Mining and Health Status in Peru
Evidence for a period of minor environmental protection

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List of Acronyms

ARI	Acute Respiratory Illnesses
EIA	Demographic and Health Survey
ENDES	Encuesta Demográfica y de Salud Familiar (Demographic and Health Survey)
EQS	Environmental Quality Standards
INEI	Instituto Nacional de Estadística e Informática (National Statistics Office)
MEF	Ministerio de Economía y Finanzas (Ministry of Finance)
MINEM	Ministerio de Energía y Minas (Ministry of Energy and Mining)
MPL	Maximum Permissible Limits
OCMLA	Observatorio de Conflictos Mineros Latino Americano (Latin American Observatory of Mining Conflicts)
OEFA	Organismo de Evaluación y Fiscalización Ambiental (Environmental Protection Agency)

Abstract

This research studies the relation between health status and exposure to mining activities in Peru as an indicator of possible effects from pollution. It engages with different types of literature to try to create a contribution to the environmental justice movement and evidence for the case of mining in Peru. The document relies on data from the Demographic and Health Survey from Peru (ENDES) and data on the location of the main producing mining units in the country for the period 2014-2019. To explore this relation, the research approach employs a fixed effect model, with two variations, first considering the changes when taking into account the effects from mining royalties and the specific effects from metallic mining; and second, it includes variables which indicates the ethnic identities, in an attempt to observe health disparities across them. The results suggest a negative effect of a direct exposure to mining on the hemoglobin levels on blood and on the height to age indicator, which represents stunting, both for the case of children. Moreover, the estimates indicate a major incidence of Acute Respiratory Infections in children with a *quechua* identity, within a mining context. Opposite to the hypothesis, a closer distance to mining units was associated with less incidence of depression, which is considered to be a result of positive expectations that mining can generate. Overall, it was observed that although mining can affect health negatively, there are multiple mechanisms through which mining can have an impact on lives, therefore it is still challenging to find a more direct relation between the variables of interest as well as other variables which can explore health. Finally, the data availability only allowed to explore the variables which were mentioned, not broader understandings of health and unfortunately, the research could not find a clear relation among health, mining and conflicts.

Relevance to Development Studies

Recently, a series of policies took place in Latin America which neglected the social an environmental protection as the cost for expanding investment and extraction. Even though there is evidence that links resource abundance with health indicators, it is relevant to keep updating this evidence, to inform policy of possible health threats, under the mentioned context. The fact that policy making follows a causal logic makes it challenging to attribute health problems to the presence of one particular activity; along with the "polluter pays" principle in environmental regulation in Peru finding compensations for affected communities results problematic when responsibility cannot be legally proven.

Broadening the study of health disparities, with respect to mining expansion can call attention on the importance to keep strengthening legal systems and secure health and environmental rights Cartwright (2016). This and similar discussions could be useful to rethink the policy criteria in approaching the evaluation of environmental risks, extraction and health.

From an academic dimension, this research tries to integrate the methods and previous knowledge from the resource curse literature with the lenses of environmental justice, by looking at differential effects considering the social positionality and simply by acknowledging that health disparities constitute a problem on their own.

Keywords

Mining, environmental protection, environmental justice, exposure to pollution, stunting, underweight, anemia, IRA, mental health

Chapter 1
Introduction

"It is painful to live in Cerro de Pasco" says one news headlight from April 2020, reporting the story of hundreds of families who travelled from Cerro de Pasco, a city 4,000 meters above sea level, to the capital of Peru, Lima and were camping outside a public hospital for several weeks demanding medical attention due to high levels of metals in their blood, the result of years of mining pollution (RPP Noticias, 2020). The news article reminds the public of previous similar events, like how in 2018 more than 3,000 people -two thirds being children younger than 11 years old- walked to the capital to demand responsibility for years of health and environment destruction (Martinez, 2018). Likewise, communities in Challhuahuacho district in Cusco presented proves of having lead in their blood and were calling for the State´s attention, to act on the companies broken promise of not polluting, as it had stated in their Environmental Impacts Assessment (EIA) (RPP Noticias, 2019).

As these examples illustrate, mining remains a conflicted activity in Peru, given the high political relevance coexisting with social discomfort around it. According to the Annual Mining Report of the Peruvian Ministry of Energy and Mining (MINEM, for its Spanish acronym) of 2019, the mining sector constitutes "one of the pillars of macroeconomic stability, as well as the motor for economic growth and integral development for the country" (Ministerio de Energía y Minas, 2020, p.5, own translation), attributing the continuous economic growth of the past 20 years to the sector's leadership in exports and investment. In contrast, Peru registered 222 cases of social conflicts in 2019, 64% of which were motivated by socio-environmental reasons and 66,2% of them (94 in total) related to the mining sector (Defensoría del Pueblo, 2020, p.110). These numbers are representative of a usual situation, since the amount of mining related conflicts represent the major portion of them, as shown in the following table:

Table 1.1
Social conflicts related to mining in Peru

Year	Number of registered social conflicts	Conflicts related to mining activities	% of total conflicts
2019	222	94	42.3%
2018	232	95	40.9%
2017	256	106	41.4%
2014	276	119	43.1%

Source: 2015b, 2018, 2019b, 2020 Defensoría del Pueblo.

This divergence between the benefits and disadvantages generated by mining is necessarily a policy concern and causes the central government, specially, to promote dialogue actions and the creation of funds or mechanisms that can serve to finance a major provision services or to address specific demands (Defensoría del Pueblo, 2020, p.113). Nevertheless, policy decisions also follow changes in the international environment, which can at the same time exacerbate tensions between the goods and bads from mineral extraction. For instance, during the past decade, amid a regional economic slowdown and decrease of international commodity prices, a series of policy changes were promoted in order to maintain investment levels and try to counter the negative effects on the economy; these were specially problematic because the proposed strategy to attract investment consisted on decreasing or "softening" the amount and rigour of social and environmental permits to access resources, and although these were general measures, they resulted more beneficial for companies that operated in the extractive sector (ANC et al., pp. 26-29).

The main concern of this research lies precisely in the contradictions found in the promotion of an expanding extraction through mechanisms like the legislation changes described before, despite the possibility of being detrimental to people's welfare, particularly for their health. Overall, an unhealthy environment can be related to a deficient health status, however, health disparities can rise because of this type of political action that does not act upon risk factors affecting more marginalize communities, especially if they have already been exposed to environmental risk for decades. In this case, the potential long-term effects on people's health, as a consequence of a weakening national environmental protection should have been in place as a policy evaluation criteria, to justify an intensification of investment.

To understand the relevance of studying the health-related consequences of environmental change, we can look at the World Health Organization(WHO) report on the burden of disease from environmental factors. According to the report, the estimated diseases burden[1] in 2016 was of 24% and 19% in low- and middle-income countries in America (WHO, 2019); some of the risk factors identified as a product of industries' operations are air, water and soil pollution, occupational risks, built environments (land-use patterns and roads) and man-made climate change and ecosystem change (Prüss-Üstün et al, 2016, p.3). When it comes to mining, the nature of the activity requires for environment changes; for instance, it requires major infrastructure projects, which can generate air pollution due to soil removal. Moreover, pollution can vary according to the type of operations, products associated and general care for controlling externalities. In that sense, there is a burden of disease that can come from economic activities and it is most definitely not equallydistributed.

