

**International Center for Public Policy**

**Working Paper 19-08**

**August 2019**

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Evidence from Oil Spills in the Peruvian Amazon**

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# **Environmental Disasters and Mental Health: Evidence from Oil Spills in the Peruvian Amazon**

Alberto Chong and Carla Srebot\*

August 2019

## **Abstract**

Using a difference-in-difference approach, we test the causal link between environmental disasters and mental health indicators in rural areas of Peru by exploiting the spatial variation of exogeneous oil spills as well as the differences in their timing for the period 2014–16. We find that, after controlling for time-varying controls and for year fixed effects, oil spills lead to significantly higher probability of suffering psychological distress, such as lack of motivation, fatigue or feeling of failure. In particular, we find that an individual is 25.2 percentage points more likely to suffer from depression after an oil spill occurrence. Falsification tests provide further support that the main results are not simply the result of spurious correlations.

**Keywords** Oil Spills, Environmental Disasters, Mental Health, Depression, Amazon, Peru

**JEL classification** O1, I15, I39

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**Acknowledgements:** We are very grateful to Arlette Beltran, Juan Castro, Yulia Valdivia, Daniel Velazquez and Gustavo Yamada for comments and suggestions. The standard disclaimer applies. All errors remain our own.

## **Introduction**

At the time of its inauguration in 1977, the Peruvian government envisioned the construction of the North Peruvian oil pipeline as the first step in the quest to free the country from foreign oil dependency. This pipeline was a huge endeavor and connected the Peruvian Amazon, where significant oil reserves had been previously discovered with the existing refineries in the country's Pacific coast. This allowed the Amazonian oil to be processed and then transported elsewhere usually by sea. The length of the oil pipeline is more than 1,000 kilometers and was designed to transport 100,000 barrels per hour. As such, its construction required considerable engineering accomplishments, even more so as in order to reach the refineries in the Peruvian coast the pipeline first had to cross the Andes' mountains up to an altitude of nearly 2400 meters above sea level. Understandably, once completed the pipeline was considered a major success and a source of national pride.

More than four decades have passed since the most important Peruvian oil pipeline was built and with time, lack of maintenance, and intentional attacks, severe deterioration has occurred. For instance, the Peruvian Agency for Environmental Assessment and Enforcement reports dozens of oil spills as time passes, which have accelerated dramatically in recent years. As an example, in 2016 there were seventeen oil spills representing more than the 58 percent of the total number of barrels spilled between 2011 and 2017 (OEFA, 2017). Not only have oil spills affected the ecosystem of the Peruvian Amazon, but they have also impacted the welfare of surrounding communities. These environmental disasters cause massive damage to the population around the pipeline including loss of cultivation areas and livestock, infrastructure damage, as well as major contamination to water sources and soil. In addition, these disasters severely increase the vulnerability of the communities to numerous diseases, such as diarrhea, allergic dermatitis,

pharyngitis, bronchitis (OEFA, 2016). For instance, as a result of a specific spill that occurred in 2014 the Ministry of Health reported that high-exposure individuals exhibited a level of mercury and cadmium in urine significantly above the reference range (MINSa, 2016).

As unfortunate as the material losses and diseases resulting from oil spills are there is an additional negative externality on the population, which may be equally or even more painful than the described above. In fact, the seemingly randomness and unexpectedness of environmental disasters, such as oil spills may jeopardize the mental health of individuals in ways that are particularly difficult to measure, as households and related property do not have to be directly impacted by the oil spills to suffer such consequences, but simply located in the basic geographical range of direct impact. Previous studies in other disciplines, in particular psychology show findings that are consistent with this idea. For instance, their related literature on oil spills shed light on the negative effects of these disasters on mental health indicators. In several studies in psychology, it has been documented that spill-affected residents are more likely to feel anxious, depressed, drink more, and have more thoughts of suicide than the non-affected residents after the event (Gould et al., 2015; Cope et al., 2013; Lee and Blanchard, 2012; Gill et al., 2014; Palinkas, 1993). The mechanisms behind these findings rely on the premise that disasters disrupt participants' lives, work, family, and social engagement (Osofsky et al., 2011; Hansel et al., 2015), which is positively associated with psychological distress. The vast majority of studies, however, are limited in scope as they employ limited sized samples and as a result tend to be underpowered and likely endogenous. In this context, our paper adds to the literature by providing causal evidence of the impact of environmental disasters on mental health outcomes, a concern that to our knowledge has

not been previously addressed in Economics.<sup>1</sup> We believe that this makes our approach to be particularly relevant given its potential public policy implications.

