in family unit and presence of parental figures (already presented). Row "b" (1b-5b) presents the same analysis without adjusting for the bias. Row "c" (1c-5c) shows results of baseline specification requiring two matches for each observation. Row "d" (1d-5d) presents results of the same baseline model excluding the number of children in the family unit control. Row "e" (1e-5e) shows results of baseline specification requiring exact matching also for the number of children in the family unit. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Chapter 4

Quality Time with the Offspring and Parenting Style: Reconsidering Parents' Equality Concerns among Families with an Ill Child

Quality Time with the Offspring and Parenting Style: Reconsidering Parents' Equality Concerns among Families with an Ill Child[1]

Francesca Marino[2]

University of Padua

Abstract

This paper studies parental decisions on resource allocation in a condition of a strong and evident ability imbalance among the offspring: when one of the children is considered mentally or physically disabled. Standard economic models posit that parents should optimally invest more in the more able child, however empirical evidence has shown that when deciding resource allocation parents' equality concerns seem to prevail despite children's innate ability levels. This analysis identifies causal changes in parental inputs given to children, more specifically quality time and parental attitude, due to living with an ill sibling among sibling couples in the Panel Study of Income Dynamics by using matching techniques. Parents seem to devote more quality time to girls and older children in case the other sibling is considered ill as in current setting, while they provide "warmer" parenting to boys. Moreover, they show higher levels of parental distress. Even if these results seem to confirm that parents tend to invest more on the more able child, further investigations highlight that these children are more involved in activities with the ill sibling. However emerged differences in inputs received during childhood are relevant in this setting since they may stem future effects over socioeconomic and labour market achievements.

JEL Classification: J24, J13, J16, C21.

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[2] Dept. of Economics, University of Padua, Via del Santo 33, 35121, Padua, Italy,
e-mail: *francesca.marino@studenti.unipd.it*; *andeor@msn.com*

4.1 Introduction

The decision of how many resources parents allocate to the offspring in relation to children's unobservable ability levels represents an important topic in economic theory. This paper will study typical parental decisions on input allocation when one of the children suffers from a chronic illness, and therefore presents different ability levels and different needs with respect to the rest of the offspring.

Economic models originally described the optimal allocation decision of parental resources among the offspring as an investment decision of parental inputs: money, time and material resources. Parents, given their own payoff function, had to maximize their offspring's quality, measured as their future income (Becker and Lewis, 1973; Becker and Tomes, 1976, 1986; Becker, 1991). The main conclusions stemming from such approach posit parents to invest more resources in the more able child, and to compensate the gap later in life through money transfers at the less able child[3].

Leaving aside budget constraint problems, parental investment decision in children does not regard exclusively how much allocating to each child, but also what kind of resources. Recent economic research has focused on two main factors that have proven to influence children's outcomes: time spent with parents and parenting style. Both resources are important factors in shaping children's cognitive and noncognitive skills, which are important factors for their future labour and socioeconomic outcomes like schooling choices, educational attainment, wages and employment status (Heckman *et al.*, 2006; Carneiro *et al.*, 2007; Cunha and Heckman, 2008; Lleras, 2008; Lindqvist and Westman, 2011; Heckman *et al.*, 2010; Cobb-Clark and Tan, 2011; Heckman *et al.*, 2013).

Most of recent economic research has focused on the role of time parents spend with children in order to explain the potential beneficial effects on cognitive skills. Such analyses were feasible thanks to the recent wide availability of time diaries data[4], and to the relatively easiness in quantifying parental time with the child through this measure. Of course such analyses are not exempt from endogeneity issues: parents should be able to observe children's innate ability level and act allocating different time quantities to the offspring in order to compensate potential weaknesses (Hsin, 2007), in contrast to what stated by the literature above. Several studies have recognized the need of taking into account the endogeneity of parental resources allocated to children according to their ability level (Todd and Wolpin, 2003, 2007; Cunha and Heckman, 2008; Del Boca *et al.*, 2014). Following standard economic theory we should expect that parents dedicate more time to the better endowed child, however econometric evidence has shown that parents' decisions are more affected by their equality concerns, splitting available resources equally among children (Price, 2008).

[3] This results relies on the assumption that parents exhibit the same payoff curve for every child, but if children differ in their initial ability level, their optimal strategy is to move resources to the more able child to maximize overall payoff.

[4] Alternatively, other researches like Ruhm (2004) employed mother's working status to proxy for the quantity of time spent with children. However mother's working status is not a completely accurate measure of time spent with children, since mothers seem to adapt their time schedules in order to maintain a certain stability in the total time spent with the offspring despite their employment status (Bianchi, 2000; Huston and Aronson, 2005).

On the other hand the role of parental attitude is gaining more attention in last years. Even though sociological and psychological literature have long studied the implications of parenting styles on children's outcomes (Steinberg *et al.*, 1992; Amato and Fowler, 2002; Belsky and Fearon, 2004; Aunola and Nurmi, 2005; Spera, 2005; Huver *et al.*, 2010; Chan and Koo, 2011a), recently Fiorini and Keane (2014) have recognized its importance in economic studies. In order to understand what parental behaviours boost virtuous or vicious reactions in children, the present study will rely on some sociological and psychological constructs that have proven to affect some economically relevant outcomes. According to the categorization proposed by Lamborn *et al.* (1991), parenting styles can be divided in authoritative, authoritarian, indulgent and neglectful according to parental levels of involvment in children's activities and supervision. In their paper Fiorini and Keane (2014) conclude that a right mix of parental warmth ad effective discipline positively affects chilldren's noncognitive skills. Another important dimension is highlighted by Yeung *et al.* (2002), who include the role of parental emotional distress. This dimension seems relevant especially in this context, since several studies have concluded that parents of children with disabilities show higher livels of stress (Koegel *et al.*, 1992; Baker *et al.*, 2002, 2003; Dabrowska and Pisula, 2010). More importantly, in families in which one of the children is considered physically or mentally disabled the high levels of parental stress could affect also all healthy children in the family.

In this study I try to overcome any potential endogenity problem in resources' assignment due to children's unobserved ability level by identifying families in which there is an evident ability imbalance within the offspring. The main assumption is the following: whatever ability level of a child, if his or her sibling suffers from certain physical or mental disabilities, by definition this child will be better endowed than the sibling. The aim is to test if parental equality concerns in resource allocation are confirmed or not under strong and evident ability imbalance among the offspring. In this case several mechanisms could affect parents' decisions. Having an ill child can be both time and resource consuming. Parents could be lead to devote more of their time and financial resources to take care of the child in need. At the same time they could have the incentive not to provide less resources to the healthy child, both for equality concerns and for efficiency reasons as in classic economic theory. Moreover I will take into account other modifications in parental inputs, such as parenting style and parental stress, that might be enacted by the presence of an ill child among the offspring and result in affecting healthy children in the household. The empirical investigation will employ matching techniques, more specifically Nearest Neighbour Matching. This setting allows to estimate the causal effect of having an ill child by comparing the treated and control groups, respectively healthy children with an ill sibling and healthy children with a healthy sibling. The identification is made by pairing siblings' couples from the second wave of the Child Development Supplement in the Panel Study of Income Dynamics.

The analysis will study parental decisions in terms of quality time spent with children, parental attitude and parental stress with a special focus on children's gender and birth order. To my knowledge, no other study has used this particular household condition to check if parents' equality concerns on equal resources' allocation are met or challenged. The findings of this paper highlight that parents act differently according to children's gender and birth order. Girls and older children seem to benefit from an increase in time spent in quality activities. More specifically the increase in quality time is due to mothers allocating more time to children with respect to fathers. However from further analyses it seems that this increase in quality time is actually due to a higher involvement in quality time activities with the ill sibling. Ill children benefit on average from more quality time, especially with mothers: results suggest that girls and older children usually participate to those activities. Therefore even if it seems that parents invest more on the more able child, dedicating more quality time to healthy siblings, further analyses do not completely support this theory, linking higher quality time to greater involvment in time spent with the ill child. Parenting seems to be sensitive to children's gender: results show that mothers tend to provide warmer parenting to boys. This evidence calls for future investigations on the sensitivity of parenting style according to child's gender, and how this could affect children's future development. Lastly, parents show overall high levels of stress measured as psychological problems, self efficacy and self esteem.

The paper is organized as follows: section 4.2 presents economic literature on parental inputs, more specifically on the roles of parental quality time, parental attitude and parental stress, and children's outcomes. Section 4.3 will discuss the sample, the measures adopted in the analysis and the empirical methods used in the study. Section 4.4 will show the results of the paper and lastly section 4.5 will discuss the main conclusions and implications of the paper.

4.2 Parental Inputs and Children's Outcomes

This section will provide an overview of the potential parental inputs that could be affected by the presence of an ill child among the offspring exerting an influence on all the children in the household: quality time spent with parents, parental attitude[5] and parental stress levels.

Quality Time The amount of time parents spend with their children has always been identified as a fundamental mean of transimission of skills and knowledge from parents to children. Many studies have focused on the role of time spent with mothers in determining especially cognitive skills (Carneiro and Rodrigues, 2009; Del Bono *et al.*, 2014). Moreover, time with parents has been extensively analysed in relationship with birth order differences: firstborns tend to receive more quality time with respect to later borns (Price, 2008), while in developing countries the relationship is reversed (De Haan *et al.*, 2014).

However, not all the time children spend with parents may be important in shaping children's skills. Hsin (2009) suggests that the importance of time spent with children depends on the level of cognitive stimulation provided by parents[6]. The fundamental contribution by Price (2008) provides a clear definition of quality

[5] In the coming paragraphs parental attitude and parenting style will be used as synonims.

[6] For example Huston and Aronson (2005) used total time mothers spent with children, that can be considered as a proxy for quality time. However subsequent studies have highlighted that the allocation of time mothers allocate to children is affected by several factors, among which their educational level (Nicoletti and Tonei, September 2015).

time, requiring on the one side that the child needs to be at the center of the attention in the activity, and determining on the other side clear groups of quality time activities[7]. Using a similar categorization of quality time, Fiorini and Keane (2014) conclude that the time children are involved in educational activities, especially with their parents, is a fundamental determinant for cognitive skills' development. Still using the definition of quality time by Price (2008), Monfardini and See (2012) distinguish the level of parental involvment in the activity in whether the parent was participating or just around while the child was involved in the activity.

More importantly, some characteristics of the mother, like the educational level, appear to be fundamental in shaping children's skills, strongly affecting the effectiveness of quality time. For example Hsin (2007) finds that the time mothers spend playing with their children positively affects their language development only if the mother is verbally skilled. Another dimension affecting the allocation of quality time regards the age of the child: while growing up parents spend less time with their children (Price, 2008), even if parental quality time is more productive during childhood, while it is substituted by alone quality time during adolescence (Del Boca *et al.*, 2012).

This study will explore the total amount of quality time children spend with both parents. Since I am also interested in exploring differences among parents, along with the total time spent with both figures I will distinguish among total time spent with the mother and with the father[8]. Considering the quality of parental time spent with children, there seems to be no systematic difference whether children spend time with the mother or with the father (Averett *et al.*, 2005). However the amount of time fathers spend with children seems to be affected by the gender composition of the offspring (Lundberg, 2005), since fathers seem to spend more time with boys than with girls.

Parental Attitude The role of parental attitude on determining children's outcomes has gained attention in economic literature only in relatively recent years, while sociological and psychological studies have been aware of the topic for a longer time. For this reason I will consider literature from several disciplines to analyse the possible determinants of parental attitude that are relevant for the purpose of this study.

The most comprehensive scale of parental attitude is the one proposed by Lamborn *et al.* (1991), according to which parental attitudes can be described according to their level of acceptance/ involvement and of parental strictness/supervision. Following this categorization, parental attitudes can be grouped in four parenting styles: authoritative, authoritarian, indulgent, and neglectful[9]. Lamborn *et al.* (1991) show that parenting

[7] Price (2008) identifies quality time activities the following: reading, playing, helping with homework, talking and listening, helping and teaching, doing arts and crafts together, eating together, playing sports with the child, attending performing arts, attending museums, participating to religious activities, looking after and taking physical care of the child.

[8] The approach of this paper is different from the one in Price (2008), where time spent with mothers and fathers is considered separately.

[9] In Lamborn *et al.* (1991) parenting styles are described as authoritative: high acceptance/involvment, high strictness/supervision; authoritarian: low acceptance/involvment, low strictness/supervision; indulgent: high acceptance/involvment, low strictness/supervision; and neglectful: low acceptance/involvment, low

style is able to affect children's school achievement, and psychological well being. A strong association between parenting styles and youth outcome has been found also among juvenile offenders in Steinberg *et al.* (2006): in their study those who described their parents as authoritative were more psychosocially mature, less likely to show behavioural problems and more academically competent than those who reported to have neglectful parents. The positive effect of authoritarian parenting on school achievements is found also in Steinberg *et al.* (1992), Davis-Kean (2005), and Cosconati (2009)[10]. The main hints from literature describe parenting style to be more associated to family structure than on social class (Chan and Koo, 2011b), and it does not seem to depend on ethnicity or gender (Steinberg *et al.*, 2006).

In economic literature parenting skills are usually considered among the "environmental" factors affecting children's outcomes (Heckman and Masterov, 2007), especially considering the positive effect of parenting practices on children's motivation and emotional development (Cunha *et al.*, 2006). For the scope of the current study however it has to be noted that several studies have analysed the role of parenting practices on children's accumulation of human capital (Pensiero, 2011), especially in relation with socioeconomic status (Ermisch, 2008; Carolan and Wasserman, 2014; Flouri *et al.*, 2014)[11], while the role of parenting style in affecting children's outcomes is more subtle. Parenting style and parenting practices describe two different concepts: according to Spera (2005) parenting practices refer to the specific behaviours parents use when socializing with their children, while parenting style describes the emotional athmosphere in which parents raise their children.

A comprehensive study of parental inputs and children's outcomes is performed in Fiorini and Keane (2014): the effect on mother's parenting style and time spent in educational activities are considered jointly in the production of cognitive and noncognitive skills' development. This study is the first one in economic literature to conclude that a parenting style that is a mixture of effective, but not harsh discipline and warmth performs best in terms of children's noncognitive skills. This evidence calls for the need of further investigation of the role of parenting style, other than parental practices, in shaping children's skills.