For the case of Peru, the disease burden from mining has being documented by diverse sectors, academic, as well as civil society organizations to call attention, especially on emblematic cases of severe pollution. For example, in the case of Pasco, Astete et al. (2009) and the NGO Source International in 2016 performed different evaluations of health status, through blood, hair and anthropometric measurements; in the first case, 84.7% of 200 children from two communities within 5 to 7 km from mine tailings, were intoxicated by lead and a high frequency of undernourishment and chronic anemia; while for the second study 100% of 102 children from two small towns had high concentrations of lead, four times higher for children residing in the area directly exposed to mining, but 36 times higher than the reference standard; also, concentrations of aluminium was three times higher and arsenic, manganese, chromium and iron, were twice as high, compared to the referenced measures (Asociación Civil Centro de Cultura Popular Labor, 2018, p.62). In a more southern region of the country, Amnesty International warned that in Espinar, Cusco, 41 out of 58 water points, tested between 2012 and 2013, contained at least 1 heavy metal above the Maximum Permissible Limits (MPL); they also reported that 97.3% of 506 people showed to have lead in their blood; 50.2%, cadmium; 45.6%, mercury, and 65.6% tested for arsenic (Amnesty International, 2017).

Just as well, previous research has studied mining environmental pollution, given the possible health implications. There has been a focus on lead exposure, for its toxicity, and it has been found to be strongly associated with growth impairments among children and low levels of hemoglobin in blood, however the severity also depends on the levels of exposure and could have more severe consequences. Furthermore, Von der Goltz and Barnwal (2019)

[1] The disease burden can be understood as the amount of diseases or health loses which can be attributed to environmental factors (WHO, 2019)

list a series of possible health consequences from polymetallic mines, such as neurodevelopmental damage, anemia, growth deficits and respiratory diseases, due to the risk coming from the emission of heavy metals, lead and SO2. With a different focus, Ignasiak et al. (2007) test the effects of lead exposure on physical conditions of children between 7-15 years old living in the vicinity of copper smelters and refineries and tested for lead in blood, to see exposure manifest through stunting.

On the other hand, Dudka and Adriano (1997) identify that large amounts of solid waste can contain traces of metals that go in the soil, either from tailings or acid drainage; also smelting and refining activities can generate atmospheric emissions of particulate matter and metallic traces, but these also can land on earth; which generates acidification and can affect soil biology, a potential risk factor for health, depending on the diet of people, as well as the complexity of other factors which can play a role in affecting human health.

On the basis of what previous authors and epidemiological studies have identified regarding the health implications from mining, the mechanism of how his activity and environmental protection policies can have an impact on health status is defined in Figure 1.1. The relationship displayed is not straight forward regarding the effects of activities, since the effects come from different angles, in more or less direct ways and in different time frames; this premise gives a first sense of the limitations in finding the consequences of minor environmental protection, if we focus on health indicators.

All things considered, the objective of the research is to contribute to the environmental justice evidence around the effects of mining in Peru, by analysing the correlation between health status and the exposure to mining activities, which will be seen using measures of geographical proximity. The specific objectives include exploring the effects on morbidity and health conditions that can be related to the presence of mining; a second and third objective involve observing differential effects based on ethnicity, and exploring elements such as conflicts and participation in our analysis. In order to address these objectives, the following research questions are formulated:

Research question:

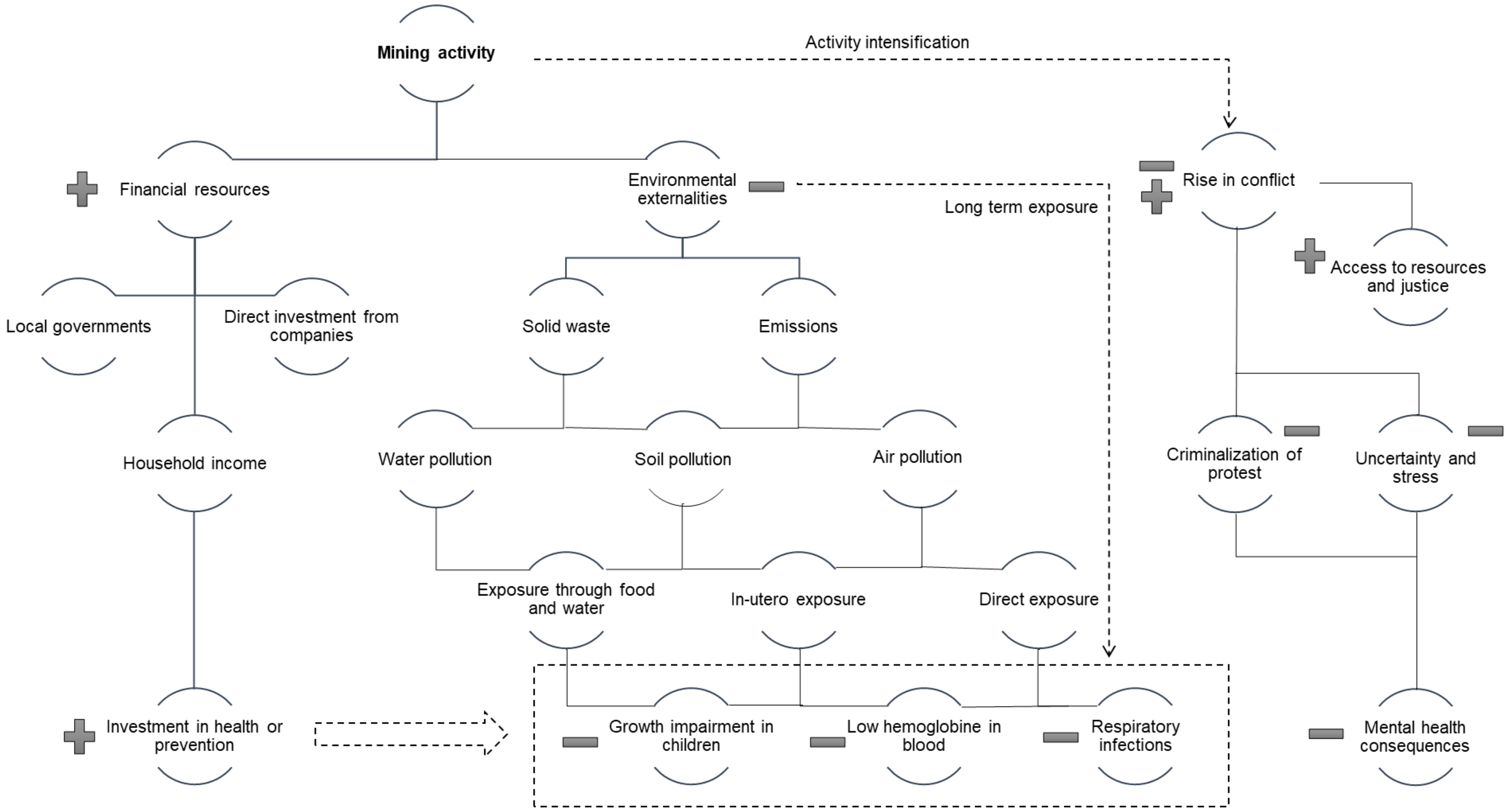
What are the effects of mining activity in Peru on the health of communities located in nearby areas amid minor environmental protection?