In this paper we study whether environmental disasters and, in particular, oil spills occurring in the North Peruvian oil pipeline have an impact on broad measures related to mental health, including lack of motivation, lack of sleep, depression, tiredness and fatigue, loss of appetite, poor concentration, inability to move, feeling of failure, and desire to die. We focus on short-term impacts, which are defined as those measured up to one year after the environmental disaster occurred. The reason why we do this is straightforward as our main objective is to understand whether it is possible to measure the immediate impact on mental health.

In addition, we take a conservative approach, and instead of using the full sample of oil spills that have occurred in the Peruvian oil pipeline, we focus on the two largest pipeline breakdowns during 2011–17, which have also been clearly proven to be the result of decay as certified by the government and not by intentional attacks or other arbitrary acts that may have occurred.<sup>2</sup> We exploit spatial and time variation in the occurrence of these two very large oil spills in the North American oil pipeline using a difference-in-difference approach in which the measured treatment effect is driven by the fact that these two breakdowns have been proven random. In order to determine the treatment group, we use the emergency reports of the National Institute for Civil Defense (INDECI) concerning the affected communities. On the other hand, we choose the control area as a set of districts contiguous to the impact area that have never had an

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<sup>1</sup> To our knowledge, the closest study to ours in Economics is Pesko (2018), which studies hurricane Katrina and focuses on broad mental health issues and on specific substance abuse.

<sup>2</sup> In recent years there has been some controversy that a number of oil spills in the North-Peruvian oil pipeline may have been caused intentionally. The specific motivation for doing this is unclear, but some claim that this may occur either to steal oil or as a form of protest by communities surrounding the oil pipeline. For instance: <https://gestion.pe/economia/empresas/comunidad-implicada-rotura-oleoducto-norperuano-pide-indemnizacion-dano-ambiental-253515>

oil spill. Our main finding is that after the occurrence of these environmental disasters, the individuals who live in our treatment group are more likely to suffer from mental health issues than non-affected individuals who reside in our control areas. In particular, we find that oil spills lead to a significant increase in the probability of experiencing a desire to die, a feeling of failure, lack of motivation, and tiredness and fatigue. Dramatically, we find that the treatment group shows an increase of 25.2 percentage points more likely to suffer depression with respect to our control group.

The remainder of this paper is organized as follows. Section 2 summarizes the relevant related literature on oil spills, natural disasters, and mental health. Section 3 and 4 describe the data and empirical strategy, respectively. In Section 5 we present our results along with robustness checks. Section 6 concludes.

## **Relevant Literature**

Natural and related disasters vary in scale, magnitude, duration and loss of resources. Some events cause local damage, whereas others cause catastrophic damage throughout cities and regions. What these events have in common is the disruption of the *status quo* of the affected population, in both socio-economic and psychological terms, exceeding the response capacity of individuals. The studies on Hurricane Katrina give useful insights of the magnitude of the damages caused by these events. Pesko (2018) explores the effects of this hurricane on outcomes related to behavioral health and specifically on substance use, including smoking. Based on a difference-in-difference approach, he finds causal evidence that this natural hazard increases poor mental days by 18.8 percent for the first month after Katrina. Moreover, his study suggests that the Katrina is associated with an increase in the adoption of risk behaviors, as it increases smoking among lifetime smokers until a year and a half later. In line with the previous research, Picou and Hudson

(2010) find that Katrina significantly increases the levels of depression and psychological stress for both remaining and returning residents, as well as the rates of family separation and financial problems. Zahran et al. (2011) suggested that hurricane exposure incremented the expected count of poor mental health days by 18.7 percent, mainly affecting single mothers who experienced an increase of 71.88 percent.