For this analysis it will be fundamental to include all controls that could determine simultaneously the presence of an ill child in the household and the outcomes, like parenting style. In this case parenting style may vary according to the number of children: parenting style could be less stimulating when parents face demands from multiple children (Baydar *et al.*, 1997a,b; Heiland, 2009), or could be more effective when experience increases (Neidell, 2000).

This investigation will consider parenting style in light of the categorizations suggested by the literature above, starting from the hint that the presence of an ill child among the offspring could change parental

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strictness/supervision

[10]In this case the conclusions of Cosconati (2009) are that setting strict rules benefits children in terms of an increase in study time among those children that tend to value less human capital investments

[11] Main findings in literature suggest that whealthier families adopt more beneficial parenting practices that favour children's outcomes and therefore reduce social mobility among classes (Ermisch, 2008), however good parenting practices can still offset the disadvantage given by having poor parents (Flouri *et al.*, 2014).

attitude. This possibility can be seen as a positive, or a negative, externality that the ill child poses on his/her healthy siblings[12]. Moreover, the measures employed for parenting style will try to provide an external assestment of the phenomenon rather than a self-reported one, as explained in Section 4.3, because parental measures may be biased. One possible source of bias may stem from parental stress levels, that could determine greater psychosocial problems among parents of ill children. For this reason this further measure will be taken into account in the current investigation. The following paragraph contains a brief overview on parental stress levels inside families with an ill child.

Parental Stress Broad evidence from psychological and medical literature presents a clear increase in psychological problems among parents of mentally ill children. Overall it seems that parents of autistic children face greater burdens in terms of higher parental stress (Koegel *et al.*, 1992; Hastings and Johnson, 2001; Dabrowska and Pisula, 2010), mainly because being a parent of an autistic child represents a strong emotional burden (Hastings, 2007).

However there seems to be an overall increase in stress levels among all parents of disabled children, with mothers being the ones bearing the most negative effects in terms of social exclusion, parenting stress and psychological distress[13] (Estes *et al.*, 2009; Di Giulio *et al.*, 2014).

The actual cause of parenting stress seems to lie behind the ill child's behaviour, which represents a greater burden in everyday life for parents than the mental impairment of the child itself[14] (Baker *et al.*, 2002, 2003). This mechanism could explain the usually lower levels of stress observed among parents of children with Down syndrome compared to parents of autistic children (Dabrowska and Pisula, 2010).

Concluding, having an ill child could affect the level of stress and psychological problems of parents, especially among mothers. Differently from some of the studies cited above, parental stress will be evaluated only on the primary caregiver of the mother, which in most of the cases, given the construction of the dataset, coincides with the biological mother of the child. Even though in the setting of the current study I cannot distinguish by the "severity" of the illness, parenting stress and psychological problems will be evaluated using different measures, in order to infer a common pattern inside families of disabled children. The precise description of the measures and their interpretation can be found in the following section.

[12] This statement holds if we hypothesize that parents apply the same parenting style to the entire offspring.

[13] In the paper by Estes *et al.* (2009) mothers of children with Autism Spectrum Disorders recorded higher levels of parental stress and psychological problems than mothers of normally developing children. In the report by Di Giulio *et al.* (2014) mothers and fathers of disabled children show different social and psychological patterns: while fathers show lower levels of emotional exchanges, mothers are more likely to report feelings of emptiness, loneliness and rejection, resulting in lower levels of sociality.

[14] Even if the paper by Neece *et al.* (2012) does not address directly the problem of parenting stress among families with a disabled child, their study highights that the relatioship between parenting stress and children's behavioural problems is actually bidirectional for both mothers and fathers.

4.3 Data and Empirical Strategy

PSID and Child Development Supplement The empirical analysis of this paper relies on data from the Child Development Supplement (CDS) from the Panel Study of Income Dynamics (PSID)[15]. The main body of PSID collected information from a nationally representative sample of households residing in the United States in 1968, that were subsequently re-interviewed through the years. The hierarchical feature of PSID allows to identify familiar relationships across households, since the study continues to follow every member of the original sample households that become indipendent units of observation when they leave the initial family.

The CDS was a special supplement of PSID aimed at studying many aspects of children's lives, especially their emotional and physical well-being, and it comprised also a Time Diary section to track the activities in which the child was engaged during the day. The initial setting of CDS in 1997 (CDSI) selected all families of PSID sample with at least one child aged between 0 and 12. In cases were more than one children lied in the eligible age range, CDS randomly chose the two to observe. That brings to have complete information only on maximum two children for each family, however complete information on household composition can be easily drawn by the main dataset. After the first wave, children that participated to CDSI and were still aged under 18 were re-interviewed in 2002 (CDSII) and again in 2007 (CDSIII). By the composition of the dataset, great part of the sample is still observed in CDSII, while sample size significantly drops in 2007.

Time Diaries modules contain detailed information on the timing and duration of children's activities during one randomly selected week day and one randomly selected weekend day. It categorizes children's activites and keeps track of who was with the child, and his/her level of active engagement in the activity.

Given the illness identification requirements explained below, I cannot use information from the first wave of the CDS, because I need all children to be in their school years. For this reason the work will use data from the CDSII, which still contains nearly all the observed sample in CDSI, but at the same time guarantees that all children are enrolled in school. Lastly, CDSIII does not contain enough information because children were not re-interviewed once they turned 18 or left schooling. The sample size issue is even more relevant because the current setting will require that children are living with both biological parents, or at least with the biological mother, therefore reducing the number of eligible observations.

From Table 4.2 it shows that sample size in the following analyses will depend on the outcome variable of interest. Unfortunately less information is available for Time Diaries modules, reducing total eligible sample to 557 observations, of which 488 belong to the control and and 69 to the treated group. More information is available for parenting style and parenting stress. Table 4.3 shows the distribution of main controls used in the analysis among the two groups for the case in which I have less information (i.e. when analysing Time

[15]Panel Study of Income Dynamics, public use dataset. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI 2016. The collection of data used in this study was partly supported by the National Institutes of Health under grant number R01 HD069609 and the National Science Foundation under award number 1157698.

Diaries), however no differences emerge when using the bigger sample (not shown).

Illness Identification This studies identifies ill children those reported to have been categorized for Special Education needs. More specifically, PSID asks the following question to primary caregivers about each child in the survey: "Has the child ever been classified by a school as needing special education?"[16]. By the construction of the survey, the dataset used can only observe two randomly chosen children that lie in the eligible age range, comprising all children between 5/6 and 18 years old in CDSII. The randomness of the sample should protect the results against possible bias given by the presence of ill siblings among the unobserved children still aged among the eligible range. The design cannot however guarantee against unobserved ill siblings outside the sample when those are aged below 5 or above 18. I can partially offset this problem by requiring the total number of siblings in the households as a further control.

Special Education in the United States is provided under several regulations, the most important one being the Individuals with Disabilities Education Act[17] (IDEA). Under this regulamentation not every child with learning and attention problems is automatically assigned to special education, but it involves several procedures determined by the IDEA itself. Children that suffer from certain illness conditions like physical or mental impairments are initially entitled for Special Education. The illnesses defined by the law are the following: autism spectrum disorders, deafness and/or blindness, emotional disturbances, hearing impairment, visual impairment, orthopedic impairment, speech and/or language impairment, specific learning disabilities like dyslexia, dyscalculia and dysgraphia, traumatic brain injury, intellectual disabilities, multiple disabilities and other cases of health impairments like Attention-Deficit-Hyperactivity-Disorders. Whenever a child enters school, whether there is a previous diagnosis or just a suspect difficulty in normal learning processes, an evaluation process needs to be started in order to assess in first place if the child suffers from the specific condition, and then if he or she needs Special Education at school. The design of the IDEA guarantees that all eligible children are provided with free public education adequate to their needs. Moreover, the process can be started in the school either by parents' or school's initiative at no cost for the family. This mechanisms should exclude the presence of eligible children inside the control group: in cases in which households may not know child's particular conditions or do not want the child to be categorized for Special Education, the school needs to start the process indipendently whenever the child cannot keep up with regular learning programmes.

The illness identification process requires the child to be officially diagnosed for Special Education. This process is determined by a pool of medical and psychological expert as defined by the IDEA. After the initial diagnosis each child can then be associated to Special Education classes according to a specific education plan defined by the school, the family and some experts. Since I cannot account for all the factors that may affect the actual placement in Special Education classes, this study requires only the diagnosis for Special

[16] The questionnaire requires to specify that in this case Special Education is intended for children with learning disabilities or language problems, and not for gifted children.

[17] Individuals With Disabilities Education Act, 20 U.S.C. 1400 (2004).

Education, and not the use of Special Education classes. Due to incomplete questionnaires, I cannot control for the complete characteristics of the children diagnosed for Special Education. Considering the looser sample requirements in the following analyses, that is restricting to all children with a sibling in CDSII that live with at least the biological mother, in CDSII 200 children were reported to have been categorized for Special Education at least once in their life, meeting the illness identification in the current study, while 1483 had never been diagnosed as such. Among the 200 "ill" children, 130 children were actually enrolled in a Special Education class or program, while 69 were not and there is incomplete information for one observation. Unfortunately there is information on the condition that determined Special Education diagnosis only for the 130 children currently enrolled in a program. Learning disabilities and Attention Deficit Hyperactivity Disorders are the most common diagnosed conditions, accounting respectively for almost 65% and 16% of total cases. At the same time there are only few observations recording Down Syndrome, Celebral Palsy, and Epilepsy[18].

From the diagnosis process it emerges that enrolment in school is a fundamental step for Special Education diagnosis. For this reason I include in the treated group all children with an "ill" sibling but who have never been diagnosed for Special Education. This setting should guarantee that all children can be rightfully considered healthy, otherwise they would have already been diagnosed for Special Education since they are all enrolled in school. I exclude all cases in which both children are considered ill. These observations would bias the results, and their exclusion also protects from cases in which genetic and/or socioeconomic factors are a strong predictors of children's health. It has to be noted that the categories included in Special Education represent permanent conditions that will last for the entire childhood and in most of the cases for the entire life of the child. At the same time the causes behind those conditions are not completely genetic. Some of the other causes can be reconduced to unpredictable conditions before birth, during labour or immediately after birth[19]. For this reason once I exclude siblings' couples in which both children are "ill", I should exclude all cases in which genetic factors or parental behaviour are a strong predictor of Special Education conditions. Moreover, in the analyses I will control for mother's education and age that should proxy for prenatal behaviour affecting child's health outcome.

Quality Time This study will derive Quality Time measures from the information contained in Time Diary modules in CDS. Among all activities in which the child is engaged in, I identify eleven groups of activities that can be considered quality by the original definition by Price (2008) and employed also in Del Boca *et al.* (2012) and Monfardini and See (2012). According to the initial categorization proposed by Price (2008) I consider quality time activites those in which the primary focus is the child, or there is at least a reasonable amount of interaction. Therefore I require not only that the parent is present or surveilling the child, but he/she must be actively involved in the activity. The eleven groups of activities aggregated in the final quality time measure are the following: time spent reading, playing (excluding sports), doing homework,

[18] Complete information can be found in Table A.4.

[19] More general information on the causes of each condition can be found in https://www.nichd.nih.gov/health/topics/Pages/index.aspx.

talking, doing arts and crafts, eating, playing sports, attending performing arts, attending museums, engaged in religious activities, and in physical care.

Duration of the activities in CDS is expressed in seconds, but for the final scores I will present the results in hours. After summing total time spent in quality activities in one week day and in one weekend day, I express weekly total quality time as:

$$\textit{Weekly Quality Time}_i = (\textit{Week-Day Quality Time}_i \times 5) + (\textit{Weekend-Day Quality Time}_i \times 2)$$

Quality Time is expressed as total time in quality activities in which at least one of the parents was actively involved. The analyses will also provide differentiation about the amount of time in which the mother and father were present. From preliminary summary statistics found in Table 4.2 there seems to be no difference from sample comparison[20].

Parental Attitude Parental attitude will be measured through three main indices, some constructed by variables originally comprised in the HOME score. The Home Observation for Measurement of the Environment-Short Form (HOME) aims at measuring the level of cognitive stimulational and emotional support that children receive from parents. CDS contains track of the variables included to sum the final HOME score, originally developed by Caldwell *et al.* (1984). Even though the aim of the paper is to study parental stimuli provided to children, resticting the analysis to the final score would impose an over semplification of the dimensions underlying parental attitude facets. The use of the HOME score has been criticized also by Fiorini and Keane (2014), in favour of more extensive measures of parental inputs. The analysis of parental attitude will be based on three indices measuring parental warmth, punitive parenting and a so called "strictness" index. The first two are derived by HOME score variables, while the strictness index is derived by some questions expanded in CDSII studying family rules and their enforcement within the family. Parental warmth is measured similarly to the one used by Fiorini and Keane (2014) and Yeung *et al.* (2002), however they do not concide completely. Similar measures are employed also in McLeod and Shanahan (1993) and Belsky *et al.* (2005). Punitive parenting is close in nature to the "spanking" index proposed by Yeung *et al.* (2002), but is constructed using different items. Lastly the so called "strictness" index aims at measuring how many rules the child has and if they are actually enforced by parents. It is close to the measure of effective parenting proposed by Fiorini and Keane (2014), but again it differs in items used for the construction of the index. All the questions included in the final score refer to the primary caregiver of the child, but the items included in parental warmth and punitive parenting indices are assesstments made by the interviewer about in-house interactions, while items included in the strictness index refer to primary carigivers' reports of family rules and enforcement. The positive feature of measures assessed by an external interviewer is that they should not be biased by parental reporting, however they are restricted to the relatively short time period of observation. On the other hand parental reported measures could be biased by different parental perception of everyday life, but at the same time they could provide a more round picture

[20] In order to understand how quality time is composed, Table A.3 presents summary statistics for the different components of quality time.

of family arrangements. Table A.1 contains precise information on the questions associated to each variable.

In order to construct final scores for the three parenting style groups, for each variable I associated a dummy, and the final score was the average response of that category on a 0-1 continuum[21]. Results of a confirmatory factor analysis proved that the association was consistent with the parenting styles suggested by literature. Table 4.1 shows the results of the factor analysis. In order to be retained the imposed threshold of rotated factors was 0.3: in this case it can be seen from Table 4.1 that all but one variable loaded in the associated factors.