Sub questions

1. What are the effects on morbidity and health conditions related to a major exposure to mining activities?
2. What are the health effects of mining among different ethnic identities?
3. To what extend does a better health status relate with the existence of social conflicts related to mining?

The hypothesis departs from the contradiction found among policies which promote the expansion of mining, while neglecting social and environmental standards. Therefore, considering a long- term exposure to activities, it is believed that a major proximity to mining operations should result in worse health indicator. Additionally, health disparities might be larger when considering differences among ethnic identities, which correlate to the geographic location of certain communities. Finally, seeing conflict as a democratic tool, it is expected to observe a positive relation between health status and the development of them.

Figure 1.1
Relationship of mining, environmental effects and health



The relevance of this research derives from the focus on the context in which promotion of policies of minor environmental protection, like the legislation changes during the las decade, took place. Accordingly, political actions leveraging different interest while creating disadvantages for more marginalized groups are a timely and shared concern in Peru and many neighbouring countries.

This document is organized as follows. Chapter 2 provides further information on the background of the problem and highlighting the context in which the legislation changes in Peru and other countries came into place as part of a regional phenomenon at the end of the super cycle of high commodity prices. Chapter 3 reviews the literature, theoretical and empirical evidence relevant to this document, we integrate two main pillars, the resources curse literature and the environmental justice approach. Chapter 4 focuses on the methodology employed for the analysis, data and variables description and the empirical approach. Chapter 5 describes the findings and provides an analysis of them and finally, Chapter 6 focuses on the conclusions.

Chapter 2
Background of the problem

The evolution of extractive activities in Peru and Latin America interacts with the installation of the prevalent economic model in most countries, which has also shaped the institutions and legislation related to the functioning of the mining sector, along with the external economic conditions, like the volatility of mineral commodity prices, particularly over the last 20 years. Although mining in Peru comes from a historic tradition of resource extraction, its relevance today is related to neoliberal reforms introduced in the country, which promoted major investment in primary sectors, trade openness and minor government intervention. From this point, primary export activities like mining have materialized the economic model prevalent in Peru since the 1990s. As it is portrait by Svampa, Peru became part of the commodity consensus, in which case being part of the global economic and political order is sustained by having an extractivist model (Baca, 2017, p.7) and as Pedraglio explains, the Peruvian government locates its legitimacy in this model, in which primary extractions is the centre given the contributions it had on the reduction of poverty (Pedraglio on Baca, 2017, p.8), despite the inequality also related to its development.

Moreover, alongside the economic reforms, environmental legislation has been inevitably influenced by neoliberalism as well (Liverman and Vilas, 2006) and environmental institutionality in Peru developed with many similarities to the rest of the region, where similar political and economic processes also took place. The first institutions centred around environment date from the 1990's and the creation of an environmental authority, from 2008, in accordance with similar milestones in countries like Chile and with international trade agreements' conditions (Baca 2017:64; Ballón et al. 2017:65). Over the years, environmental management gained relevance and evolved from been scattered among different government bodies and sectors, towards the concentration of these functions into one specialized environmental authority. And although the creation of environmental institutions is considered a success, many processes have had slower developments and faced with resistance. For instance, the framework for environmental assessment for large projects related to natural resources developed more slowly, perhaps due to the opposition of private interest and because it was used as an instrument to counter economic slowdown periods (Ballón et al. 2017:66). In that sense, it is agreeable that the impacts of mining and similar extractive sectors are also shaped by the politics that surround them, they are "politically volatile", as Liverman and Vilas claim (2006, p.356), because they do not only relate to the existence of resources but to the institutional arrangements around it and the balancing of different interests.

Parallel to the development of environmental institutionality, the decade of 2000 was a period in which mining and other extractive sectors increased their significance for the economy, due to the large revenues that were product of increased commodity prices. Nevertheless, around 2014, when the booming cycle of commodity prices was declining, conditions for investment became less favourable, therefore the government in Peru proposed a series of measures to counter the slowdown, however, these resulted into controversial and very contested policy decisions. For instance, among many measures, a weakening of environmental control was proposed in order to boost investment. Ballón et al. (2017) clarify that these legislation changes in Peru were also found in many countries across Latin America and are a result of the aftermath of the last super-cycle of high prices and demand for commodities (Ballón et al., 2017, p.3); they use the concept of "race to the bottom" to refer to how policy responses of drastic changes in legislation around environment and social protection were put in place as an attempt to balance the minor revenues from extractive industries.

As part of the policy changes in Peru, Law N° 30230 was approved in 2014 in order to keep attracting and increase investment; it proposed changes and even weakened environmental legislation, in order to decrease operational costs for companies and ease investment procedures. In its formulation, Law N° 30230 relied on market mechanisms to prevent environmental damage, however, in practical terms companies were given tax exceptions, environmental fines were suspended for a period of 3 years, assessment procedures for permits were simplified, among others. This law was very controversial among environmental NGO's and environmental authorities because it was considered a way backwards in the achievements of environmental institutionality (Gonzales Tovar, Monterroso et al. 2014, pp. 1-2). In an interview done by Mongabay in 2017, after the three-year period of restriction of environmental regulation, various experts explained that Law N° 30230 had not achieved the expected results on investment or prevention of environmental damage. Instead, the Environmental Protection Agency (OEFA) had reported a major number of infractions, since on average, mining companies went from 10% to 37% of infraction of environmental obligations and there was an increase on environmental conflicts (López, 2017).

According to a report prepared by several NGO in response to the law, the private sector was the main beneficiary, specially companies in charge of large investment projects and it created disadvantages for communities and indigenous communities in different aspects. Regarding the changes in environmental legislation, Law N° 30230 decreased the costs of committing infractions, given a minor severity of corresponding punishments. Some of the changes made and their potential effects are shown in Appendix 1.

In brief, institutional development since the 1990's and the legislation changes that took place over the last decade are part of a similar process taking place in the whole Latin American region, which has adopted economic models that are highly dependent on the expansion of extractive activities, in different degrees. Following Arsel, Hogenboom and Pellegrini (2016), many countries in Latin America are examples of extractive imperatives. In fact, for the case of Peru, the expansion of extractivism took place alongside the development of redistribution policies, such as the creation of *canon minero* (a tax applied to mining activities), as the "participation of local and regional governments in the income and revenues obtained by the State from the extraction of metallic and non-metalic mineral resources" (Ministerio de Economía y Finanzas, n.d.); nevertheless, as Arsel, Hogenboom and Pellegrini (2016) explain how despite high commodity been a driver for the installation of a extractive imperative, the absence of it, would not make it disappear (Arsel, Hogenboom and Pellegrini, 2016 p.81). The fact that for countries like Peru, it is necessary to sustain the functioning of mining and extraction in general creates a contradiction with other policy objectives, specifically related to social and environmental protection, given the risks and hazards that extractivism could bring for people's welfare, if environmental regulation is undermined in order to expand extractive activities.