Beyond the physical devastation, Katrina leads to elevated mental health difficulties among survivors. Regarding the related-psychology literature, Rhodes et al. (2010) show that after Hurricane Katrina the prevalence of serious mental illness doubled and the rates of posttraumatic stress disorder (PTSD) amounts to nearly half of the respondents. Similarly, Sastry and VanLandingham (2009) find that the residents of New Orleans who survived Hurricane Katrina exhibit high levels of mental illness one year after the storm. The previous studies emphasize that individuals who experience more stressors and property damage are more likely to experience symptoms of mental illness, PTSD, and marginally higher levels of perceived stress (Rhodes et al., 2010; Sastry & VanLandingham, 2009). Not only did resource losses in the form of housing damage have an impact on mental health, but also hurricane-related injury and death are positively and statistically significantly associated with higher levels of anxiety and unhappiness (Robertson et al., 2009; Kimball et al., 2006).

The massive destruction of the ecosystem by oil spills severely impacts the population nearby the pipeline that depend on natural resources for their social and economic sustenance. The dramatic loss of productive infrastructure and high vulnerability to diseases and food insecurity can jeopardize the mental health of the spill-affected individuals. In this context, some public health literature tries to assess the magnitude of the associated social negative impact. Most of oil spills studies involve psychological and psychiatric effects resulting from the Exxon Valdez oil

spill in Alaska, in 1989 as well as of the 2010 explosion of the Deepwater Horizon oil platform and subsequent months-long oil spill in the Gulf of Mexico. Palinkas et al. (1993) find that after the Exxon Valdez spill, anxiety rates, post-traumatic stress disorder (PTSD) and depression increase significantly in residents with a high spill-exposure. In fact, they report that the odds of suffering generalized anxiety disorder (GAD) and PTSD among individuals from high-exposure communities are twice as high in relation to those individuals from non-exposed communities. In addition, they suggest that the probability of suffering high depression is 1.8 times greater among the individuals who reside near the spill, relative to the ones who reside in areas further away.

In relation to the long-term impact of oil spills, Picou and Gill (1996) find that approximately 18 months after the Exxon Valdez oil spill, the affected communities exhibit significantly higher levels of psychological stress relative to individuals located outside of the environmental disaster area. The latter findings can be attributed to the substantial income loss that workers from the fishing and oil-related industries faced after the spill (Picou & Gill, 1996; Arata et al., 2000). Due to the disruption of their main labor activity, residents that rely on these industries for their source of income are more likely to feel anxious or depressed, drink more, and have more thoughts of suicide than the non-affected residents (Gould et al., 2015; Cope et al., 2013; Lee and Blanchard, 2012; Gill et al., 2014).

In addition, some recent studies show that the greatest effect on anxiety after 2010 Gulf Oil Spill is related to the extent of disruption to participants' lives, work, family, and social engagement, supporting the lessons learned following the Exxon Valdez oil spill and suggesting that mental health effects may also impact the long term as recovery appears to be slow (Osofsky et al., 2011; Hansel et al., 2015). Other spills such as the Sea Empress oil spill in the southwest of Wales, in 1996, and the Prestige oil spill in Spain, in 2002, are also explored in recent research.

For instance, Sabucedo et al. (2010) explore the mental health of the Prestige oil spill affected population approximately one year after it occurred. Their results suggest that symptoms of anxiety, depression, hostility, and obsessive-compulsive disorder are positively and significantly associated with the level of exposure. Similarly, Lyons et al. (1999) find that living in the area exposed to the Sea Empress oil spill is significantly related to higher past-month anxiety and depression symptoms four weeks after the spill.

The literature on environmental disasters appears to show that the psychological impact on the affected population is as significant as the material one. It reveals that post-disaster mental health and psychological distress worsen according to the level of exposure as well as with the extent to which those catastrophic events disrupt the daily life of the people who experience them. Interestingly, despite the several attempts at establishing a causal link between environmental disasters and, in particular, oil spills and mental health the related empirical evidence is rather weak. As described above, our paper aims to fill this gap and answer this question.