Parental Stress The level of parental stress will be studied through three measures: the K6 Non-Specific Psychological Distress Scale, the Pearlin Self-Efficacy Scale, and the Rosenberg Self-Esteem scale. These measures are complementary in describing individuals' psychological well being evaluated under different aspects of one's personality.

The questions are asked to the primary caregiver of the child. The analyses regarding parental distress will impose that the child is living at least with the biological mother. By the data it emerges that in 96% of the cases in the sample the primary caregiver, and therefore the respondent of the module, was the biological mother, with the remaining sample mainly represented by biological fathers.

The K-6 Non-Specific Psychological Distress Scale is aimed at distinguishing cases of serious mental illnesses in survey contexts like CDS. It comprises six questions, asking if and how frequently the person has felt sad, nervous, restless, hopeless, worthless or that everything was an effort during last four weeks. Responses are expressed on a 5-point Liker scale, a final score of 13 or higher indicates potential psychological problems. More information about the construction of the score and on the use of the K6 can be found respectively in Mainieri (2006) and Kessler *et al.* (2003).

The Pearlin Self-Efficacy Scale measures individuals' level of self control over several aspects of one's life. The construction of the score in CDSII comprises less items respect to the original scale by Pearlin *et al.* (1981), however it follows the same criteria. Questions used to construct the final score ask the person if he/she ever feels helpless, to have little control, to be pushed around, and not to be able to solve problems. A higher score in Pearlin Self-Efficacy Scale indicates higher levels of self control. More specific information on the construction of the final score are contained in Mainieri (2006).

Finally, the Rosenberg Self-Esteem scale is a commonly used measure to describes the extent of a person approval or disapproval toward oneself. The scale comprises ten questions: if the person feels like a failure, to have good qualities, to have a positive attitude, if he/she feels useless at time, thinks to be no good, if he/she considers him/herself a person of worth, if he/she is satisfied with him/herself, if the individual has not much to be proud of, if he/she wants more respect and lastly if the individual thinks to do things well. Similarly to the Pearlin scale, higher scores indicate greater levels of self-esteem. Again, more detailed information on

[21] The thresholds associated to each group of variables and the dummyfication process are clarified in Table A.1

scale construction can be found in Mainieri (2006).

Empirical methodology: Nearest Neighbour Matching This investigation will use matching techniques, more specifically Nearest Neighbour Matching to estimate causal changes in parental inputs given to the offspring due to having an ill child. The aim is to compare healthy children with an ill sibling to healthy children with a healthyl sibling. Matching identifies observational counterfactuals according to some specific observable variables, given that the setting satisfies some basic requirements: the unconfoudedness and the common support assumptions.

Unconfoundedness implies that the selection into treatment depends only on observable, and observed variables, and that the setting allows to observe all the variables that determine the assignment into treatment and the outcome at the same time. On observed variables, more importantly, it has to be noted that they need to be independent from the treatment. In this case having an ill child could affect households' income an labour market participation. Since this possibility has to be taken into account, retained controls need to be unaffected by the presence of an ill child or pre-determined, i.e. fixed before the birth of children (Caliendo and Kopenig, 2008).

Since matching is determined by observable variables, common support assumption (CSA) requires enough density in covariates' distribution among the treated and control samples. Therefore, given observable variables, the common support or overlap assumption requires that there is not perfect predictability of assignment into treatment (Heckman *et al.*, 1999). One immediate difference between Ordinary Least Squares (OLS) and matching techniques is that in the latter case estimations do not need to satisfy CSA.

Summarizing, basic assumptions are related to the exogeneity of the assignment into treatment: in this case having an ill sibling must be considered randomly assigned among households given observable variables used in the analysis. Moreover, such variables must be exogenous, i.e. they do not have to be influnced by the treatment.

Considering the illness categories included in Special Education diagnoses, medical literature has not found a precise causal identification of the mechanism that determine many of the illnesses. Besides Down syndrome, which is caused by unpredicatable mistakes in cell division before or immediately after conception, the causes of other conditions can be summarized in complications during pregnancy, infections, early-life complications and genetic mutations[22]. For this reason, after controlling for households' and children's characteristics that could proxy for the probability of having an ill child, I consider the treatment to be randomly assigned among families. Such setting should guarantee the satisfaction of unconfoundedness assumption, which cannot be directly assessed otherwise. The full list of controls included in the analysis is explained below.

This study will employ Nearest Neighbor Matching, a matching algorithm that identifies the closest match possible for each observation given the observed variable defined by the setting. The chosen matching

[22] For more information on the possible determinants of the conditions included in Special Education groups see for example `https://www.nichd.nih.gov/health/topics/Pages/index.aspx`.

algorithm follows the Abadie and Imbens (2006) model, with Mahalanobis distance matrix. It allows to partially neglect the CSA, since matched observations are chosen in order to minimize the distance among covariates' values for each matched pair. It ensures a better quality of matches respect to applying "plain" Propensity Score Matching, and it determines the exclusion of potentially bad matches that could bias the results. Finally, the estimation will require robust standard errors instead of bootstrapped ones, which proved not to be efficient when linearity of estimates is unmet like in this case (Abadie and Imbens, 2008).

Along with matching results, this paper will present OLS results. OLS estimations permit the inclusion of the variables possibly affected by the treatment, like household income and mother's employment level that have to be excluded by construction when performing matching. Both in OLS and matching some unobservable variables could bias obtained estimates. The main difference that leads to adopting matching instead of OLS in this case regards the weighting scheme adopted by the two methods. On the one hand, as noted by Angrist and Pischke (2008), OLS regressions produce a variance - weighted average of the effect of the treament on the outcome. This technique aims at minimizing squared errors, therefore giving important weight at margin observations. On the other hand via CSA, matching assigns more weight to observations with similar covariates' values. Differences in outcomes is due to differences in weighting schemes unless the treatment is independent on the controls (Angrist and Pischke, 2008).

As explained above, the Child Development Supplement was administered to the same children in 1997, 2002 and 2007. However in the current analysis I cannot exploit the panel dimension of the data for two main reasons. The first one regards the illness identification, which requires children to be in their school years in order to ensure that all children eligible for Special Education are diagnosed as such. By the construction of the data in 1997 a great part of the sample was not in schooling, since it comprised children between 0 and 12 years old. The second issue regards the sample size in the third wave, since observed children in the original sample were not re-interviewed once they turned 18. This sample size issue gains even more importance because this setting observes only children living with both biological parents, and excludes only children. Since the data allows to observe two children in each household, the analysis could have exploited household's fixed effects. However in the case of the current study it is hard to assume that households' fixed effect are the same inside families in which there are simulataneously ill and healthy children. Therefore matching represented a possible solution to find the counterfactual observation for children living with an ill sibling among the control group (and viceversa), trying to minimize possible bias given by the characteristics of disposable data.

Concluding, given the characteristics and the requirements needed for Nearest Neighbour Matching, this setting will impose exact matches on children's grade and gender. Additional controls will require the closest match possible for children's ethnicity, birth order, sibling's gender and age, number of biological siblings living in the same household, and lastly primary caregiver's age group and educational level. Moreover, the matching algorithm will adjust for the possible bias given by continuous variables like sibling's age, number of biological siblings living in the family unit and primary caregiver's age group (Imbens, 2004; Abadie and

Imbens, 2006). Some could argue that the number of chilren in a family could be affected by the presence of an ill child. This issue will be faced in several analyses in the paper.

Since I measure quality time as total time in which the child is actively engaged in some activities with any of the parents[23], children living with non-biological parents could represent a source of bias in this case. The sample used in the analysis will use exclusively children living with both biological parents when studying the amount of quality time spent with parents, and it will be restricted to children living at least with their biological mother when studying parenting style and parental distress.

4.4 Empirical Evidence

Summary Statistics and preliminary analyses The sample is composed by all children in the survey with a sibling with a completed questionnaire in CDSII. Moreover, I require that all children and their siblings live with both biological mother and father when investigating on quality time, while I will require only the presence of the biological mother for the other dimensions, i.e. parental attitude and parenting stress. This change in sample requirements explains the different sample sizes observed in Table 4.2. Restricting the sample to children living with both biological parents reduces the sample to 557 children, of which 69 living with an ill sibling and 488 with healthy siblings. Sample size significantly increases with Warm and Punitive parenting indices, comprising 700 observations of which 110 with an ill sibling. Similarly the Strictiness index counts on 949 eligible observations, composed by 137 children living with an ill sibling and 812 living with a healthy sibling. Differences in sample size in this case are given by the number of completed answers in each module used for the construction of the index. As already said, the Warm and Punitive parenting indices rely on the same set of questions admnistered from the HOME questionnaire, that required the physical presence of a specialized interviewer. This particular characteristic determined a drop in sample size respect to questions comprised in the Strictness Index that were part of the main questionnaire in CDSII. Parenting Stress measures show similar sample size to the Strictness Index. In these cases the eligible sample will be composed by 949 observations, of which 137 have an ill sibling and 812 have a health sibling[24].

From Table 4.2 it emerges that children with ill siblings seem to receive on average more quality time from parents, more precisely it seems that mothers are the ones that devote more time to these children, but the difference is not statistically significant. Similarly for Warm and Punitive parenting, children with an ill sibling tend to receive warmer and more punitive parenting, but these differences have no statistical significance. However the treated group, i.e. children living with an ill sibling, show on average lower scores

[23] The analysis will include also quality time divided by the amount of time spent with each parent. However children living with non-biological parents, or children living without that specific parental figure could show a priori lower levels of quality time and bias obtained estimates. Using exclusively children living with both biological parents is commonly used when analysing quality time (Del Boca *et al.*, 2012; Monfardini and See, 2012).

[24] For the Rosenberg Self Esteem measure the total sample drops to 941 observation because it contains only 804 children with a healthy sibling, while the treatment group size is unchanged to 137.

for strict parenting by about five percentage points with a significance level of 5% and an average score in the overall sample of 0.75. More interestingly, parenting stress shows a clear pattern from sample comparisons. Primary caregivers of children with an ill sibling score higher on parental distress (1.6 points more with an overall average score around 4), show lower levels on self efficacy (nearly 0.2 points on an overall sample mean score by 3.15), and record lower self esteem (0.12 points less on an overall score in the sample by 3.43). All parenting stress differences among the two samples have a 1% significance level.

Table 4.3 shows differences in sample composition with respect to the covariates that will be used in the main analyses[25]. The figures refer to the stricter sample requirements of the analysis, that is requiring children to live with both biological parents. However no difference is shown when using the alternative sample definition. Strong statistical differences regard mainly the gender of the ill sibling and the numerosity of the household. As it regards the gender of the sibling, it emerges that ill children are more likely to be boys. This evidence is supported by a usually higher genetic predisposition among boys of showing illnesses for which females are immune carriers. The number of children living in the family unit shows a different pattern: it seems that the treated group is more likely to be formed by families with four and five children (respectively number of biological siblings living with the child equal to three and four), than with two-children households (one biological sibling living with the child). These differences will have to be evened out after the matching. Moreover, differences in household size in this case seem to exclude that parents strategically decide to stop having children when one is showing signs of physical or mental disability, since there is no statistical difference on birth order among the two samples, and ill children seem to be placed more on large households with respect to healthy siblings' couples. One last remark regard the primary caregivers' age group. In Table 4.3 it seems that there are no observations among the 17-20 and the 21-25 groups respectively among the control and the treated samples. Once again, these differences should not be observed after the matching, likely by excluding those groups from the matched sample.

Covariates Balance The model that performed better in terms of covariates' balance proved to be the 1:1 matching, meaning that each observation in the treated group is matched with one observation in the control group and viceversa. Checking for covariates' balance is an important step in matching analyses, since it ensures that obtained estimates are not biased by differences among samples. Table 4.4 provides results of covariates' mean differences and variance ratios among the treated and control groups before and after matching. Results in the table refer to the wider sample of the analyses, that is when requiring eligible children to live with the biological mother. Differences among covariates' means should ensure that after the matching procedure there is sufficient equality among covariates' distribution (Rosenbaum and Rubin, 1985). However considering this measure alone exposes to two major problems: there is no confidence interval applied to the measure, therefore there is no adequacy threshold one can apply to obtain results. The other problem, hihglighted by Ho *et al.* (2007), regards the possibility that bias remains even if covariates' means

[25] A more detailed description of the covariates used in the analysis and the PSID questionnaire they were extracted from can be found in Table A.2.

are similar. A suggested solution is variances' comparison, which should provide a more complete description of the degree of similarity of the covariates between the two groups. Usually this last measure is applied to continuous variables, however I propose it also for dummy variables since they compose the majority of controls in the sample. From Table 4.4 it seems that most covariates reach a good degree of balance among the two samples after the matching. The only problem is given by two categories of primary caregiver's age group (51-55 and 56-60 years), since in the sample they contain respectively five and two observations all contained in the control group. In the matching procedure the observations in these categories have been matched with those in the closest age group, which explains their inclusion in the matched sample. This finding does not create a problem for obtained results, first of all because of the scarce numerosity of those observations[26], and then because as highlighted by Ho *et al.* (2007), priority in covariates' balance needs to be given to the most important covariates, like in this case children's gender, grade and birth order. A possible "confidence interval" for this measure is proposed by Austin (2009), suggesting the use of the 2.5th and 97.5th percentiles' values of a F-distribution, with in this case 591 and 591 degrees of freedom[27]. The suggested values of 0.85 and 1.18 represent intuitively a threshold to evaluate obtained variance ratios in Table 4.4. Nearly all values lie in the value range. Of course this method is mostly reliable when working with continuous covariates, while it is not very indicative especially with categorical controls with few observations, like in the category "other" in the ethinicity control or in the 61 + age group for primary caregivers.

Good covariates balance is also displayed in Figure 4.1. Kernel densities show a good degree of similarity between covariates' distribution after the matching procedure. In this case the graph for primary caregiver's age range is not shown: due to the absence of treated observations among the 51-55 and 56-60 groups, this method fails at providing a graphical representation of the groups' distribution.