Chapter 3
Theoretical framework and empirical evidence

The main theories and empirical evidence that will guide this research are presented in this chapter. The starting point for the literature search were the works that studied the relationship between mining and conflict in Peru, especially the contributions of Arellano-Yanguas (2011) and Orta-Martinez, Pellegrini and Arsel (2018). This allowed to understand that the implications of resource extraction are dependent on social and political dynamics, therefore it is necessary to understand the potential consequences of mining, locating the political context. With that in mind, it was also understood that although the resource curse literature is widely used in economic research to evaluate the impacts of resource extraction, it was possible to include other concepts from more critical approaches, which question some preconception. The search included alternative concepts to broaden the definitions of health effects; for instance, authors within the environmental justice framework explain that diseases as well as hazards ought to be defined considering their cultural interpretations (Nixon, 2011 and Cartwright, 2016).

3.1. The resource curse

As a starting point, the resource curse literature studies how large amounts of natural resources can worsen economic and political performance, even though experiences across countries have been diverse; basically, relying on resource revenues is related to inadequate levels of consumptions and investment and a rising inequality (Humphreys, Sachs and Stiglitz, 2007). Other consequences are related to the weakening of democracy, increased corruption, and accountability problems (Humphreys, Sachs and Stiglitz, 2007, pp. 11-12). Within a context of natural resource abundance, the authors explain that there are economic and political effects which interact and result in a "rent-seeking behaviour" (Humphreys, Sachs and Stiglitz, 2007, p.4), by which private and public actors seek for opportunities to maximize their own benefits from extraction, instead of using their positions in policy for the general welfare; for example, corporations looking for the least costly way to access resources in exchange for political revenues, which ultimately undermines social and environmental responsibilities.

This literature can be looked at through different angles, depending on the disciplines that study it (Gilberthorpe and Papyrakis, 2015, p.382), however, it is straight in explaining the potential problems related to the existence of natural resources; it is also possible to identify solutions that point at stronger institutional arrangements. Nevertheless, the limitation of this approach lies in the focus on overcoming the negative consequences of resource abundance in order to turn the curse into a blessing; instead of actually questioning the inherent problem of extractivism in perpetrating inequality and affecting marginalized communities significantly more. In other words, only using the lenses of the recourse curse literature does not alone allow to question how to go about the prevalence of a "extractive imperative" mentioned in the previous section (Arsel, Hogenboom and Pellegrini, 2016).

Within previous evidence, we find studies linking the existence of natural resources and negative health consequences at a macro scale (Gilberthorpe and Papyrakis, 2015). For example, Wigley (2017) analyses 167 countries in the period 1961-2011 to see the contributions of oil exploitation on children's health, and results indicate that in petroleum rich countries child mortality is poorer, compared to countries that did not have abundant petrol resources; the research links revenues from extraction to a loss of incentives to invest in public health.

Similarly, but using indicators of government expenditure, Cockx and Francken (2014) look at the world countries over a 14-year period to find a relationship between natural resource abundance or dependency and public health expenditure and find a negative relation between them. They argue that resource dependency creates a deterioration of state accountability, increases state independence and volatility from revenues, and hence motivates policies that do not prioritize welfare. In the same way, Kim and Lin (2017) analyse a panel of countries for the period 1970–2011, to check the long-run relationship of natural resource dependence and human capital, looking at achievements in education and life expectancy. This research includes variables of political and social institutions, to represent the context in countries, which creates mixed results; however, they find that natural resources and health go in opposite direction, pointing at political gains from revenues as the reason for decreasing incentives to serve the public.

The three cases can exemplify a rent-seeking behaviour and show evidence of an inverse relationship between major income from resource extraction and expenditure in health or health status; however this is a point were limitations lie, since health performance is directly linked to public investment or the use of financial resources, instead of problematizing more the generation of health risk from extractive industries. Also, despite Kim and Lin (2017) highlight the importance of including institutional variables to understand and explain the correlation between health results and resource abundance, these analyses are not critical enough to the facts that differentially impacting human health is problematic enough, and this calls for the need to include a more justice-focused analysis. Of course, this is understandable considering the possibilities that results from having countries as the units of observation and that the research objective point more at proving the theory (Gilberthorpe and Papyrakis, 2015, p.387).

Research using individual level data can bring an opportunity to include more critical approaches, as it looks into more case specific variables like being located in a mining community and variables of political and social dynamics. For example, Hota and Behera (2015) evaluate the environmental impacts of mining at a local level, by looking at agricultural productivity and human health; they observe increased air and water pollution, loss of cultivable land and biodiversity as a result of open pit coal mining (Hota and Behera, 2015, 685). Using an "effects-on-production" and "human-capital" approach, the authors find lower agricultural productivity in mining communities, compared to non-mining ones, as well as major incidence of respiratory illnesses, which were actually higher for women (Hota and Behera, 2015, 683). In this case, the data is helpful to identify different levels of impact depending on social characteristics; moreover, authors recommend institutional arrangements such as defining property rights through negotiations, which include collective action as a mechanism to pressure regulatory changes, which can introduce an alternative concept towards understanding other underlying reasons of disparities in health.

Following the identification done by Gilberthorpe and Papyrakis (2015) of the fragmentation of the resource curse literature, studying these processes has been mainly done by disciplines different to economics and using methodologies that do not necessarily point at testing theories. This gives an idea that, for the purpose of this research, there is a need to engage with more critical literature employed in anthropology, for instance, to study the implications of mining at a micro scale with a different approach, keeping in mind the existence of an extractive imperative which is shaping the impacts of mining in Latin America.

3.2. Environmental justice perspective

Environmental justice studies emerged as a product of social movements in the United States fighting racism around the fact that people of colour and poor communities faced ecological risks and hazards in a greater proportion compared to an average middle-class white person (Mohai, Pellow and Roberts, 2009, p.406). This body of literature provides a critical lens to think of unequal impacts from resource abundance, where the starting point is a mismatch between profit maximization and socio-environmental welfare and social and political interactions and context to define these impacts.

Departing from this incompatibility, Daniel Faber (2017) reminds us that policies aiming at economically and politically efficient results do not guarantee an equal impact on people. In fact, the burdens from ecological damage weight more depending on the balance of powers among the state, companies and social movements (Faber, 2017, p.62). As the author explains, the least empowered communities, which have fewer means to defend themselves will suffer the most (Faber, 2017, p.61), in accordance with their less favourable social positionality or the different intersection of identities (for example, being indigenous of certain social class and gender living in a remote rural area) which result in the creation of "sacrifice zones", following Lerner (2010, quoted in Faber, 2017), where particular communities bare high concentration of toxic waste, air pollution, loss of livelihoods, health problems, etc., and it becomes unsafe even to breathe or drink clean water (Faber, 2017, pp. 62-63). The author highlights that without the corresponding regulation, companies are not likely to internalize socioenvironmental damage. Bringing this definitions to the purpose of this research, it is adequate to ask whether communities located within mining operations have become a sort of sacrifice zone in Peru and how the development of this sector is enhancing health disparities in the country.