## **Data**

We exploit spatial and time variation of two major environmental disasters created by breakdowns in the North-Peruvian oil pipeline and estimate causal effects on mental health indicators one year after exposure the oil spill. We focus on the period 2014 to 2016.<sup>3</sup> We gather data from four sources of information: the Peruvian Demographic and Health Survey (DHS), the National Institute for Civil Defense (INDECI, by its Spanish acronym), the Environmental

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<sup>3</sup> We restrict our sample to these specific years, as our main interest is to study short-term impacts. An additional advantage of doing this is that by doing this we are able to maximize our sample size when matching with the three other datasets employed.

Assessment and Enforcement (OEFA), and the Supervisory Body for Investment in Energy and Mining (OSINERGMIN, by its Spanish acronym).

### *Mental Health Outcomes*

Data on mental health are available from the Demographic and Health Survey (DHS). The DHS consists of a stratified household sample and it is representative at the regional level. This survey contains information on detailed aspects of individuals related to demographic, social and mental health indicators of the population over 18 years of age, as well as georeferenced household information, as latitude and longitude of each household is included. We focus on those households that are located on the terrain and regions where the pipeline is laid out. They specific departments where the oil pipeline are located are Piura, Cajamarca, Amazonas, Loreto and Lambayeque, in the northern part of the country.<sup>4</sup> For our empirical analysis, we use data from repeated cross-sections provided by DHS between the years 2014 and 2017. We restrict our attention to these years only given data limitations. Whereas overall data on mental health indicators are available since 2013, latitude and longitude household information are available since 2014, only.

In order to quantify the impact of oil spills on mental health outcomes we consider nine categorical variables from DHS: lack of motivation, depression, lack of sleep, tiredness and fatigue, loss of appetite, poor concentration, inability to move, desire to die, and feeling of failure. Given that these variables tend to be correlated, we also identify an unobservable (latent) factor, which captures the shared variance of the variables mentioned through a factorial model (see Appendix 1). The latent factor, thus, is an overall indicator of the degree of psychological distress

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<sup>4</sup> For informational purposes, a Department in Peru is equivalent to a State in the Union

that an individual may have experienced.<sup>5</sup> In addition, we also tested each of our nine categorical variables by using a simple dichotomous approach. In the specific case of these nine categorical variables, we assign each of them a value of 1 if in the past two weeks the individual felt feelings or mental health issues described for at least one day. Finally, we also employ a set of socio-demographic characteristics as control variables at both the individual and household levels, which also come from DHS.

### *Oil Spills Indicator*

Information on the exact date of occurrence of the oil spills comes from datasets provided by the Environmental Assessment and Enforcement (OEFA) and the Supervisory Body for Investment in Energy and Mining (OSINERGMIN). In particular, we construct a unified database that includes specific information of all the North Peruvian pipeline spills that occurred between 2011 and 2017 including location, number of barrels that were spilled to the ground, date, cause, and the affected area in square meters (see the Appendix 2). When excluding all the oil spills that were caused by reasons other than random ones we end up with a restricted sample of fifteen oil spills, which have been government-certified to have been provoked by events such as corrosion, landslides, overall decay and related repair failures.<sup>6</sup> Furthermore, we take a very conservative approach and out of this restricted sample, we focus on the two largest oil spills, which both happened to occur in 2016. While we focus on these two episodes, it should be said that they represent more than the 53 percent of the total barrels lost during 2011–17. The reason for taking

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<sup>5</sup> The survey asks individuals to respond for the presence of these mental health symptoms for the case of two weeks prior to the day that the survey was performed.

<sup>6</sup> We identify that other twenty oil spills episodes are due to third party attacks. While this is a relatively large number of episodes, the total number of barrels lost as well as the relative area affected is rather limited. In addition, the government was not able to identify the causes of fourteen oil spills. Finally, an additional three oil spills received no classification at the time of data collection (see Appendix 2).

this conservative approach is related to the above-described limitations on household survey data as well as to avoid endogeneity issues as much as possible as they that may bias our findings.<sup>7</sup>