Baseline results Table 4.5 shows results from baseline specification on total quality time spent with parents. It seems that parents spend nearly three hours more a week in quality activities with children that have an ill sibling. However by dividing results by gender and birth order it emerges that this increase in total quality time in the overall sample is actually due to girls and older children. Girls benefit from an increase in total quality time by about three hours and a half, while the increase among older children is slighltly greater than five hours a week. In the overall sample the average weekly quality time spent with either parents was equal to nine hours. Table 4.5 shows also that the increase in total quality time spent with either parent is actually due to mothers spending more time with children, while fathers do not show different time allocation among families with an ill child. Since the sample is composed by children living with both biological parents, results from this analysis shows that fathers do not systematically change the amount of time allocated to children, while mothers are more responsive to children's needs. It seems that by having an ill sibling, children receive more attention by parents. However when dividing total quality time in its activites there is no specific increase in any group, meaning that there is a general increase in quality

[26] Repeating the analyses excluding a priori observations in the 51-55 and 56-60 years primary caregiver's age group delivers the same results (not shown).

[27] From Table 4.6, 592 couples of observations were matched in the procedure.

time, but there is no activity more sensitive to the presence of an ill child[28]. The question that arises at this point regards the nature of the time spent together: do mothers spend more time with ill children and involve healthy children too, or compensate by investing more on the more able child? Further explorations in robustness checks section will try to answer this question.

Table 4.6 presents results on the three different parenting style indices considered in this investigation: Warm Parenting, Punitive Parenting and Strictness Index. Differently from previous analyses the sample is including all children living at least with the biological mother, in this case more than 90% of primary caregivers for these children is composed by their biological mother. The only difference that emerges from the results regards Warm Parenting: children that live with an ill sibling receive warmer parenting. The increase is equal to 5 percentage points in whole sample, with the average value in the overall sample close to 0.6. Again, by dividing the sample evidence shows that boys benefit from the presence of an ill child in the house, while there is no difference at birth order level. In this case the estimated increase in Warm parenting among boys is close to 10 percentage points. Therefore results bring to the conclusions that in this particular household's condition mothers' parenting style is affected by the gender of children, favouring boys over girls. At the same time there is no significant change in the levels of Punitive parenting and Strictness Index.

Lastly Table 4.7 contains results on primary caregivers' associated level of psychological distress, self efficacy and self esteem. Psychological distress levels are higher inside families with an ill child: the K6 measure increases by 1 point among these families, with the overall average score being equal to 3.9 points[29]. This effect is far from determining severe psychological problems, however it pictures a situation of greater distress among mothers of ill children. Higher stress levels are associated especially if the healthy child is a girl and if the ill child is the older one. These differences at the gender and birth order levels would be more interesting to explore, in order to investigate which household dynamics trigger such effects. Unfortunately at the stage of the current analysis it is not possible to provide a clear interpretation of such mechanisms. The Pearlin Self Efficacy scale shows a clear decrease of primary caregivers' levels of self efficacy, equal to 0.15 points, with the average value in the overall sample being equal to 3.15. Similarly the decrase in Self Esteem measured by the Rosenberg scale is equal to 0.11 points, and the mean score in the total sample is equal to 3.4. In both cases there is no systematic difference at the gender and birth order levels. Summarising, results on parental distress confirm overall higher levels of parental psychological stress and lower levels of self efficacy and self esteem generally highlighted by literature.

Robustness checks: alternative specifications In order to exclude the possibility that our results are biased by possible endogenous controls I propose several modifications to the original model.

[28] Table A.3 shows sample statistics among the activites that were included in quality time measure. From sample comparison it seems that parents spend more time eating and less time practising sport with the child in presence of an ill sibling. However from results in Table A.5 there is no clear effect on a specific quality time component, excluding a half an hour weekly quality time increase in time talking with mothers.

[29] In the K6 Non-specific psychological distress measure values greater than 13 indicate psychological problems.

Those changes regard the imposed sample restriction on biological parents and the family size. As already mentioned, the number of children inside a family could be affected by the presence of an ill child: parents could decide not to have further children if they face an excessive burden with the ill child, or could decide to increase the number of children in the family in order to look after the ill child in a prospective point of view. In either cases, postestimation evidence has shown to have sufficiently balanced this control, so it should not posit any problem to obtained estimates. I propose two main checks to see how obtained results change manipulating the control on the number of children in the household: excluding the control from the analysis and/or restricting the sample only to four children households, in order to exlcude that the effect estimated is due to "extreme" observations. Sample size restriction on family composition were crucial for a correct identification of the mechanisms of interests: changes in quality time spent with parents may be extrememly sensitive to whether the child is actually living with his/her biological parents or not. At the same time parenting style could be differently exerted by caregivers if they are not biologically related to the child, and the same could hold for parenting stress. Changes in sample restrictions are aimed at verifying if the results obtained still hold in broader samples or are biased by counfounding factors that may have been ruled out with the original sample restrction.

Quality Time The first check on quality time spent with parents regards family size and the optimal number of matches required. Table 4.8 reports baseline results dropping the control for the number of biological siblings (columns 1-5), and restricting the analysis only to households with four children (columns 6-10). Results confirm that there is no significant alteration of quality time results, even if in the latter case there is a small drop in matched sample's size. Last column of Table 4.8 replicates the baseline model requiring a higher number of matches, equal to two. Once again baseline results are confirmed, however the original model proved to performed better in postestimation statistics (comparison not shown). Results in Table 4.8 report only the effect on total quality time spent with either parents, however dividing the analysis by total time spent with mothers and fathers as in Table 4.5 the same pattern is confirmed (not shown).

Similarly to Price (2008), I try to replicate obtained results by Ordinary Least Squares and Tobit estimation techniques. In this case the sample is the same of the original analyses, but I can add controls for household's income level, primary caregiver's working status, I can use the exact age of the primary caregiver in spite of his/her agegroup. Moreover, I also introduce an interaction between child's and sibling's gender to see if there is any influence on the total amount of quality time parents allocate to the offspring. The use of Tobit techniques is justified by the presence of some observations that do not spend quality time with mothers or fathers[30]. Table 4.9 shows that OLS and Tobit techniques are able to identify the increase in mother's quality time, even though with a slight underestimation of the time spent with children.

At this stage an interesting question could regard the reasons behind the nature of the increased quality time healthy children living with an ill sibling benefit from. Unfortunately there are not sufficient time diaries

[30] In the eligible sample 72 observations spent no quality time with the mother, 175 spent no quality time with the father, and 60 observations spent no quality time at all.

observation for ill children that could lead to a correct estimation through matching techiniques. Time diaries for children in CDS have information of the people present with the child during each activity, however there is no identification of which sibling was involved in the activity. Therefore any information on whether a sibling was participating to the activity respresents a spurious information in cases of three or more children present in the household, which are an important part of the original sample. However comparing sample statistics among ill children and the ordinary control group, it emerges that ill children receive on average about two and a half hours more of quality time from either parents and two hours more of quality time from mothers, with the differences being statistically significant[31]. Moreover, repeating OLS and Tobit estimations, it seems that ill children benefit on average from four hours more of total quality time, and two hours and a half more from mothers[32]. These results seem to confirm that parents devote more more quality time to ill children, and that healthy children, more specifically girls and older children, seem to benefit most likely taking part to these activities.

Parenting Style and Parental Stress In baseline analyses regarding parenting style and parenting stress the sample comprised all children living with at least the biological mother. Therefore in Tables 4.10 and 4.11 modifications from the original model regard sample restrictions[33]. In Table 4.10 columns 1 to 5 report the findings adding the control for parental presence: whether the child lives only with the biological mother or with both biological parents. Column 6 to 10 repeat baseline estimations without sample restrictions of the original model, that is including all children regardless of the presence of the biological mother and still adding the control for parental presence. Lastly in columns 11 to 15 results are obtained without using the control for the number of biological siblings present in the household. In Table 4.10 results are shown only for the Warm Parenting index, since it was the only one to show a significant pattern in baseline analysis. Results are confirmed: when changing parental controls and sample restrictions there is a clear increase in warm parenting among boys. In Table 4.11 results are shown only on the total sample, withouth dividing by child's gender or birth order[34]. Increases in primary caregiver's psychological distress, and decreasing levels of self efficacy and self esteem are confirmed when using parental living conditions controls (column 1), when using the whole sample without restrictions (column 2), and when excluding the number of biological siblings living in the household from the specification (column 3).

Interestingly, results on ill children do not highlight any different parenting style to ill children with respect to the control sample. At the same time primary caregivers show similar pattern on parenting stress with respect to previous findings[35].

[31] Results are shown in Table A.6 in the Appendix.
[32] Results of OLS and Tobit estimations are contained in Table A.7 in the Appendix
[33] The same modifications are applied in both tables.
[34] Results dividing by child's gender and birth order confirm confirm previous findings (not shown).
[35] Besides sample comparisons among ill children and control group in Table A.6 , that highlight warmer and more punitive parenting on average among the ill children group, results from nearest neighbour matching exclude the possibility of different parental attitude (not shown). Results in Table A.8 show that the increase in parental distress, present also in sample comparisons in Table A.6, is confirmed by matching techniques.

4.5 Conclusions

This paper studied parental inputs provided to the offspring, in terms of time allocation, parenting style and parenting stress, under a situation of strong ability imbalance among the siblings: when one is considered physically or mentally disabled. Parental inputs given to children are able to shape children's cognitive and noncognitive outcomes, for this reason the current investigation included the effect on parenting style and parenting stress along with the more commonly used concept of quality time.

This setting allowed to verify if standard economic models of resources allocation's decisions positing that parents should optimally invest more on the more able child were verified in this case. Interestingly, econometric investigations like Price (2008) proved that usually parents tend to equally split the amount of quality time spent with the offspring at each time, despite their age and ability levels.

This study employed siblings' couples aged between 0 and 18 from the Panel Study of Income Dynamics. Results obtained by Nearest Neighbour matching by comparing the treatment and control groups[36], allow to estimate the average treatment effect of having an ill sibling with respect to having a healthy sibling.

In order to exclude external factors that could bias the results, the effect on quality time was estimated only on children living with both biological parents. In this case results highlight that healthy children living with an ill sibling seem to spend with parents nearly three more hours each week in quality time activities with parents with respect to the control group. In first place by dividing the results by gender and birth order it emerges that the result on the overall sample was actually due to the female and older children subsamples. Girls spend about three hours and 24 minutes of quality time more than the control group, while the increase is close to five hours for older children. This results are similar to McHale and Pawletko (1992)[37]. Interestingly, mothers seem to devote more time to children in this particular situation, while the amount of time devoted by fathers is not affected. Given the setting of this paper, some considerations need to be pointed out about the other mechanisms that could determine resources' allocation besides the evident ability imbalance. Results highlight that healthy children living with an ill sibling benefit from more quality time from mothers with respect to similar children living with a healthy sibling. This could be due to the decision of parents to invest more time on the healthy child. However, it could also be due to parents generally investing more time taking care of the ill child, and involving the healthy child in these activities. Further investigations seem to favour this possibility, since on average children in the ill group receive about two weekly hours of quality time more than healthy children. Moreover, OLS and Tobit estimations indicate that ill children seem to receive between two and three hours more of quality time than healthy children[38]. The possibility that siblings of ill children are more involved in the care of the sibling has also been recognized

[36] In this setting the treated group was formed by healthy children with an ill sibling, and the control group was represented by healthy children with a healthy sibling

[37] McHale and Pawletko (1992) use the amount of mother child activities, which does not coincide with the measure of quality time used in this investigation, but it can be considered a good proxy.

[38] Due to reduced sample size it was not possible to run a Nearest Neighbour matching estimation in this case.

by previous studies (Stoneman *et al.*, 1988; Gamble and McHale, 1989; McHale *et al.*, 1989; Boyce and Barnett, 1993; Williams *et al.*, 1993). Whether the observed increase in quality time among children living with an ill sibling is due to more attention devoted by parents, or a greater involvement in sibling's care, these children could benefit from more time spent with mothers, especially in a prospective point of view. Further investigations are required in order to fully comprehend the nature of this quality time increase and its usefulness for healthy children.

Investigations on parenting style highlight an interesting pattern at the gender level: mothers seem to provide warmer parenting to boys. Results show an increase by 10 percentage points in warm parenting index among boys, while there is no effect on the strictness and punitive indices. Parental stress is overall high and confirming findings by previous studies: mothers of children with an ill sibling have higher levels of psychological distress and lower levels of self esteem and self efficacy. While the effect of parental stress can be interpreted as a negative spillover that the presence of an ill child in the household exerts on the healthy one/ones, parenting style seems to follow a more complex pattern. Since the same caregivers report warmer parenting with boys, but no different attitude with ill children, it seems that parents respond differently, providing warmer parenting to boys. Further investigations on this sample (not shown) indicate that parents do not seem to provide sistematically different parenting styles to boys and girls. However it could be that in particular conditions, like when having an ill child among the offspring, parents tend to involve more in everyday activities girls and older children, and to provide warmer parenting to boys. Specific mechanisms and causes behind this results should be investigated in order to comprehend parental responses to particular household's conditions.

From an economic perspective, the effects that the presence of an ill siblings have on the healthy one seem positive, in terms of more quality time spent with parents and warmer parenting style received. Even if these results seem to confirm that parents tend to invest more on the more able child, further investigations highlighted that these children are more involved in activities with the ill sibling. Therefore even if they benefit from more mother's quality time with respect to children with healthy siblings, results seem to endorse equal time allocation among the offspring as in Price (2008). Actual consequences on children's outcomes due to quality time and parenting style differences could be evaluated on educational achievement and labour market outcomes later in life.