Although Faber's analysis is based on the U.S., there are important features of these inequalities which can be used in different contexts, in relation to political decisions on where to locate polluting industries and whether there are tools available for the disempowered communities to move out of a situations they face. Following Faber (2017), the political and economic structures generate the conditions for the system to discriminate the least empowered and benefit capital, by allowing access to cheap land, favourable regulation and less likelihood to encounter resistance or a strong opposition (Faber, 2017, p. 64), which is why the author calls out the necessity to keep strengthening the resistance from the environmental justice movement, given the battle it receives from neoliberals and a captured state (Faber, 2017, p. 70).

3.2.1 Further understandings of health

An important task of the environmental justice approach is to introduce a contextual analysis and understanding of health and impacts, which includes the acknowledgment of social and political forces that shape the perceptions of them. Porto, Rocha and Finamore (2017), for instance, claimed that health implications have a political component and this position is similarly adopted by Nixon (2011), when describing what he calls slow violence, as well as Elizabeth Cartwright's definition of eco-risks (2016). A relevant contribution from these authors is the acknowledgment of how our current definitions of impacts are framed within a previous understanding of them, which can be narrow and limited by cultural definitions of violence and diseases. The authors argue that not recognizing these limitations explicitly makes certain impacts invisible, tolerable, and not associated to any preventive measure.

Rob Nixon (2011) and Elizabeth Cartwright (2016) have similar proposals on redefining our understanding of what is violence and what are risks related to environmental problems; they pay attention to elements such as time and culture to argue the need to include new meanings into policy and media, as a step to search for justice. Nixon (2011), on one hand, refers to how violence is associated with noticeable events only and how slow violence is easily erased from the memory as it lacks the characteristic of being striking (Nixon, 2011, p.2); he defines it as "slow in the moving and long in the making" since the lack of actions around it poses threats for a long period and for many generations (Nixon, 2011, p.3). These characteristics are unfortunately common for environmental problems; for example, climate change can have impacts in the long run, without necessarily implying major disasters and instead consisting of a subtle exposure to substances which are slowly damaging.

Just as well, Cartwright (2016) argues the existences of what she calls eco-risks, as impacts which are less evident and difficult to scape and are therefore perceived as acceptable. Precisely, they are defined as the "process of understanding and reacting to threats to our health and well-being that emanate from our environment" (Cartwright, 2016, p.419), because the author highlights how some health conditions from mining emanate not only from concrete facts, but also from communities' relation to the industry and cultural recognition of threats (Cartwright, 2016, p.419); therefore, the author's suggestion to identify eco-risks aims at broadening our understanding of the range of health consequences that can come from mining. Viewed in this way, we can think of eco-risks as a form of slow violence and consequently accept the fact that many impacts from industries, mining in this case, might need to be acknowledge and brought into policy. An important element to highlight is the role of time, because although economic compensations can be associated with higher tolerance of hazards, the time span is determinant for risk acceptance and reactions (Cartwright, 2016, p.420).

Even though much of Cartwright's analysis is exemplified through experiences from occupational hazards, many of the situations mentioned in her work can be imagined in a setting similar to how large mining projects are executed in Latin America, where the most exposed are rural communities from the Andes. For example, some evident hazards related to mining are chemical hazards, which are associated with higher probability of lung and nasal cancer coming in cases of coal, petrol, copper and nickel mines; and other conditions depending on the types of chemicals as well as the period of exposure, like the risk of acid mine drainage from metal ores, which can potentially cause serious water pollution (Cartwright, 2016, p. 427). Aside from them, there is another level of impacts which involves less evident effects; for which she uses a case in Guatemala as an example, in which the installation of mining brought psychological consequences to the portions of the population who were not in favour of it, due to intimidation and violence brought by groups and even guerrillas that supported the industry (Cartwright, 2016, p.429). Similarly, many advocacy NGO's and networks bring to light stories of environmental defenders and communities that resist big extractive operations, facing harassment and violence; following Cartwright, these elements that can be considered as psychosocial hazards, however the case could be that our conceptions of hazards and health do not necessarily acknowledge them as such.

One relevant element to keep in mind is that slow violence effects are more damaging for certain people who already suffer from invisibility, for instance, poverty and lack of opportunities intersect more frequently with major vulnerabilities from environmental problems, subsequently causing major obstacles for participation and resistance to call out on the impacts they face (Nixon, 2011, pp.2-4) and confront the dominant structures that determine what and who counts (Nixon, 2011, p.16). The corresponding challenge is to make stories of slow violence dramatic enough to encourage their representation in policy (Nixon, 2011, p.3) and ensure the incorporation of safety and health standards, for which the support of legal systems are essential (Cartwright, 2016, p.420).

Some idea of elements that can be understood as eco risks and slow violence when studying health effects are, for example, consequences of repression and criminalization of protests, or disparities of health based on ethnic or class. However, the challenge lies in the availability of methods to identify them and the reconciliation with the policy making logic; for Cartwright, providing medical and legal attention to health problems, rely on documenting eco-risks using ethnographic and multidisciplinary methods; on the other hand, Nixon promotes the idea of story-telling as a way to increase the attention of episodes that fit into the concept of slow violence. The approach in this research will combine an analysis of mainstream health data, complementing the information with more qualitative information which can be a representation of social and cultural understandings of health problems and risks.

One source of information to understand health effects can be to look into social conflicts that emerge around extractive projects. Within the resource curse literature conflicts are seen as a result of natural resources abundance; however, an alternative approach, conceives conflicts as pillars for democracy and as instruments for accessing justice. Both approaches result complimentary, since it is understood that the emergence of conflicts can have multiple motivations, which could as well represent demands related to health problems, in a broad sense, following the concepts proposed by Nixon(2011) and Cartwright (2016).

Albert Hirschman (1994), for instance, argued that conflicts had the functional role of holding democratic societies together, since they allow a process of confrontation and social cohesion; his view opposed to the different conception of conflicts accepted by western social sciences, such as seen as an obstacle for development. Hirschman (1994) explained that in market societies, conflicts were of high frequency and variety and never found a definite solution because in these settings, negotiation is the preferred strategy towards conflicts, and negotiations do not allow to address the growing inequalities they respond to.

On the same page and focusing on the conflictive history of oil extraction in the north of Peru, Orta-Martínez, Pellegrini and Arsel (2018), define the concept of conflict imperative as a strategy adopted by indigenous communities, in response to state incapacity and corporate impunity, which prevents them from accessing fair compensations or the possibility to participate in decision making processes regarding their territory and oil extraction. Following a four-decade history of fights among oil companies, the state and communities, they describe how under certain circumstances, engaging in conflict was the only alternative to access economic compensations, mobilize institutional changes and "to foster better environmental performance and compliance with human rights" (Orta-Martínez, Pellegrini and Arsel, 2018, p.9).