In order to determine the specific households affected by environmental disasters, we use the emergency reports of the National Institute for Civil Defense (INDECI). In these reports, INDECI lists the exact area where population suffered both from health problems and infrastructure damage as a consequence of an oil spill. In order to define the treatment group for each of the two oil spills, we construct an impact area according to the largest distance between the districts in such a way as to make sure that it comprises all the affected localities identified by INDECI. By doing this, the radius of the impact area equals to half the distance between the most remote localities affected by the observed oil spill. For simplicity, we choose the control area as a set of districts that are contiguous to the oil spill impact area but that have never had an oil spill. Furthermore, in order to make sure that the households in the control group have never been affected by an oil spill, we use an additional restriction and exclude any households located at less than twenty kilometers from any oil spill. In short, the control group is made up of those households that have not been affected by any spill, are located outside the treatment area of treatment districts, but are comparable to the households that were impacted by the oil spill as will be shown below.<sup>8</sup> (See Figure 1.)

We denote the individuals who were affected by the spills using a dichotomous variable taking the value equal to 1 if they reside within the impact area after the date the spill occurred, and a value of 0 if the household is located in a control district or was surveyed before the event. Table 1 presents the treatment-control balance. There are 391 individuals in the treatment group

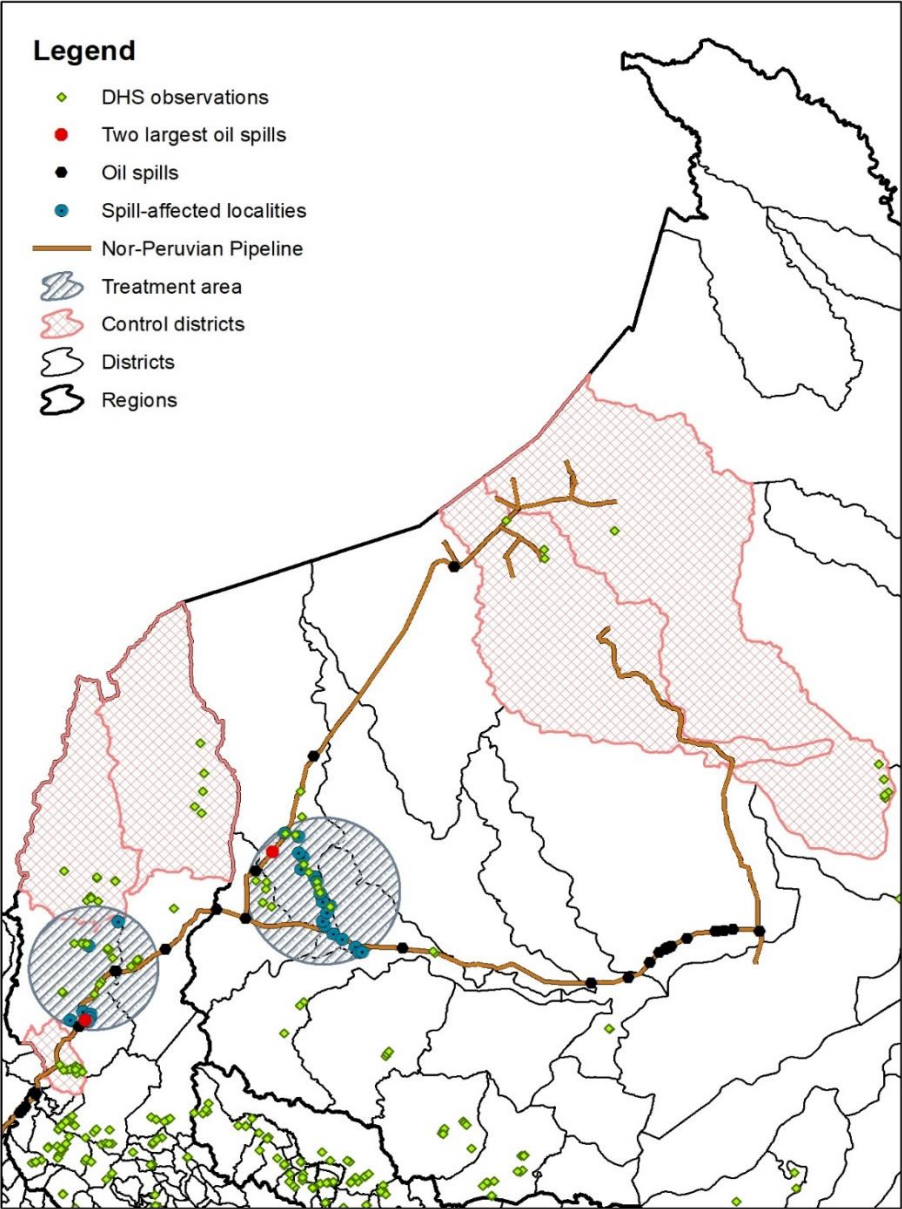
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<sup>7</sup> In fact, our results become somewhat stronger when including all the period-relevant random oil spills available in our sample.