Bibliography

ABADIE, A. and IMBENS, G. W. (2006). Large Sample Properties of Matching Estimators. *Econometrica*, **74** (1), 235–267. 4.3

— and — (2008). On the Failure of the Bootstrap for Matching Estimators. *Econometrica*, **76** (6), 1537–1557. 4.3

AMATO, P. R. and FOWLER, F. (2002). Parenting practices, child adjustment, and family diversity. *Journal of Marriage and Family*, **64** (3), 703–716. 4.1

ANGRIST, J. D. and PISCHKE, J.-S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press. 4.3

AUNOLA, K. and NURMI, J.-E. (2005). The Role of Parenting Styles in Children's Problem Behavior. *Child Development*, **76** (6), 1144–1159. 4.1

AUSTIN, P. C. (2009). Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. *Statistics in medicine*, **28**, 3083–3107. 4.4

AVERETT, S. L., GENNETIAN, L. A. and PETERS, H. E. (2005). Paternal child care and children's development. *Journal of Population Economics*, **18** (3), 391–414. 4.2

BAKER, B. L., BLACHER, J., CRNIC, K. A. and EDELBROCK, C. (2002). Behavior Problems and Parenting Stress in Families of Three-year-old Children with and without Developmental Delays. *American journal of mental retardation : AJMR*, **107** (6), 433–444. 4.1, 4.2

—, MCINTYRE, L. L., BLACHER, J., CRNIC, K., EDELBROCK, C. and LOW, C. (2003). Pre-school children with and without developmental delay: behaviour problems and parenting stress over time. *Journal of Intellectual Disability Research*, **47** (4-5), 217–30. 4.1, 4.2

BAYDAR, N., GREEK, A. and BROOKS-GUNN, J. (1997a). A Longitudinal Study of the Effects of the Birth of a Sibling during the First 6 Years of Life. *Journal of Marriage and Family*, **59** (4), 939–956. 4.2

—, HYLE, P. and BROOKS-GUNN, J. (1997b). A longitudinal study of the effects of the birth of a sibling during preschool and early grade school years. *Journal of Marriage & Family*, **59** (4), 957–965. 4.2

BECKER, G. S. (1991). *A Treatise of the Family*. Cambridge, MA: Harvard University Press. 4.1

— and LEWIS, H. G. (1973). Interaction between Quantity and Quality of Children. *Journal of Political Economy*, **81** (2), S279–S288. 4.1

— and TOMES, N. (1976). Child Endowments and the Quantity and Quality of Children. *Journal of Political Economy*, **84** (S4), S143. 4.1

— and — (1986). Human Capital and the Rise and Fall of Families. *Journal of Labor Economics*, **4**, 1–39. 4.1

Belsky, J. and Fearon, R. M. P. (2004). Exploring marriage-parenting typologies and their contextual antecedents and developmental sequelae. *Development and Psychopathology*, **16** (3), 501–523. 4.1

—, Jaffe, S. R., Sligo, J., Woodward, L. and Silva, P. a. (2005). Intergenerational tranmission of warm-sensitive-stimulating parenting: A propestive study of mothers and fathers of 3-year-olds. *Child Development*, **76** (2), 12. 4.3

Bianchi, S. M. (2000). Maternal employment and time with children: dramatic change or surprising continuity? *Demography*, **37** (4), 401–414. 4

Boyce, G. C. and Barnett, W. S. (1993). Siblings of persons with mental retardation: A historical perspective and recent findings. In *Research on Siblings of Individuals with Mental Retardation, Physical Disabilities, and Chronic Illness, Apr, 1991*, Paul H. Brookes Publishing. 4.5

Caldwell, B. M., Bradley, R. H. *et al.* (1984). *Home observation for measurement of the environment.* University of Arkansas at little Rock Little Rock. 4.3

Caliendo, M. and Kopenig, S. (2008). Some Practical Guidance for the Implementation of Propensity Score Matching. *Journal of Economic Surveys*, **22** (1), 31–72. 4.3

Carneiro, P., Crawford, C. and Goodman, a. (2007). *The Impact of Early Cognitive and Non-Cognitive Skills on Later Outcomes*. October, Centre for Economics of Education. 4.1

— and Rodrigues, M. (2009). Evaluating the Effect of Maternal Time on Child Development Using the Generalized Propensity Score. *Institute for the Study of Labor, 12th IZA European Summer School in Labor Economics*. 4.2

Carolan, B. V. and Wasserman, S. J. (2014). Does Parenting Style Matter? Concerted Cultivation, Educational Expectations, and the Transmission of Educational Advantage. *Sociological Perspectives*, **58** (2), 169–186. 4.2

Chan, T. W. and Koo, A. (2011a). Parenting style and youth outcomes in the UK. *European Sociological Review*, **27** (3), 385–399. 4.1

— and — (2011b). Parenting style and youth outcomes in the UK. *European Sociological Review*, **27** (3), 385–399. 4.2

Cobb-Clark, D. a. and Tan, M. (2011). Noncognitive skills, occupational attainment, and relative wages. *Labour Economics*, **18** (1), 1–13. 4.1

Cosconati, M. (2009). Parenting Style and the Development of Human Capital in Children. *Unpublished Manuscript, Bank of Italy*. 4.2, 10

Cunha, F. and Heckman, J. J. (2008). Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation. *Journal of Human Resources*, **43** (4), 738–782. 4.1

—, —, Lochner, L. and Masterov, D. V. (2006). Interpreting the Evidence on Life Cycle Skill Formation. *Handbook of the Economics of Education*, **1**, 697–812. 4.2

Dabrowska, a. and Pisula, E. (2010). Parenting stress and coping styles in mothers and fathers of pre-school children with autism and Down syndrome. *Journal of Intellectual Disability Research*, **54** (3), 266–280. 4.1, 4.2

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: the indirect role of parental expectations and the home environment. *Journal of family psychology : JFP : journal of the Division of Family Psychology of the American Psychological Association (Division 43)*, **19** (2), 294–304. 4.2

De Haan, M., Plug, E. and Rosero, J. (2014). Birth Order and Human Capital Development: Evidence from Ecuador. *The Journal of Human Resources*, **49** (2), 359–392. 4.2

Del Boca, D., Flinn, C. and Wiswall, M. (2014). Household choices and child development. *Review of Economic Studies*, **81** (1), 137–185. 4.1

—, Monfardini, C. and Nicoletti, C. (2012). Self Investments of Adolescents and Their Cognitive Development. *IZA Discussion Paper*, (6868), 1–35. 4.2, 4.3, 23

Del Bono, E., Francesconi, M., Kelly, I. and Sacker, A. (2014). Early Maternal Time Investment and Early Maternal Time Investment and Early Child Outcomes. *IZA Discussion Paper Series*, (8608). 4.2

Di Giulio, P., Philipov, D. and Jaschinski, I. (2014). Families with disabled children in different European countries. *Family and Societies Working Paper Series*, **23**. 4.2, 13

Ermisch, J. (2008). Origins of Social Immobility and Inequality: Parenting and Early Child Development. *National Institute Economic Review*, **205** (1), 62–71. 4.2, 11

Estes, A., Munson, J., Dawson, G., Koehler, E., Zhou, X.-H. and Abbott, R. (2009). Parenting stress and psychological functioning among mothers of preschool children with autism and developmental delay. *Autism*, **13** (4), 375–387. 4.2, 13

Fiorini, M. and Keane, M. P. (2014). How the allocation of children's time affects cognitive and noncognitive development. *Journal of Labor Economics*, **32** (4), pp. 787–836. 4.1, 4.2, 4.2, 4.3

Flouri, E., Midouhas, E. and Joshi, H. (2014). Family poverty and trajectories of children's emotional and behavioural problems: The moderating roles of self-regulation and verbal cognitive ability. *Journal of Abnormal Child Psychology*, **42** (6), 1043–1056. 4.2, 11

Gamble, W. C. and McHale, S. M. (1989). Coping with stress in sibling relationships: A comparison of children with disabled and nondisabled siblings. *Journal of Applied Developmental Psychology*, **10** (3), 353–373. 4.5

Hastings, R. P. (2007). *Stress in parents of children with autism*. Wiley-Blackwell. 4.2

— and Johnson, E. (2001). Stress in uk families conducting intensive home-based behavioral intervention for their young child with autism. *Journal of Autism and Developmental Disorders*, **31** (3), 327–336. 4.2

Heckman, J., Pinto, R. and Savelyev, P. (2013). Understanding the Mechanisms Through Which an Influential Early Childhood Program Boosted Adult Outcomes. *American Economic Review*, **103** (6), 2052–2086. 4.1

Heckman, J. J., LaLonde, R. J. and Smith, J. A. (1999). The Economics and Econometrics of Active Labor Market Programs. *Handbook of Labor Economics*, **3**, 1865–2097. 4.3

— and Masterov, D. V. (2007). The productivity argument for investing in young children. *Applied Economic Perspectives and Policy*, **29** (3), 446–493. 4.2

—, Moon, S. H., Pinto, R., Savelyev, P. a. and Yavitz, A. (2010). The rate of return to the HighScope Perry Preschool Program. *Journal of Public Economics*, **94** (1-2), 114–128. 4.1

—, Stixrud, J. and Urzua, S. (2006). The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior. *National Bureau of Economic Research*, (September 2005). 4.1

Heiland, F. (2009). Does the birth order affect the cognitive development of a child? *Applied Economics*, **41** (14), 1799–1818. 4.2

Ho, D. E., Imai, K., King, G. and Stuart, E. a. (2007). Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis*, **15** (3), 199–236. 4.4

Hsin, A. (2007). Mothers' Time with Children and the Social Reproduction of Cognitive Skills. *California Center for Population Research*. 4.1, 4.2

— (2009). Parent's time with children: Does time matter for children's cognitive achievement? *Social Indicators Research*, **93** (1), 123–126. 4.2

Huston, A. C. and Aronson, S. R. (2005). Mothers' Time With Infant and Time in Employment as Predictors of Mother Child Relationships and Children's Early Development. *Child Development*, **76** (2), 467–482. 4, 6

Huver, R. M. E., Otten, R., de Vries, H. and Engels, R. C. M. E. (2010). Personality and parenting style in parents of adolescents. *Journal of Adolescence*, **33** (3), 395–402. 4.1

Imbens, G. W. (2004). Nonparametric estimation of average treatment effects under exogeneity: a review. *Review of Economics & Statistics*, **86** (1), 4–29. 4.3

Kessler, R. C., Barker, P. R., Colpe, L. J., Epstein, J. F., Manderscheid, R. W., Walters, E. E. and Zaslavsky, A. M. (2003). Screening for Serious Mental Illness in the General Population. *Archives of General Psychiatry*, **60**, 184 –189. 4.3

Koegel, R. L., Schreibman, L., Loos, L. M., Dirlich-Wilhelm, H., Dunlap, G., Robbins, F. R. and Plienis, A. J. (1992). Consistent Stress Profiles in Mothers of Children with Autism. *Journal of Autism and Developmental Disorders*, **22** (2), 205–216. 4.1, 4.2

Lamborn, S. D., Mounts, N. S., Steinberg, L. and Dornbusch, S. M. (1991). Patterns of Competence and Adjustment among Adolescents from Authoritative, Authoritarian, Indulgent, and Neglectful Families. *Child Development*, **62**, 1049–1065. 4.1, 4.2, 9

Lindqvist, E. and Westman, R. (2011). The Labor Market Returns to Cognitive and Noncognitive Ability: Evidence from the Swedish Enlistment. *American Economic Journal: Applied Economics*, **3**, 101–128. 4.1

Lleras, C. (2008). Do skills and behaviors in high school matter? The contribution of noncognitive factors in explaining differences in educational attainment and earnings. *Social Science Research*, **37** (3), 888–902. 4.1

Lundberg, S. (2005). Sons, daughters, and parental behaviour. *Oxford Review of Economic Policy*, **21** (3), 340–356. 4.2

Mainieri, T. (2006). The panel study of income dynamics child development supplement: User guide for cds-ii. *Ann Arbor, MI: Institute for Social Research, University of Michigan.* 4.3

McHale, S. M., Gamble, W. C. and Pawletko, T. M. (1989). *Sibling Relationships and Adjustment in Children with Disabled and Nondisabled Brothers and Sisters*. Tech. rep., Society for Research in Child Development, Kansas City, MO. 4.5

— and Pawletko, T. M. (1992). Differential Treatment of Siblings in Two Family Contexts. *Child Development*, **63** (1), 68–81. 4.5, 37

McLeod, J. D. and Shanahan, M. J. (1993). Poverty, Parenting and Children's Mental Health. *American Sociological Review*, **58** (3), 351–366. 4.3

Monfardini, C. and See, S. G. (2012). Birth Order and Child Outcomes: Does Maternal Quality Time Matter? *IZA Discussion Paper Series*, **6825** (6825). 4.2, 4.3, 23

Neece, C. L., Green, S. a. and Baker, B. L. (2012). Parenting stress and child behavior problems: A transactional relationship across time. *American Journal on Intellectual and Developmental Disabilities*, **117** (1), 48–66. 14

NEIDELL, M. J. (2000). Early Parental Time Investments in Children's Human Capital Development: Effects of Time in the First Year on Cognitive and Non-cognitive Outcomes. Los Angeles: University of California. 4.2

NICOLETTI, C. and TONEI, V. (September 2015). The response of parental time investments to the child's abilities and health. *Carlo Alberto Notebooks*, (428). 6

PEARLIN, L. I., MENEGHAN, E. G., LIEBERMAN, M. A. and MULLAN, J. T. (1981). The Stress Process. *Journal of Health and Social Behavior*, **22** (4), 337–356. 4.3

PENSIERO, N. (2011). Parent-child cultivation and children's cognitive and attitudinal outcomes from a longitudinal perspective. *Child Indicators Research*, **4** (3), 413–437. 4.2

PRICE, J. (2008). Parent-Child Quality Time Does Birth Order Matter? *The Journal of Human Resources*, **43** (1), 240–265. 4.1, 4.2, 7, 8, 4.3, 4.4, 4.5

ROSENBAUM, P. R. and RUBIN, D. B. (1985). Constructing a Control Group Using Multivariate Matched Sampling Methods that Incorporate the Propensity Score. *The American Statistician*, **39** (1), 33–38. 4.4

RUHM, C. J. (2004). Parental Employment and Child Cognitive Development. *The Journal of Human Resources*, **39** (1), 155–192. 4

SPERA, C. (2005). A review of the relationship among parenting practices, parenting styles, and adolescent school achievement. *Educational Psychology Review*, **17** (2), 413–437. 4.1, 4.2

STEINBERG, L., BLATT-EISENGART, I. and CAUFFMAN, E. (2006). Patterns of competence and adjustment among adolescents from authoritative, authoritarian, indulgent, and neglectful homes: a replication in a sample of serious juvenile offenders. *Journal of Research on Adolescence*, **16** (1), 47–58. 4.2

—, LAMBORN, S. D., DORNBUSCH, S. M. and DARLING, N. (1992). Impact of parenting practices on adolescent achievement: authoritative parenting, school involvement, and encouragement to succeed. *Child development*, **63** (5), 1266–1281. 4.1, 4.2