Similarly, Arellano-Yanguas (2011), defines different types of social conflicts in Peru, pointing out the existence of conflicts in which communities and companies are confronted in order to access the same resources. The author distinguished shades of conflicts and argues that many conflicts correlate negatively with booming periods and that in cases where communities perceived little or no alternative to extraction, conflicts tend to be less. Also, many of them use iconic cases (all-or-nothing type of conflicts) as a reference to pursue their goals; in that sense, many times, conflicts use an environmental discourse to access a variety of demands; however, Arellano-Yanguas (2011) makes an relevant point as he finds that regardless of the discourse implied in the conflicts, demands tend to disagree, at least to some extent, with the subject of negotiations, because they mostly focusses on material agreements and could be disregarding other demands, more related to environmental justice, for example.

On the other hand, literature also suggests more nuanced types of responses. Some of the authors mentioned before argued that many times conflicts serve a purpose for accessing demands, however, it could be the case that agreements derived from conflicts do not cover all expectations and needs from communities or they do not really address all the scope of impacts that a community can be facing. Departing from Areyano-Yanguas' (2011) explanation of the cases in which communities rely less on conflicts because they do not see other feasible alternatives for likelihood, we can also find situations in which the effects perceived from mining or other extractive activities do not lead to conflicts. Similarly, and also within

Latin America, Van Teijlingen, K. (2016) sees discourses around mining as projects of governmentality. Located in the context of the rebirth of a more progressive state in Ecuador, the author finds that the discourse which posed mining as essential for the development agenda helped shaped the subjectivities (new regimes of truth) of communities and managed not only to avoid the occurrence of conflict, but to receive the support from factions of the population towards mining projects, although not in a totalizing way (Van Teijlingen, 2016, p. 910).

As another example analysing power, John Gaventa (1982) studies the long-standing inequality scene in the Appalachian valley, a coal mining region with high poverty rates and an apparent passivity from locals towards abuses from companies exploiting the resources in the area (Vernon, 1981; Fischer, 1981). Focusing on power relations in the region, the author argues that the presence of a ruling group that dominates political and economic power creates an effect of indoctrination by which beliefs are questioned and changed, in favour of the interest of the powerful and reinforces the condition of the powerless; in that sense, a change in the lack of response from these communities would require a shift in the power structures, which would imply the availability of tools for participation in the decision-making processes (Vernon, 1981; Fischer, 1981). These examples give a sense of the possibility of not encountering reactions from affected communities and of the relevance of looking at the construction of power dynamics and discourses around extractive activities.

With that premise, looking at the demands and development of conflict can hold information of further health effects, or reflect those effects which are not being reflected in the usual ways of studying health. Precisely, incorporating an environmental justice lenses, implies questioning our usual methods and means to identify impacts in the first place, and help think about how to introduce a wider contextual analysis into the results. At the same time, it is useful to think on how to approach common sources of information to provide evidence that can serve the environmental justice in more affected communities. In sum, the environmental justice approach helps analyse the results from data on health and mining, instead of providing specific methodologies; the findings should allow to ask whether we are facing cases of slow violence and what has allowed for that, as well as the existence of risks, which are normally not seen as such.

3.3. Previous empirical research

The impacts of mining in Peru have been researched from different perspectives, however, research focusing on health is probably more related to case studies, which try to find some causal relation between them. Nevertheless, research which relies on larger data and which is not case specific can also be mentioned; for instance, Bebbington and Bury (2009) look at the impacts on livelihoods, including health, through the combination of potential negative effects on water and land resources and the relation held with the mines. For the case of Cajamarca, the authors indicate that only 29% of households who sold land to the company or were involved in community development programs from mines had higher access to health services evidencing a short term nature of such effects; however, analysis on water quality indicated low environmental standards and declaration of illnesses from communities (Bebbington and Bury, 2009, p.17298).

Using distance variables Saha et al. (2011) study health status in mining communities in the state of Orissa, India and try to determine whether Orissa could be a case of environmental injustice; the authors explain that in the State in study, mining expansion was promoted as a means for local economic development, but this policies actually increased the costs bared by local communities, specially indigenous communities, due to forced displacement as well as higher rates of environmental-related diseases. The research correlates the presence of respiratory illnesses and malaria to proximity to mining sites, using a multivariate regression and GIS methods and finds a positive effect of distance to higher incidence of disease. Similarly, Von der Goltz and Barnwal (2019) use individual data of 44 countries to test whether there is a co-existence of health illnesses related to metal mining pollution, with wealth gains; they also rely on variables of distance to mining sites to approximate exposure to pollution. Their results confirm a trade-off between economic benefits and health loss in mining communities, since mining works as a way to attract families to mining areas, given the economic opportunities, but at the same time creates a major exposure to harmful health risks, from pollution. As they narrate, they find compensated impacts because "living in mining communities goes hand in hand with economic benefits (…), there is no indication that ill health is caused by deprivation. Rather, health impacts arise despite wealth gains." (Von der Goltz and Barnwal, 2019, p.2). Finally, specifically exploring the effects of lead pollution, the authors find worse health illnesses related to it only in the case of households close to mines and not otherwise.

In the case of Peru, Orihuela et al. (2019) try to see the relation between the proximity to mining liabilities, health and agriculture with a gender perspective in Peru; they find a negative correlation among these and with higher negative impacts on women. Despite the limitation they face regarding the information available on liabilities and the amount of pollution they represented, the results do suggest the presence of risk factors for health, coming from mining (Orihuela et al., 2019, p.6).

The findings from Orihuela et al. (2019) correlate to warnings presented in reports by the Ombudsman Office and an environmental NGO about the hazards from mining on health and human rights. Specifically, the Ombudsman Office (Defensoría del Pueblo, 2015a) presented a report calling out on the growing number of liabilities from mining and oil operations in the whole country, which lacked adequate solutions, given the institutional and legal challenges to secure their remediation. On the other hand, CooperAcción (2019) carried out a qualitative research to make visible how fundamental human rights, stated by the country's constitution as international agreements adopted by States and companies, were violated in mining communities in the south of Peru. With respect to health rights, the analysis focused on the implications of mining activities on water and explained that operations not only affected the quality and availability of it, but altered social, cultural and economic dynamics that take place around this resource. Furthermore, the report addresses a disruption on the right to a healthy environment as institutional arrangement around operations, without a proper consultation process resulted in air and acoustic pollution (CooperAcción, 2019, p.64). These two mentions are relevant to understand the use of a human rights and environmental justice lenses, as the objective is precisely to highlight persistence of disparities, and the systemic ways of excluding certain communities from a better health quality.