<sup>8</sup> We have selected nearby districts that have available information (DHS observations) before and after spills date.

and 454 in the control group. Considering the main observable variables as gender, age, years of education, marital status, among others; we do not find major statistical differences between both groups. These results suggest that both the treatment and control group are statistically identical.

**Figure 1. Treatment definition**



**Table 1.** Descriptive statistics pre-treatment

	Mean		
	Treatment	Control	Difference
Average age	31.201 (0.929)	32.277 (0.720)	-1.076 (1.152)
% Male	0.438 (0.053)	0.393 (0.052)	0.044 (0.073)
Average years of education	6.181 (0.327)	6.399 (0.423)	-0.218 (0.525)
% Married	0.153 (0.036)	0.150 (0.051)	0.002 (0.061)
% Urban	0.201 (0.136)	0.156 (0.115)	0.045 (0.174)
Average number of household members	5.222 (0.152)	5.237 (0.206)	-0.015 (0.251)
% Male household head	0.868 (0.052)	0.855 (0.025)	0.013 (0.056)
Average age of household head	36.958 (1.054)	37.636 (1.027)	-0.678 (1.444)
% Access to electricity	0.333 (0.122)	0.185 (0.086)	0.148 (0.146)
Average distance to nearest river	4.492 (1.419)	5.362 (1.584)	-0.870 (2.087)

**Notes.** \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors in parentheses. The mean and its standard error are clustered by primary sampling unit. The average distance to pipeline and the average distance to nearest river are measured in kilometers.

## Empirical Strategy

Our main empirical strategy exploits spatial and time variation in the occurrence of oil spills in the North-Peruvian oil pipeline by using a difference-in-difference approach to the evaluation of their causal effect on outcomes related to mental health. Given the surprise nature of these spills, they can credibly be characterized as exogenous and the pre-event period should not include anticipatory behavior in the affected localities. The latter allows for a well-identified

analysis of how oil spills can negatively impact mental health outcomes. The validity of the empirical strategy relies on the assumption that the evolution of the outcomes in the affected and non-affected areas would have been similar in the absence of the oil spill. Moreover, for the identification strategy to be valid, we need the following three conditions to hold. First, no selective spatial sorting across treatment areas occurred. It is important to exclude spatial sorting across treatment regions (Bursztyn & Cantoni, 2016). This condition is quite plausible in our case because according to the National Oil Company the pipeline is considered to be of national strategic importance and as such, the exact location of the pipeline remains confidential and unavailable to the general public.<sup>9</sup> Hence, if individuals decide to live in locations near the oil pipeline, chances are that they make this decision without knowing the location of the pipeline before moving.

The second condition that should hold in order to support our identification strategy is that the households within the treatment area are indeed affected by the spill. The latter condition means that households who reside in the affected areas did not emigrate right before the spill. The plausibility of this condition relies on the fact that we use pre- and post-spill data on households of affected and non-affected areas. We consider households who resided in the same district for at least two years before they were surveyed, which guarantees short-term exposure to crude oil impacts. The third condition is that the measured treatment effects are driven by random breakdowns in the pipeline and not by the people in the treated or control areas. As explained above, we avoid this potential source of endogeneity by considering oil spills that were provoked by corrosion, decay, landslides, and other repair failures. This allows us to identify the causal effect of short-term exposure to oil spills on mental health indicators.