STONEMAN, Z., BRODY, G. H., DAVIS, C. H. and CRAPPS, J. M. (1988). Childcare responsibilities, peer relations, and sibling conflict: Older siblings of mentally retarded children. *American Journal on Mental Retardation*. 4.5

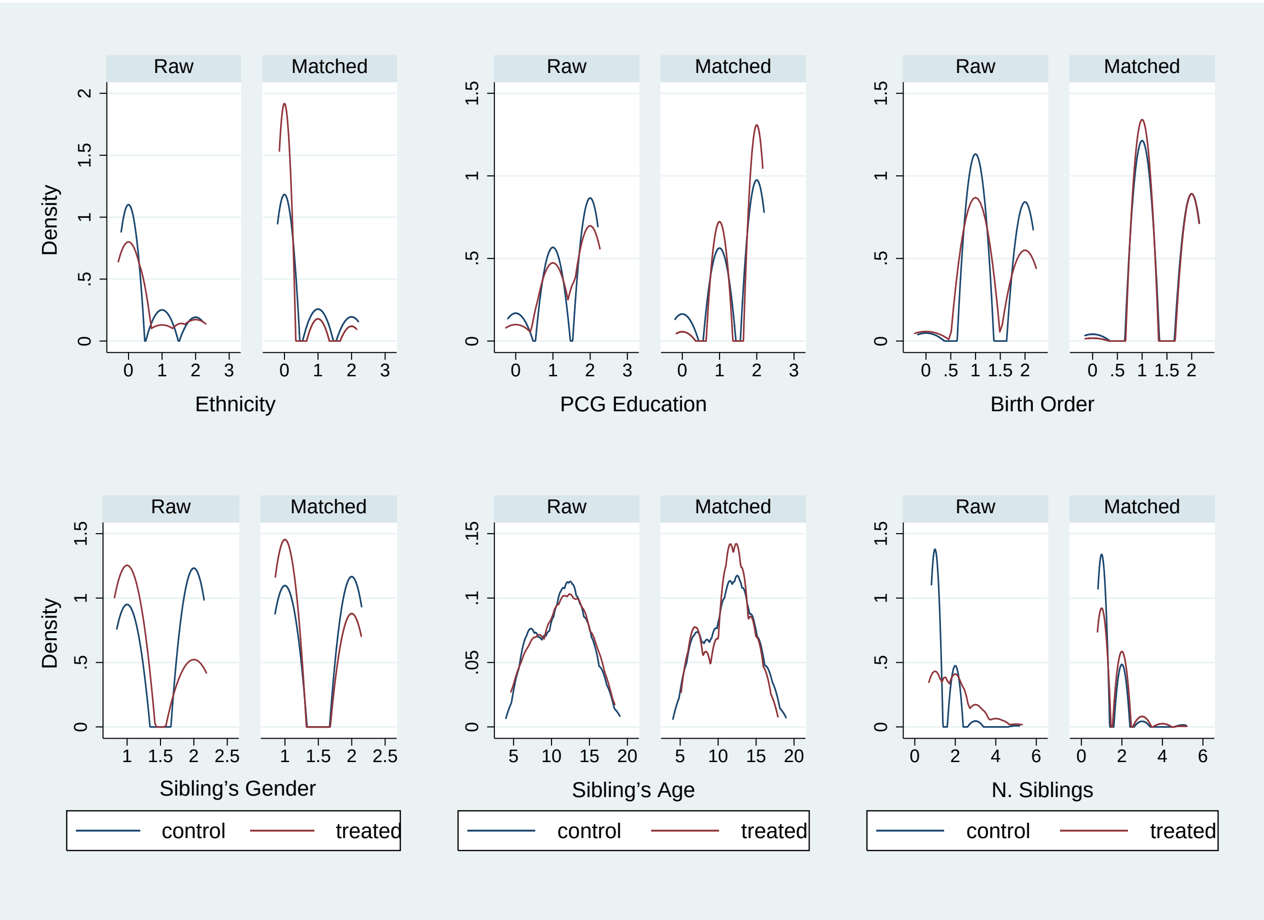
TODD, P. E. and WOLPIN, K. I. (2003). On the Specification and Estimation of the Production Function for Cognitive Achievement. *The Economic Journal*, **113** (485), 2–33. 4.1

— and — (2007). The Production of Cognitive Achievement in Children: Home, School, and Racial Test Score Gaps. *Journal of Human Capital*, **1** (1), 91–136. 4.1

Williams, P. D., Lorenzo, F. D. and Borja, M. (1993). Pediatric chronic illness: effects on siblings and mothers. *Maternal-Child Nursing Journal*. 4.5

Yeung, W. J., Linver, M. R. and Brooks-Gunn, J. (2002). How money matters for young children's development: parental investment and family processes. *Child development*, **73** (6), 1861–1879. 4.1, 4.3

***Fig. 4.1** – Covariates' Kernel density plots*



Note: Covariates' Kernel densities after baseline Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, birth order, sibling's age and gender, education of the primary caregiver, primary caregiver's age group and number of biological siblings living with the child. Bias adjusted for primary caregiver's age group, sibling's age and number of biological siblings living with the child. The sample is composed of all children with a sibling living with the biological mother and never diagnosed for Special Education needs. Blue: control sample (healthy children with a healthy sibling). Red: treated sample (healthy children with an ill sibling).

Table 4.1 – Parenting style, factor loadings

	Warmth Factor	**Punitive factor**
Variable	Factor loading #1	Factor loading #2
Respond to questions	0.4034	
Physical affection	0.4857	
Provide toys	0.3482	
Voice conveyed feelings	0.5244	
Spontaneous praise	0.6570	
Warm - affectionate	0.5418	
Demonstrate achievement	0.5367	
Encouraged to talk	0.5402	
Emotional response	0.6008	
Diminutives	0.4338	
Scold - Criticize		0.6588
Shouted		0.5801
Showed annoiance		0.5363
Slap - spank		
Shook - grabbed		0.3042
Obs.	1202	1202
N. of Items	10	4
Chronbach's alpha	0.774	0.626

	Strictness Factor
Variable	Factor loading
Limits on :	
Amount of TV	0.6692
Kind of TV	0.6946
Bedtime	0.6307
Limits of sweets	0.7094
Social interactions	0.5876
Afterschool activities	0.6413
Homework	0.6857
Enforce rules on:	
Amount of TV	0.6804
Kind of TV	0.7026
Bedtime	0.6331
Limits of sweets	0.6998
Social interactions	0.6010
Afterschool activities	0.6493
Homework	0.6835
Obs.	1478
N. of Items	14
Chronbach's alpha	0.902

Results of confirmatory factor analysis are lead on each table separately. In each group factors are identified imposing eigenvalue>1. In order to be included in the category the imposed loading threshold was 0.3 for the rotated factors.

Table 4.2 – Parental inputs, sample statistics and t-tests

	Whole sample			No Ill sibling			Ill sibling			
Variable	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Difference
Parental quality time:										
Quality time - Total	557	8.933	0.283	488	8.862	0.297	69	9.440	0.914	-0.578
Quality time - Mother	557	7.371	0.243	488	7.267	0.251	69	8.109	0.842	-0.842
Quality time - Father	557	5.417	0.239	488	5.369	0.252	69	5.753	0.748	-0.384
Parental attitude:										
Warm index	810	0.5789	0.008	700	0.578	0.009	110	0.585	0.020	-0.008
Punitive index	810	0.035	0.004	700	0.035	0.004	110	0.038	0.011	-0.019
Strictness index	949	0.747	0.008	812	0.755	0.009	137	0.701	0.024	0.054 **
Parental distress:										
K6 - Psychological Distress	941	4.030	0.118	804	3.792	0.122	137	5.423	0.362	-1.631 ***
Pearlin - Self Efficacy	941	3.148	0.019	804	3.177	0.020	137	2.982	0.052	0.195 ***
Rosenberg - Self Esteem	943	3.443	0.015	806	3.460	0.016	137	3.338	0.037	0.122 ***

Note: "Whole Sample" is composed of all CDSII children with a sibling with a complete interview in CDSII and never diagnosed for Special Education needs. "No Ill Sibling" comprises all healthy children with a sibling that has never been diagnosed for Special Education needs. "Ill Sibling" subsample is composed of all healthy children with a sibling that has been diagnosed for Special Education needs. Last column presents results of a t-test of mean comparison among "No Ill Sibling" and "Ill Sibling" subgroups. *** p<0.01, ** p<0.05, * p<0.1

Table 4.3 – Covariates sample statistics and t-tests

	Whole Sample			No Ill Sibling			Ill Sibling			
	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Difference
Gender										
Male	557	0.46	0.02	488	0.47	0.02	69	0.38	0.06	0.09
Female	557	0.54	0.02	488	0.53	0.02	69	0.62	0.06	-0.09
Grade										
1^{st}	557	0.064	0.014	488	0.070	0.012	69	0.030	0.020	0.041
2^{nd}	557	0.092	0.012	488	0.092	0.013	69	0.087	0.034	0.005
3^{rd}	557	0.095	0.012	488	0.094	0.013	69	0.101	0.036	-0.008
4^{th}	557	0.122	0.014	488	0.117	0.015	69	0.159	0.044	-0.043
5^{th}	557	0.074	0.011	488	0.073	0.012	69	0.072	0.031	0.001
6^{th}	557	0.104	0.013	488	0.113	0.014	69	0.043	0.025	0.069 *
7^{th}	557	0.108	0.013	488	0.107	0.014	69	0.116	0.039	-0.009
8^{th}	557	0.052	0.009	488	0.057	0.011	69	0.014	0.014	0.043
9^{th}	557	0.090	0.012	488	0.090	0.013	69	0.087	0.034	0.003
10^{th}	557	0.065	0.010	488	0.057	0.011	69	0.116	0.039	-0.059 *
11^{th}	557	0.054	0.010	488	0.049	0.010	69	0.087	0.034	-0.038
12^{th}	557	0.032	0.007	488	0.027	0.007	69	0.072	0.031	-0.046 **
13^{th}	557	0.048	0.009	488	0.053	0.010	69	0.014	0.014	0.039
Ethnicity										
White	557	0.659	0.020	488	0.656	0.022	69	0.681	0.057	-0.025
Black	557	0.176	0.016	488	0.182	0.017	69	0.130	0.041	0.052
All the rest	557	0.165	0.016	488	0.162	0.017	69	0.188	0.047	-0.027
Birth Order										
Twins	557	0.029	0.007	488	0.029	0.008	69	0.029	0.020	-0.000
Older	557	0.465	0.021	488	0.457	0.023	69	0.522	0.061	-0.065
Younger	557	0.506	0.021	488	0.514	0.023	69	0.449	0.060	0.065
Sibling's Gender										
Male	557	0.506	0.021	488	0.480	0.023	69	0.696	0.056	-0.216 ***
Female	557	0.494	0.026	488	0.520	0.023	69	0.304	0.056	0.216 ***
Sibling's Age										
Age	557	11.253	0.139	488	11.232	0.150	69	11.406	0.380	-0.174
PCG Education										
< high school	533	0.107	0.013	465	0.103	0.014	68	0.132	0.041	-0.029
high school	533	0.330	0.020	465	0.325	0.022	68	0.368	0.059	-0.043
> high school	533	0.563	0.022	465	0.572	0.023	68	0.500	0.061	0.072
PCG Age Class										
17 - 20	557	0.002	0.002	488	0	0	69	0.014	0.014	-0.014 ***
21 - 25	557	0.013	0.005	488	0.014	0.005	69	0	0	0.014
26 - 30	557	0.126	0.0141	488	0.125	0.015	69	0.130	0.041	-0.005
31 - 35	557	0.196	0.017	488	0.189	0.018	69	0.246	0.052	-0.058
36 - 40	557	0.361	0.020	488	0.371	0.022	69	0.290	0.055	0.081
41 - 45	557	0.224	0.018	488	0.223	0.019	69	0.232	0.051	-0.009
46 - 50	557	0.079	0.011	488	0.078	0.012	69	0.087	0.034	-0.009
N. of Biological Siblings in Household										
One	557	0.637	0.020	488	0.666	0.021	69	0.435	0.060	0.231 ***
Two	557	0.302	0.019	488	0.291	0.021	69	0.377	0.059	-0.086
Three	557	0.043	0.009	488	0.033	0.008	69	0.116	0.039	-0.083 ***
Four	557	0.014	0.005	488	0.008	0.004	69	0.058	0.028	-0.050 ***
Five	557	0.004	0.003	488	0.002	0.002	69	0.014	0.014	-0.012

Note: "Whole Sample" is composed of all CDSII children with a sibling with a complete interview in CDSII, living with both biological parents and never diagnosed for Special Education needs. "No Ill Sibling" comprises all healthy children with a sibling that has never been diagnosed for Special Education needs. "Ill Sibling" subsample is composed of all healthy children with a sibling that has been diagnosed for Special Education needs. Last colum present results of a t-test of mean comparison among "No Ill Sibling" and "Ill Sibling" subgroups. *** p<0.01, ** p<0.05, * p<0.1

Table 4.4 – Covariates balance after Nearest Neighbour Matching

	Standardized Differences		Variance Ratio	
	(1) Raw	(2) Matched	(3) Raw	(4) Matched
Ethnicity				
Black	-0.030266	0.020513	0.979377	1.017425
Other	0.082853	-0.124079	1.191048	0.722176
PCG Education				
High School	-0.106740	-0.008272	0.950531	0.996603
> High School	-0.131077	-0.024315	0.990876	0.999014
Birth Order				
Older	0.110908	-0.045927	0.994837	1.000124
Younger	-0.083570	0.086555	0.989816	1.005642
Sibling's Gender				
Female	-0.308667	-0.218576	0.940301	0.954419
Sibling's Age				
Age	0.230186	0.098327	1.121374	0.941688
Biological Siblings in Household				
Number	0.483901	0.024737	2.532173	1.032132
PCG Age Group				
26-30	-0.1219038	-0.1102813	0.712691	0.721524
31-35	0.0974957	0.2276699	1.191106	1.394839
36-40	-0.0144673	0.0859315	0.992007	1.080361
41-45	0.0306054	-0.0557262	1.049384	0.926186
46-50	-0.0002042	-0.0265374	1.006189	0.914021
51-55	-0.142279	-0.154568	0	0
56-60	-.089712	-0.082269	0	0
61 +	0.0087015	-0.171808	1.024247	0.650059

Note: Columns 1 and 2 present the standardized difference between the control and treated sample respectively before and after the matching. Columns 3 and 4 show the variance ratio between control and treated samples respectively before and after matching. Raw sample includes all eligible observations. Matched sample includes only the observations selected in the Nearest Neighbour Matching. Balance check performed after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, primary caregiver's age group, child's birth order, sibling's gender and age, number of biological siblings in the family unit.. Bias adjusted for number of children living in the family unit, sibling's age and primary caregiver's age group.