Furthermore, there is research which focuses on differentiated impacts due to social positionality. Brain (2017) reviews several pieces of literature to synthetize the impacts of mining on livelihoods in the Andes; the results indicate that mining can affect the assets and conditions (such as the environment) which ultimately affect a household capacity to make a living (Brain, 2017, p. 412). With respect to variables related to environmental elements, the conclusions indicate that livelihoods are affected specially through water quantity and quality alteration, because of its effects on agriculture and farm productivity, but also because of direct impacts on human and animal health (Brain, 2017, p. 413). One key element, which will be used in this research is the highlight of how socially-constructed hierarchies of gender and race shape experiences regarding mining effects; for instance, the author exemplifies how indigenous women tend to be marginalized in development projects, even when gender variables are included in policy (Brain, 2017, p. 415).

On the other hand, research which does not necessarily focus on mining is also used as reference to study health indicators, especially in children, and their relationship with environmental variables. Many result useful, as they make use of the Demographic and Health Surveys (DHS). For instance, Assaf et al. (2018) analyse the correlation of environmental variables and children's health and mortality for 12 countries in Sub-Saharan Africa, Latin America and the Caribbean and Asia; they look at forest cover and loss, as well as proximity to protected areas and water as environmental variables. In their work they argue that a good environmental quality is associated with having availability of clean water, for example, and environmental changes can increase the presence of negative health conditions and diseases, such as diarrhea, malaria and malnutrition, which increase the probability of child mortality (Assaf et al., 2018, pp.1-3). In that same line, Landrigan et al. (2018) review the report by the Lancet Commission on Pollution and Health which analyses data from the global burden of diseases and find that 940,000 deaths in children in 2016 were caused somehow by air, water, soil, or chemical pollution. The review highlights a rise in non-communicable diseases, especially for children and the under characterization of chemical exposure consequences, which decreases the evidence that can be generated on the pollutants. (Landrigan et al., 2018, p. 2389). Regarding low to middle income countries, an increase in diseases is associated with a major demand for energy, growing cities and intensification of activities like mining; moreover, the burdens of pollution were more intensified for marginalized and poor communities (Landrigan et al., 2018, p. 2390). Following this logic, it is important to include specific indicators for children, as the evidence points at them being more vulnerable to impacts, and also, the works mentioned confirm the need to look at differential impacts across different social groups.

The resource curse literature has given evidence on a negative correlation between health and resource abundance and research at a micro level has also allowed to link the existence of pollution to major incidence of health conditions, such as low hemoglobin in blood and growth impairments. Complementary, research within the environmental justice movement has stablished links between respiratory illnesses and pollution in particular geographic areas, inhabited by communities which are already marginalized. We use this premises to also explore the correlation of health conditions, exposure to mining activities and differential effects across ethnic groups to contribute to the environmental justice evidence for the case of communities exposed to mining in Peru, where this sector is many times attributed as the cause of social demands.

Chapter 4
Research methodology and data

4.1. Data sources

4.1.1 Demographic and Health Survey - ENDES

The data source employed for health indicators comes from the annual Demographic and Health Survey from Peru (ENDES for its acronym in Spanish), which was pooled into a dataset for the period 2014 – 2019, since the information from these years is georeferenced. The ENDES survey was implemented in Peru as part of the DHS Program[2] since 1986 and has been constantly executed by the National Statistics Office (INEI in Spanish) (INEI, 2018c). Since 2008, ENDES is a main information source for planning in Peru, since it provides information on indicators of status and trends in fertility, mortality, family planning, nutrition, maternal and children's health, access to identity and health conditions related to transmittable and non- transmittable diseases.

This survey has been conducted annually since 2003 and from 2009 onwards, it uses a panel sample of clusters for every 3-year period; however, it does not follow the same households every year, which is why the survey does not constitute a balanced panel data. According to the survey's description, it employs a probabilistic cube sampling method, which allows to have a balanced sample with estimates equal to the ones of the population, since it replicates its structure in terms of age groups, sex and other balancing variables; in that sense, for every sampling period, the information regarding the structure of the population is updated to maintain the balance and stability of indicators (INEI, 2019b). The samples are selected in two stages, first at a cluster level in which there is an equal proportion of rural and urban households and then at a household level (INEI, 2019b). The sampling design described was updated in 2015 and that explains the main differences between the sample composition in 2014 and the years after. As it is seen in Table 4.1, the number of clusters for the period 2015-2019 is more than double compared to 2014, however the clusters are composed of a minor number of households (19 households in 2014, on average versus 10 in 2015 and later).

Table 4.1
ENDES design per year

Sample period	Year	Clusters per year	Total households
2018-2020	2019	3,254	36,760
	2018	3,254	36,760
2015-2017	2017	3,175	35,910
	2016	3,175	35,910
	2015	3,175	35,900
2014	2014	1,558	29,806

Source: INEI (2019b, 2018b, 2017b, 2016b, 2015b, 2014b)

[2] As part of the DHS program, the ENDES survey maintains many of the main questionnaires and variables from the DHS design. In that sense, it is appropriate to follow the Guide to DHS Statistics (Croft et al., 2018) regarding the calculation of indicators and analysis of data.

In general, the DHS surveys -and the ENDES survey- collect information on household and individual characteristics, which allows to first select eligible members to respond to specific questionnaires (Croft et al., 2018, p.1.13). Given this design, it is possible to find information from the same individual within different questionnaires and makes it necessary to be careful when building a final data set with all the variables of interest.

The ENDES survey employs three main questionnaires directed for households and members who are regular residents: women from 12 to 49 years old, children younger than 5 years old, and one member of the household who is older than 15 years old. The main themes of the survey allow to obtain variables corresponding to the next general subjects:

a. Household characteristics, including access to health insurances and social programs
b. Social and demographic characteristics
c. Measurement of iron in blood (anaemia) for children and women
d. Acute respiratory illnesses (ARI) in children
e. Children's early development and anthropometric measures
f. Mental health in adults

For this research, the data is constructed by pooling the annual data sets of the six year period 2014-2019, resulting in different data sets depending on the dependent variable or the corresponding household member under analysis, whether it is children or adults.

The final data contains observations from all 25 regions of the country, however not all districts. Nevertheless, given that information is georeferenced at a cluster level, the sample is restricted based on the distance to the closes mine, which constitutes a useful criteria since geographical limits of territory do not prevent effects from pollution reaching districts in which mining does not take place.

4.1.2 Mining information

The main sources for mining information are annual publications of the Ministry of Mining and Energy of Peru, which consist of maps locating the main producing formal mining units in the country. Each publication contains information of the previous years, therefore the files used correspond to those published from 2015 to 2020.

For the whole period we have information of 825 mining units across the country (104 to 151 units active each year). The variables contained in the dataset are the following:

- Region, province and district where the mining unit is located
- Operating company
- Main products extracted
- Type of mining (superficial, underground, or refining and smelting operations; as well as the distinction between metallic and non-metallic mining)
- Geographical coordinates (except for 5 observations).

To complete this information, we make use of public statistics from the transparency portal of the Ministry of Finance in Peru (MEF) to include financial information of royalties received by local governments where there are mining operations. This information is relevant because a share of extraction revenues is transferred to municipalities, even if they are not a mining district, but are part of a mining region or province. On many occasions, these resources constitute a large portion of local governments' budget and its availability can impact public health spending and people's health status as well.