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<sup>9</sup> Petroperú (2017)

In order to estimate the effect of oil spills on mental health outcomes, we implement a difference-in-difference strategy using a linear probability model of the form:

$$(1) \quad m_{ijt} = X_{ijt}\beta + \mu_j + \lambda_t + \gamma(Time_{jt} \times Treat_{ij}) + \varepsilon_{ijt}$$

where  $m_{ijt}$  is the mental health indicator<sup>10</sup> of the individual  $i$  in the area  $j$  in the year  $t$ , with  $t$  ranging from 2014 to 2017;  $Treat_{ij}$  distinguishes observations in the treatment group of the area  $j$  from those in the control group of the same area;  $Time_{jt}$  is a dummy equal to 1 if the area  $j$  had an oil spill prior the year  $t$ ;  $X_{ijt}$  is a set of time-varying controls at the level of individuals and ‘spills areas’;  $\mu_j$  are ‘area’ fixed effects and  $\lambda_t$  are year fixed effects.

We also calculate the impact of oil spills on the latent factor psychological distress. Specifically, we estimate the following model:

$$(2) \quad y_{ijt} = X_{ijt}\beta + \mu_j + \lambda_t + \gamma(Time_{jt} \times Treat_{ij}) + \varepsilon_{ijt}$$

where  $y_{ijt}$  is the psychological distress indicator of the individual  $i$  in the area  $j$  in the year  $t$ .

In the two previous specifications, the coefficient of interest is  $\gamma$  and it denotes the causal effect of being affected by an oil spill. Our identifying assumption is that, conditional on area, time fixed effects and time-varying controls  $X_{ijt}$ , the occurrence of oil spills is orthogonal to the error term. To do so, the standard errors are clustered at the primary sampling unit allowing for within household conglomerate serial correlation because unobserved factors may be correlated over time.

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<sup>10</sup> Mental health variables: lack of motivation, depression, lack of sleep, tiredness and fatigue, loss of appetite, poor concentration, inability to move, desire to die, and feeling of failure.

## Results

In this section, we report the main empirical results, following the analytical framework discussed above. The impact of oil spills on mental health can be attributed to different mechanisms, all of which depend on the idea that environmental disasters disrupt the *status quo* of the affected population, specially, in psychological terms. Table 2 shows the main empirical results of estimating our model under the difference-in-difference approach. It reports the estimates of  $\gamma$  from (1) and (2) the parameter associated with the interaction of treatment and time variables, and thus the impact of spills on mental health outcomes.

We find that environmental disasters in the Peruvian Amazon have a negative impact on the mental health of the affected areas. Column 1 of table 2 presents the estimate on psychological distress. In order to control for the fact that oil spills may be correlated with some specific characteristics associated with income and wealth (e.g., households in rural areas have a lower probability of having access to water and electricity), we include time-varying controls and year fixed effects. The coefficient which gauges the effect of oil spills ( $\gamma$ ) is positive and significant at the 1 percent confidence level, suggesting that oil spills lead to an increase in psychological distress in areas close to the spills, relative to areas further away.

We find that oil spills increase the level of psychological distress by 0.59 standard deviations. Columns 2 to 10 in table 2 contain the estimation results for the nine dichotomous mental health variables from the DHS. We estimate specification (1) using a linear probability approach. Our resulting estimates show that, *ceteris paribus*, an individual living in a spill-affected locality is 25.2 percentage points more likely to suffer depression after a spill occurrence. In addition, we find that oil spills lead to an increase in the probability of (i) desiring to die by 10.7 percentage points, (ii) feeling of failure by 14.2 percentage points; (iii) lacking motivation by 13.3

percentage points, (iv) being tired and fatigue by 18.2 percentage points, among others. The only variable that yields no statistically significant coefficient, albeit it yields the expected sign is the outcome variable poor concentration. All these findings are shown in Table 2.