Table 4.5 – Quality time, results

Quality Time with Parents

	(1)	(2)	(3)	(4)	(5)
Sample:	**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
ATE	2.895**	1.847	3.428**	5.397***	2.901
Std. Err.	(1.324)	(2.342)	(1.621)	(1.929)	(3.497)
Obs.	260	87	173	86	53

Mother Quality Time

	(6)	(7)	(8)	(9)	(10)
Sample:	**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
ATE	2.850**	2.013	3.228**	4.907**	3.046
Std. Err.	(1.165)	(1.740)	(1.540)	(1.979)	(2.950)
Obs.	260	87	173	86	53

Father Quality Time

	(11)	(12)	(13)	(14)	(15)
Sample:	**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
ATE	0.794	-0.885	1.854	0.750	1.330
Std. Err.	(1.128)	(1.879)	(1.393)	(1.396)	(2.957)
Obs.	260	87	173	86	53

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, birth order, sibling's age and gender, education of the primary caregiver, primary caregiver's age group and number of biological siblins living with the child. Bias adjusted for primary caregiver's age group, sibling's age and number of biological siblings living with the child. The sample is composed of all children with a sibling living with both biological parents and never diagnosed for Special Education needs. The estimated Average Treatment Effect (ATE) is estimated on total quality time spent with any of the parents (columns 1 - 5), on quality time spent with mother (columns 6 -10) and on quality time spent with the father (columns 11 -15). The ATE is estimated alternatively on the whole sample (columns 1, 6 and 11), on boys only (columns 2, 7 and 12), on girls only (columns 3, 8 and 13), considering only older children (columns 4, 9 and 14) and lastly considering only younger children (columns 5, 10 and 15) . Quality time espressed in hours. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4.6 – Parenting Style, results

		(1)	(2)	(3)	(4)	(5)
Sample:		**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
Warm Index	ATE	0.0488*	0.0968***	0.0254	0.0479	0.0198
	Std. Err.	(0.0281)	(0.0373)	(0.0392)	(0.0487)	(0.0553)
	Obs.	592	278	314	148	144
Punitive Index	ATE	-0.00686	-0.0124	0.00763	-0.00254	0.0186
	Std. Err.	(0.0166)	(0.0282)	(0.0181)	(0.0174)	(0.0426)
	Obs.	592	278	314	148	144
Strictness Index	ATE	-0.00335	-0.0401	0.0305	0.0218	-0.0449
	Std. Err.	(0.0346)	(0.0618)	(0.0376)	(0.0673)	(0.0549)
	Obs.	745	323	422	206	214

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling's gender ans age, number of children in the family unit, and primary caregiver's age group. Bias adjusted for number of children living in the family unit , sibling's age and primary caregiver's age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. In columns 2 and 3 analyses are performed exclusively on the male and female subsamples respectively. In columns 4 and 5 analyses are performed respectively on earlier-borns and on laterborns. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.7 – Parental Distress, results

		(1)	(2)	(3)	(4)	(5)
Sample:		**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
K6 Psychological Distress	ATE	1.040**	0.456	1.493***	-0.357	1.536**
	Std. Err.	(0.476)	(0.824)	(0.495)	(0.945)	(0.762)
	Obs	740	323	417	204	214
Pearlin Self Efficacy	ATE	-0.146**	-0.140	-0.127*	0.109	-0.160
	Std. Err.	(0.0690)	(0.120)	(0.0768)	(0.118)	(0.129)
	Obs	740	322	418	205	214
Rosenberg Self Esteem	ATE	-0.109**	-0.175**	-0.0548	0.0193	-0.0955
	Std. Err.	(0.0511)	(0.0841)	(0.0605)	(0.0966)	(0.0869)
	Obs	741	323	418	205	214

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling's gender ans age, number of children in the family unit, and primary caregiver's age group. Bias adjusted for number of children living in the family unit , sibling's age and primary caregiver's age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Column 1 presents results on the overall sample. Column 2 and 3 present results respectively dividing the sample by gender (male and female). Columns 4 and 5 present result repeating the analysis respectively on older children and on younger children. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.8 – Quality time, alternative specifications

Quality Time with Parents - Without number of siblings

	(1)	(2)	(3)	(4)	(5)
Sample:	**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
ATE	3.347**	2.623	3.121**	5.027***	3.513
Std. Err.	(1.341)	(2.488)	(1.589)	(1.897)	(3.237)
Obs.	260	87	173	86	53

Quality Time with Parents - Only up to 4 children households

	(6)	(7)	(8)	(9)	(10)
Sample:	**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
ATE	2.948**	1.281	3.423**	7.462***	2.171
Std. Err.	(1.354)	(2.373)	(1.670)	(2.120)	(3.767)
Obs.	255	86	169	75	35

Quality Time with Parents - 1:2 NN Matching

	(11)	(12)	(13)	(14)	(15)
Sample:	**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
ATE	3.153**	1.914	4.057**	6.643***	2.929
Std. Err.	(1.273)	(2.242)	(1.623)	(1.792)	(3.352)
Obs	260	87	173	86	53

Note: baseline specification results are obtained by Nearest Neighbour (NN) Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, birth order, sibling's age and gender, education of the primary caregiver, primary caregiver's age group and number of biological siblings living with the child. Bias adjusted for primary caregiver's age group, sibling's age and number of biological siblings living with the child. Sample is composed by all children with a sibling living with both biological parents and never diagnosed for Special Education needs. In columns 1 - 5 results are obtained excluding the number of biological siblings in the household among the controls and bias adjument variables. Column 6 -10 present the estimated Average Treatment Effect (ATE) including exclusively children living with up to three biological siblings. Columns 11 - 15 present the baseline specification results requiring two matches (1:2) for each observation in the sample. The ATE is estimated alternatively on the whole sample (columns 1, 6 and 11), on boys only (columns 2, 7 and 12), on girls only (columns 3, 8 and 13), considering only older children (columns 4, 9 and 14) and lastly considering only younger children (columns 5, 10 and 15). Quality time espressed in hours. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.9 – Quality time, OLS and Tobit estimations results

Dependent variable: Total Quality Time spent with						
	Parents	Mother	Father	Parents	Mother	Father
	(1)	(2)	(3)	(4)	(5)	(6)
Model:	OLS	OLS	OLS	Tobit	Tobit	Tobit
Ill Brother	1.928	1.687*	0.640	1.928	1.880**	0.900
(dummy)	(2.463)	(0.879)	(0.845)	(2.419)	(0.901)	(0.977)
Younger Sibling	-0.542	-0.399	-0.309	-0.542	-0.601	-0.110
(dummy)	(2.778)	(0.971)	(0.971)	(2.728)	(1.028)	(1.186)
Interaction: Child's gender- Sibling's gender :						
Male - Female	-1.759	-0.0269	0.225	-1.759	-0.240	0.160
	(2.158)	(0.712)	(0.717)	(2.119)	(0.770)	(0.860)
Female - Male	-2.118	0.224	0.00661	-2.118	0.110	-0.125
	(1.923)	(0.634)	(0.683)	(1.889)	(0.674)	(0.814)
Female - Female	0.872	0.336	-0.00335	0.872	0.371	-0.224
	(2.125)	(0.660)	(0.634)	(2.086)	(0.692)	(0.777)
Child's Age	-1.805***	-0.602***	-0.231*	-1.805***	-0.697***	-0.244
	(0.435)	(0.149)	(0.140)	(0.427)	(0.157)	(0.170)
Sibling's Age	-0.638	-0.0904	-0.0658	-0.638	-0.0864	-0.0836
	(0.424)	(0.144)	(0.137)	(0.417)	(0.153)	(0.169)
Constant	126.2***	14.39***	6.137***	126.2***	15.09***	6.070***
	(5.641)	(1.922)	(1.798)	(5.540)	(2.058)	(2.274)
Sigma				15.61***	5.535***	6.292***
				(0.802)	(0.219)	(0.327)
Observations	507	507	507	507	507	507
R-squared	0.187	0.179	0.068			

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Quality time espressed in hours. Results of Ordinary Least Squares estimations (columns 1 -3) using covariates shown and the following additional controls: ethnicity, primary caregiver's educational level and age, household's income level, primary caregiver's employment status, number of biological siblings in the family unit. Columns 4 -5 present results using a Tobit estimation model using the same controls of the OLS model and requiring positive amount of quality time hours (lower limit = positive amount of time).

Table 4.10 – Parenting Style, alternative specifications

Adding parental controls

		(1)	(2)	(3)	(4)	(5)
Sample:		**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
Warm Index	ATE	0.0499*	0.0938**	0.0144	0.0384	0.0146
	Std. Err.	(0.0281)	(0.0392)	(0.0396)	(0.0547)	(0.0543)
	Obs.	592	278	314	148	144

Without sample restrictions

		(6)	(7)	(8)	(9)	(10)
Sample:		**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
Warm Index	ATE	0.0434	0.0921**	0.0287	0.0734	0.0146
	Std. Err.	(0.0265)	(0.0360)	(0.0370)	(0.0448)	(0.0476)
	Obs.	642	296	346	172	182

Dropping number of biological siblings

		(11)	(12)	(13)	(14)	(15)
Sample:		**Whole Sample**	**Male**	**Female**	**Older Children**	**Younger Children**
Warm Index	ATE	0.0497*	0.0858**	0.00636	0.00949	0.0246
	Std. Err.	(0.0280)	(0.0387)	(0.0402)	(0.0499)	(0.0570)
	Obs.	592	278	314	148	144

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling's gender ans age, number of children in the family unit, and primary caregiver's age group. Bias adjusted for number of children living in the family unit , sibling's age and primary caregiver's age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. In columns 2, 7 and 12 analyses are performed exclusively on the male subsample. In columns 3, 8 and 13 analyses are performed exclusively on the female subsample In columns 4, 9, 14 and 5, 10, 15 analyses are performed respectively on earlier-borns and on laterborns. The first group (columns 1-5) presents results adding if living with both biological parents / only biological mother to baseline controls. Second group (columns 6-10) presents baseline specification results without restricting the sample to children living with at least the biological mother, and still adding if living with both biological parents / only biological mother to baseline controls. Last group (columns 11-15) presents results dropping from baseline specification the control for the number of child's biological sibling living in the household. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.11 – Parenting Stress, alternative specifications

		(1)	(2)	(3)
		Adding Parental Controls	**Without Sample Restrictions**	**Dropping number of biological siblings**
K6 Psychological Distress	ATE	0.991**	0.797*	1.028**
	Std. Err.	(0.459)	(0.424)	(0.432)
	Obs.	740	832	832
Pearlin Self Efficacy	ATE	-0.140**	-0.154**	-0.155**
	Std. Err.	(0.0676)	(0.0653)	(0.0637)
	Obs.	740	832	832
Rosenberg Self Esteem	ATE	-0.123**	-0.134***	-0.146***
	Std. Err.	(0.0491)	(0.0471)	(0.0472)
	Obs.	741	833	833

Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling's gender ans age, number of children in the family unit, and primary caregiver's age group. Bias adjusted for number of children living in the family unit , sibling's age and primary caregiver's age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. The first column presents results adding if living with both biological parents / only biological mother to baseline controls. Second column presents baseline specification results without restricting the sample to children living with at least the biological mother, and still adding if living with both biological parents / only biological mother to baseline controls. Last column presents results dropping from baseline specification the control for the number of child's biological sibling living in the household. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A.1 – Parenting style variables, description and codification