**Table 2.** The effect of oil spills on mental health outcomes

Variables	(1) Principal- component Factor (Psychological distress)	(2) Lack of motivation	(3) Depression	(4) Lack of sleep	(5) Tiredness & fatigue	(6) Loss of appetite	(7) Poor concentration	(8) Inability to move	(9) Desire to die	(10) Feeling of failure
Spills	0.5883*** (0.1500)	0.1328*** (0.0467)	0.2518*** (0.0545)	0.1323** (0.0600)	0.1818*** (0.0640)	0.1119** (0.0464)	0.0380 (0.0482)	0.0711* (0.0366)	0.1067*** (0.0368)	0.1423*** (0.0443)
Constant	-0.5064* (0.2625)	-0.0017 (0.1002)	0.1379* (0.0791)	0.0785 (0.0925)	0.1365 (0.1160)	0.0373 (0.0661)	0.0326 (0.0725)	-0.0797 (0.0656)	0.0577 (0.0536)	0.0615 (0.1034)
Observations	677	677	677	677	677	677	677	677	677	677
R-squared	0.0893	0.0768	0.1046	0.0594	0.0693	0.0397	0.0234	0.0431	0.0600	0.0746
Clusters	26	26	26	26	26	26	26	26	26	26

**Notes.** \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Robust standard errors in parentheses. Standard errors are clustered by primary sampling unit. All regressions include year and spill fixed effects. The full set of control variables at individual level includes: age, indicator for male gender, marital status (equal to 1 if married or cohabiting), years of education. Household controls include: number of household members, age and sex of head of household, indicator for household access to piped water, dummy for household access to electricity, and dummy for urban residence.

We conduct a falsification test to examine the sensitivity of our results and main specification. We check that the effects we find are not spurious by estimating the main regression, equation (1), on outcomes related to sexual health and media consumption, variables that allegedly are not related to oil spills. Tables 4 and 5 show estimates for the falsification test on the impact of oil spills on sexual health and media consumption, respectively. As expected, we find no effect of oil spills on the latter variables. The estimates of  $\gamma$  are not statistically different from zero (statistically insignificant at conventional levels), providing support that the main results appear not to be spurious correlations, but rather causal effects.

**Table 4.** The effect of oil spills on sexual health

Variables	(1) Total lifetime number of sexual partners	(2) Ever heard of aids	(3) Know a place to get aids test	(4) Ever been tested for aids	(5) Heard about other STDs
Spills	0.0432 (0.1308)	-0.0825 (0.0633)	-0.0618 (0.0411)	0.0876 (0.0869)	0.0942 (0.0751)
Constant	1.7300*** (0.1080)	0.9076*** (0.0293)	0.9110*** (0.0287)	0.4514*** (0.0500)	0.4666*** (0.0459)
Observations	707	754	636	585	754
R-squared	0.0049	0.0121	0.0055	0.0734	0.0222
Clusters	26	26	26	26	26

**Notes.** \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Standard errors in parentheses. Standard errors are clustered at district level. All regressions include year and spill fixed effects.

**Table 5.** The effect of oil spills on media consumption

Variables	(1) Read newspaper or magazine (at least once a week = 1)	(2) Listen to radio (at least once a week = 1)	(3) Watch television (at least once a week = 1)
Spills	-0.1102 (0.1231)	-0.0648 (0.0821)	0.0728 (0.1278)
Constant	0.3057** (0.1109)	0.7627*** (0.0881)	0.8472*** (0.0866)
Observations	754	754	754
R-squared	0.0118	0.0163	0.0076
Clusters	26	26	26

**Notes.** \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors in parentheses. Standard errors are clustered at district level. All regressions include year and spill fixed effects.

## Summary and Conclusions

This paper studies the effects of large oil spills from the North-Peruvian Pipeline on outcomes related to mental health; such as depression, tiredness and fatigue, feeling of failure, among others. We test the causal link between oil spills and mental health indicators by exploiting spatial variation of exogenous oil spills as well as the differences in timing of the spills occurred in 2016, a year in which spills increased their frequency and intensity regarding spilled barrels. We find that, after controlling for time-varying controls and for year fixed effects, oil spills lead to significantly higher probability of suffering psychological distress, such as lack of motivation, fatigue or feeling of failure. In fact, we find dramatic results regarding depression: *ceteris paribus*, an individual living in a spill-affected locality is 25.2 percentage points more likely to suffer depression after spill occurrence, relative to non-affected individuals. Our findings are quite robust: our falsification test provides support that the main results are not simply spurious correlations, but rather treatment effects. Whereas related issues have been studied in the public health literature, it has not been addressed from a more formal and systematic perspective. We

believe that this makes our approach particularly relevant given the potential public policy implications of our findings.

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