Variable	Question	Scale	Reclassification	Obs.	Mean (Std.Dev.)	Index
Respond to questions	Primary caregiver responded verbally to the child's speech, questions or requests	4 - points Likert scale. 1 - Never; 2 - Once; 3 - two or three times; 4 - four times or more	1 recoded as 0; 2, 3, 4 recoded as 1	1213	2.868 (0.924)	Warmth
Physical affection	Primary caregiver caressed, kissed, or hugged the the child	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.491 (0.801)	Warmth
Provide toys	Primary caregiver provided toys or interesting activities for the the child	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1208	1.296 (0.626)	Warmth
Voice conveyed feelings	Primary caregiver's voice conveyed positive feeling about the the child	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1211	2.856 (0.919)	Warmth
Spontaneous praise	How often did primary caregiver spontaneously praise the the child for (his/her) behavior, helpfulness, looks or other positive qualities?	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	2.086 (0.983)	Warmth
Warm - affectionate	When interacting with the the child, how often was the primary caregiver warm and affectionate?	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1212	2.625 (0.996)	Warmth
Demostrate achievement	Primary caregiver helped the the child demonstrate some achievement during visit or mentioned a particular skill, strength, or achievement.	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.583 (0.820)	Warmth
Encouraged to talk	Primary caregiver encouraged the the child to contribute to the conversation during visit	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.91 (0.943)	Warmth
Emotional response	Primary caregiver showed some positive emotional responses to praise of the the child by visitor	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1208	2.267 (0.899)	Warmth
Diminutives	Primary caregiver used some term of endearment or some diminutive for the the child's name when talking about or to the the child during visit	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.608 (0.927)	Warmth
Scold - Criticize	Primary caregiver scolded, derogated, or criticized the the child.	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.127 (0.469)	Punitive
Shouted	Primary caregiver shouted at the the child during visit	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.078 (0.347)	Punitive
Showed annoyance	Primary caregiver expressed overt annoyance with or hostility toward the the child, complained, described (him/her) as 'bad', said the the child won't mind, etc	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.066 (0.336)	Punitive
Slap - spank	Primary caregiver slapped or spanked the the child	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1212	1.004 (0.076)	-
Shook - grabbed	Primary caregiver physically restricted or shook/grabbed the the child	4 - points Likert scale	1 recoded as 0; 2, 3, 4 recoded as 1	1213	1.004 (0.076)	Punitive
Limits on :						
Amount of TV	Do you have rules about how much time the child can watch TV in a day?	1 - Yes; 5 - No	5 recoded as 0	1483	2.748 (1.985)	Strictness
Kind of TV	Do you have rules about what TV programs the child watches?	1 - Yes; 5 - No	5 recoded as 0	1483	2.011 (1.739)	Strictness
Bedtime	Do you have rules about how late the child can stay up at night?	1 - Yes; 5 - No	5 recoded as 0	1482	1.543 (1.370)	Strictness
Limits of sweets	Do you have rules about how much candy, sweets or other snacks the child has?	1 - Yes; 5 - No	5 recoded as 0	1483	2.413 (1.913)	Strictness
Social interactions	Do you have rules about which the children the child can spend time with?	1 - Yes; 5 - No	5 recoded as 0	1480	2.457 (1.925)	Strictness
Afterschool activities	Do you have rules about how the child spends time after (school/daycare)?	1 - Yes; 5 - No	5 recoded as 0	1482	1.950 (1.703)	Strictness
Homework	Do you have rules about when the child does (his/her) homework?	1 - Yes; 5 - No	5 recoded as 0	1483	1.909 (1.677)	Strictness
Enforce rules on:	How regularly do you enforce these rules?					
Amount of TV	Rules about how much time the child can watch TV in a day	1 - Never; 2 - Less than half of the time; 3 - About half of the time; 4 - Most of the time; 5 - All of the time; 6 - I don't have to enforce the rules because my the child follows them anyway	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	835	4.256 (0.829)	Strictness
Kind of TV	Rules about what TV programs the child watches	1 - 6	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	1108	4.495 (0.797)	Strictness
Bedtime	Rules about how late the child can stay up at night	1 - 6	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	1281	4.429 (0.767)	Strictness
Limits of sweets	Rules about how much candy, sweets or other snacks the child has	1 - 6	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	959	4.206 (0.877)	Strictness
Social interactions	Rules about which the children the child can spend time with	1 - 6	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	941	4.584 (0.7484)	Strictness
Afterschool activities	Rules about how the child spends time after (school/daycare)	1 - 6	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	1130	4.536 (0.692)	Strictness
Homework	Rules about when the child does (his/her) homework	1 - 6	1 and 2 recoded as 0; 3,4,5,6 recoded as 1	1146	4.629 (0.684)	Strictness

Note: Variable names are reported as used in Table 4.1. The Question column describes the exact question asked in CDSII to primary caregivers. Scale column reports the associated possible answers and the scale used for the specific questions in the original CDSII. Reclassification column reports the method used in this study to construct dummies from the original variables; it has to be noted that the same reclassification method was used for variables with the same original scale. The columns regarding Observations, Mean and Standard Error refer to the variable expressed in its original scale among the eligible sample in CDSII formed by all children living with the biological mother and with a sibling with a completed interview. Lastly, the Index column reports what index among the Warm, Punitive Parenting and Strictness Indices the single variable was used for.

Table A.2 – Variables description

Variable	Codification	Survey	Reference year
Child characteristics:			
Ill sibling	1 Sibling evercalssified in need for special education; 0 otherwise	CDSII	2002
Gender	0 Male; 1 Female	PSID Individual-level	-
Ethnicity	0 White; 1 Afro-American; 2 All the rest	CDSI	1997
Grade	1-14 Actual grade in school	CDSII	2002
Order	0 Twins; 1 Older sibling; 2 Younger sibling	calculated from birth year	-
Family characteristics			
PCG Education	Primary caregiver education level: 0 < high school; 1 high school; 2> high school	PSID Individual-level	2001
Children in FU	Number of biological siblings living in the family unit	PSID Family-level	2001
Sibling Gender	1 Male; 2 Female	PSID Individual-level	-
Sibling Age	Child's age in years measured in 2001	PSID Individual-level	2001
Living condition variables:			
Living with parents	1 child living with both biological mother and father; 0 otherwise	CDSII	2002
Possible endogenous controls:			
PCG Employment	1 currently working; 0 otherwise	PSID Individual-level	2001
Income	quartiles of income distribution: 0 first quartile, 1 second quartile, 2 third quartile, 3 fourth quartile	PSID Family-level	2003 (but referred to 2002)

Table A.3 – Quality time components, sample statistics and t-tests

	Whole sample			No Ill sibling			Ill sibling			
Variable	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Difference
Quality Time Activity:										
Reading	557	1.392	0.117	488	1.400	0.121	69	1.333	0.399	0.067
Playing	557	8.825	0.393	488	8.834	0.414	69	8.760	1.229	0 .073
Homework	557	4.445	0.221	488	4.439	0.231	69	4.489	0.717	-0.050
Talking	557	0.743	0.072	488	0.706	0.076	69	1.00	0.204	-0.299
Arts and Crafts	557	0.542	0.090	488	0.538	0.096	69	0.571	0.249	-0.033
Eating	557	6.982	0.157	488	7.095	0.169	69	6.182	0.409	0.9136 *
Sports	557	0.743	0.114	488	0.659	0.102	69	1.341	0.576	-0.682 **
Performing Arts	557	0.341	0.066	488	0.324	0.068	69	0.466	0.235	-0.143
Museums	557	0.033	0.019	488	0.038	0.022	-	-	-	-
Religious Activities	557	1.179	0.108	488	1.168	0.112	69	1.257	0.361	-0.089
Physical Care	557	0.005	0.002	488	0.005	0.003	69	-	-	-

Note: "Whole Sample" is composed of all CDSII children with a sibling with a complete interview in CDSII and never diagnosed for Special Education needs. "No Ill Sibling" comprises all healthy children with a sibling that has never been diagnosed for Special Education needs. "Ill Sibling" subsample is composed of all healthy children with a sibling that has been diagnosed for Special Education needs. Last column presents results of a t-test of mean comparison among "No Ill Sibling" and "Ill Sibling" subgroups. Activity duration is expressed in hours. *** p<0.01, ** p<0.05, * p<0.1

Table A.4 – Diagnosed conditions for Special Education placement

Diagnosis	**N. Children**	**Share**
ADHD	21	16.15%
Emotional Problems	3	2.31%
Learning Disability (Speech and Language)	24	18.46%
Learning Disability (Academic Skills)	41	31.54%
Learning Disability (General)	19	14.62%
Autism	4	3.08%
Developmental Disability/Delay	5	3.85%
Celebral Palsy	1	0.77%
Epilepsy	1	0.77%
Hearing/Sight Impairment	5	3.85%
Down Syndrome	1	0.77%
Reason not Specified	4	3.08%
Other	1	0.77%
Sum	130	100%

Note: figures refer to children in CDSII sample who have a sibling with a completed interview and are living with the biological mother. Among the 200 children ever diagnosed for Special Education, 130 report to be currently enrolled in a Special Education class or program. Figures and shares of the table refer to the 130 children for which CDSII contains report of the condition that determined the placement into Special Education.

Table A.5 – Quality time components, results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Reading	Playing	Homework	Talking	Arts and Crafts	Eating	Sports	Museums	Religious Activities	Performing Arts	Physical Care
Quality time with Parents											
ATE	0.110	0.156	-0.771	0.520	0.273	-0.0924	1.113	-0.00769	-0.139	0.666	-0.00128
Std. Err.	(0.686)	(1.834)	(0.940)	(0.357)	(0.468)	(0.621)	(0.874)	(0.00768)	(0.381)	(0.436)	(0.00128)
Obs.	260	260	260	260	260	260	260	260	260	260	260
Quality time with Mother											
ATE	0.258	0.362	0.344	0.559**	0.0737	0.609	-0.0231*	0	-0.00478	0.673*	-0.00128
Std. Err.	(0.302)	(0.293)	(0.413)	(0.278)	(0.0624)	(0.603)	(0.0134)	(0)	(0.266)	(0.390)	(0.00128)
Obs.	260	260	260	260	260	260	260	260	260	260	260
Quality time with Father											
ATE	0.0908	-0.160	0.327	0.130	-0.0263	0.310	-0.0964	-0.00769	0.150	0.0785	-0.00128
Std. Err.	(0.104)	(0.480)	(0.328)	(0.209)	(0.0215)	(0.615)	(0.0766)	(0.00768)	(0.307)	(0.192)	(0.00128)
Obs.	260	260	260	260	260	260	260	260	260	260	260

Note: Note: Results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling's gender ans age, number of children in the family unit, and primary caregiver's age group. Bias adjusted for number of children living in the family unit , sibling's age and primary caregiver's age group. ATE corresponds to the estimated average treatment effect of living with an ill sibling with respect to living with an healthy sibling. Quality time expressed in hours. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.6 – Ill children - Parental inputs, sample statistics and t-tests

	Whole sample			Healthy Children			Ill Children			
Variable	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.	Difference
Parental quality time:										
Quality time - Total	534	9.090	0.292	488	8.862	0.297	46	11.513	1.207	-2.651 **
Quality time - Mother	534	7.452	0.248	488	7.267	0.251	46	9.412	1.065	-2.145 **
Quality time - Father	534	5.517	0.246	488	5.369	0.252	46	7.088	0.971	-1.719 **
Parental attitude:										
Warm index	764	0.583	0.008	700	0.578	0.009	64	0.634	0.026	-0.057 *
Punitive index	764	0.038	0.022	700	0.035	0.022	64	0.075	0.022	-0.040 ***
Strictness index	891	0.753	0.008	812	0.755	0.009	79	0.732	0.029	0.022
Parental distress:										
K6 - Psychological Distress	883	3.906	0.118	804	3.792	0.122	79	5.063	0.431	-1.271 ***
Pearlin - Self Efficacy	883	3.161	0.019	804	3.177	0.020	79	2.997	0.061	0.180 ***
Rosenberg - Self Esteem	885	3.446	0.015	806	3.460	0.016	79	3.300	0.048	0.160 ***

Note: "Whole Sample" is composed of all CDSII children with a sibling with a complete interview in CDSII that was never diagnosed for Special Education needs. "Healthy Children" group comprises all children never diagnosed for Special Education needs. "Ill Children" sample is composed of all children ever diagnosed for Special Education needs. Last column presents results of a t-test of mean comparison among "Healthy Children" and "Ill Children" subgroups. *** p<0.01, ** p<0.05, * p<0.1

Table A.7 – Quality time for Ill Children, OLS and Tobit estimations results

Dependent variable: Total Quality Time spent with						
	Parents	Mother	Father	Parents	Mother	Father
	(1)	(2)	(3)	(4)	(5)	(6)
Model:	OLS	OLS	OLS	Tobit	Tobit	Tobit
Ill Child	4.087**	2.274*	1.765	4.087**	2.531**	2.035*
(dummy)	(2.068)	(1.219)	(1.076)	(2.030)	(1.215)	(1.185)
Younger Sibling	-0.198	-0.577	-0.791	-0.198	-0.780	-0.740
(dummy)	(2.884)	(1.034)	(1.009)	(2.830)	(1.083)	(1.224)
Interaction: Child's gender- Sibling's gender :						
Male - Female	-0.501	0.217	0.751	-0.501	0.00879	0.803
	(2.095)	(0.722)	(0.736)	(2.055)	(0.771)	(0.876)
Female - Male	-1.658	0.112	-0.569	-1.658	-0.0395	-0.754
	(2.065)	(0.664)	(0.737)	(2.026)	(0.714)	(0.897)
Female - Female	2.159	0.685	0.106	2.159	0.720	0.0223
	(2.129)	(0.716)	(0.681)	(2.089)	(0.745)	(0.828)
Child's Age	-1.963***	-0.635***	-0.262*	-1.963***	-0.735***	-0.286*
	(0.475)	(0.159)	(0.141)	(0.466)	(0.168)	(0.171)
Sibling's Age	-0.585	0.00699	0.0490	-0.585	0.0184	0.0681
	(0.441)	(0.160)	(0.146)	(0.433)	(0.168)	(0.177)
Constant	124.1***	13.16***	5.894***	124.1***	13.79***	5.730**
	(5.896)	(2.075)	(1.870)	(5.785)	(2.195)	(2.353)
Sigma				15.08***	5.573***	6.298***
				(0.811)	(0.225)	(0.339)
Observations	486	486	486	486	486	486
R-squared	0.219	0.163	0.072			

Note: robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Quality time espressed in hours. Results of Ordinary Least Squares estimations (columns 1 -3) using covariates shown and the following additional controls: ethnicity, primary caregiver's educational level and age, household's income level, primary caregiver's employment status, number of biological siblings in the family unit. Columns 4 -5 present results using a Tobit estimation model using the same controls of the OLS model and requiring positive amount of quality time hours (lower limit = positive amount of time).

Table A.8 – Parenting Stress, baseline and alternative specifications on ill children

		(1)	(2)	(3)	(4)
		Baseline	**Adding Parental Controls**	**Without Sample Restrictions**	**Dropping number of biological siblings**
K6 Psychological Distress	ATE	0.934	0.914	1.274**	1.104*
	Std. Err.	(0.593)	(0.586)	(0.593)	(0.575)
	Obs.	545	545	628	628
Pearlin Self Efficacy	ATE	-0.233**	-0.243**	-0.279***	-0.320***
	Std. Err.	(0.0975)	(0.0965)	(0.0907)	(0.0875)
	Obs.	545	545	628	628
Rosenberg Self Esteem	ATE	-0.170***	-0.181***	-0.230***	-0.245***
	Std. Err.	(0.0636)	(0.0630)	(0.0606)	(0.0600)
	Obs.	547	547	630	630

Note: results after Nearest Neighbour Matching requiring exact matching for children's gender and grade (matching 1:1). Closest match possible required for child's ethnicity, education of the primary caregiver, birth order, sibling's gender ans age, number of children in the family unit, and primary caregiver's age group. Bias adjusted for number of children living in the family unit , sibling's age and primary caregiver's age group. ATE corresponds to the estimated average treatment effect of being sill with respect to being healthy, having a healthy child in either case. The first column presents results from baseline specification. The second column present results adding if living with both biological parents / only biological mother to baseline controls. Third column presents baseline specification results without restricting the sample to children living with at least the biological mother, and still adding if living with both biological parents / only biological mother to baseline controls. Last column presents results dropping from baseline specification the control for the number of child's biological sibling living in the household. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1