4.1.3 Other sources

To compliment the analysis, we use information of social conflicts from two sources, the annual reports of the Ombudsman Office in Peru and information collected by the Latin American Observatory of Mining Conflicts (OCMLA). This information is not systematized, and therefore not included in the quantitative analysis, however, is helpful to understand some of the results. The social conflict reports from the Ombudsman Office are a monitoring instrument prepared to provide preventive information for the State, companies, and civil society in Peru. They collect information from monitoring actions by 28 decentralized offices in the country, as well as secondary information (Defensoría del Pueblo, 2019a, p.2). On the other hand, information from the OCMLA is managed by a collective of organizations who focus on providing alternatives to mining and advocating for affected communities. In that sense, information from the two sources cannot necessarily be integrated, but each can provide information on further elements that can account for health status in communities.

4.2. Variables

4.2.1 Outcome variables

Children health status will be seen through anthropometric measures of height, weight and hemoglobin levels in blood to check for **stunting, underweight and anemia**, following Assaf et al. (2018, p.6) and Orihuela et al. (2019). These variables are defined according to the number of standard deviations (SD) below the reference child growth standards mean value of the WHO, following the DHS guidelines (Croft et al., 2018, p.11.50). In that sense, the levels of stunting or underweight are severe when the z-score is below 3 SD of mean value and moderate when it is below 2 SD.

For the case of anemia, the DHS guidelines indicate that there is anemia when the hemoglobin count is less than 11 grams per decilitre. In the survey, this measure is already adjusted for altitude, as people residing above 1000 meters above sea level (m.a.s.l.) have higher level of hemoglobin (Croft et al., 2018, p.11.39).

Additionally, it is of interest to check for the presence of **acute respiratory illnesses (ARI)** in children, because as Saha et al. (2011) explained, literature has stablished a clear link between exposure to particulate matter to respiratory diseases. An important aspect to note is that ENDES only gives information of symptoms that could indicate the presence of diseases and not the illnesses per se; specifically, a children is considered to have an ARI if he or she had a cough, short and rapid breaths and a blocked chest and runny nose, in the previous two weeks. These variables are used as indicators of non-communicable diseases, which have been associated with pollution of air and water and chemical exposure (Landrigan, 2018). In this case, a variable is defined and takes the value of 1 when there is presence of symptoms of ARI.

Finally, a group of variables to represent **mental health** are used to indicate the presence of depression. This variable is included recalling Cartwright (2016) examples of what could represent an eco-risk, as well as literature that has associated psychological and emotional impacts of changes in the environment, related to fear of future risks, stress and adaptation (Perera, 2017, p.144). Following authors that have used the ENDES survey in Peru to detect the incidence of depression in adults (Martina et al., 2017; Baldeón Martínez et al., 2019), 9 variables from the questionnaire are used to obtain a score which can go from 0 to 27[3]; according to these studies for self-reported information on depression symptoms, a score of 0-9 would indicate no depression and a score of 10 and higher is an indication of presence of depression. In that sense, a dummy variable is defined with the value of 1 when the person presents depression.

4.2.2 Independent variables

The main variable used to understand the changes in health status is the **exposure** to mining activities, defined considering the distance between the cluster where household are located and the closest mining unit. This variable will represent the exposure of households to mining pollution; recalling Saha et al. (2011), proximity-based measures are reliable for representing health hazard exposure when there are no objective measures of pollution (Saha et al., 2011, p.142). However, exposure has also been used to see the effect of mining on socioeconomic variables (Orihuela et al., 2019, p.20). As it was explained, geographical coordinates are provided by both ENDES and MINEM data.

Following the strategies in Orihuela et al. (2019), Saha et al. (2011) and Von der Goltz and Barnwalb (2019), whether the exposure is more or less direct is represented by a dummy variable which takes the value of 1 when household clusters are located within 5 kilometres from mines and 0 otherwise. As mentioned, the sample is restricted to 100 kilometres within mine sites to avoid the possibility of other confounding factors.

To account for effects that can come from major revenues from mining, a variable indicating the royalties received by municipalities at a district level is included along the distance variables for a second type of specification, explained later on. To have some more clarity in this relation, in principle, the redistribution scheme of mining revenues allows subnational governments in Peru to access part of the income tax from companies; as the scheme is location based, those districts where mining operations take place are entitled to higher percentages of royalties, observing large differences with neighbouring districts. As it is currently defined, the resources coming from the income tax of mining are intended for increasing the availability of basic services and for maintenance of investment related (Ministerio de Economía y Finanzas, n.d.), therefore higher royalties could be related to better health provision and status. On the other hand, since this variable also represents the amount of operations, a major intensity of activities can at the same time reflect possible larger pollution.

Two groups of variables are used to account for differential effects. On one hand a variable indicating whether the activities in the closest mine are metallic or non-metallic will allow to understand if either of them results on worse or better health indicators. Second, a categorical variables of **ethnic** identity is found in the ENDES survey through the question "Considering your ancestors and customs, how do you identify?", for which there are 8 options (Quechua, Aymara, indigenous from the Amazon, part of an originary indigenous community, afro-peruvian, white, *mestizo*, or other). This variable should help answer one of the research questions regarding differences in health outcomes, with respect to particular groups; one limitation is that it is only available for the period 2016-2019.

[3] The nine questions in the survey ask whether the person has felt unmotivated, depressed, has presented problems for sleeping, tiredness, altered appetite, lack of attention, trouble moving, done any self-harm or has felt unwell, over the past 2 weeks. Each consists of a scale from 0 to 3 points and together add up to 27 points.

4.2.3 Control variables

Since the differences in health status variables might also be dependent on household, individual and cluster characteristics, it is important to include other observable factors into the analysis. In principle, income might be related with different health outcomes at the household level, however since the ENDES does not provide specific information on that regard, a wealth index is used, which indicates the wealth quintile the household is located in. Similarly, having access to health insurance and social programs, which promote health care services use could be confounding factors, therefore it is necessary to include them.

Other important variables to control are specified in the table below; regarding the household characteristics, the variables included are size of the household and infrastructure of the dwelling which can influence health status; e.g. the type of cooking fuel and kitchen infrastructure can also contribute to indoor pollution. Just as well, health variables of parents are controlled for analysing health status in children, since conditions as anemia in mothers, for example, could be related to higher probabilities of children having it as well; according to previous studies, it could be a result of a genetic transmission, as well as a sign of awareness of anemia and prevention. (De Pee et al., 2002; Colomer et al., 1990).

Control variables

- Household level: wealth index, access to health insurance, access to social programs, size of household, infrastructure of the dwelling
- Individual level: sex, age, education level, parent's characteristics (for the case of children's indicators)
- Cluster level: location (rural/urban), altitude

4.3. Sample description

The sample is comprised of 158,446 households[4] distributed across the six years, which are observations with a complete survey and whose cluster is georeferenced (493 observations from 2019 from the original sample had to be dropped under this criteria). The sample has been restricted only to include those households located within 100 kilometres from the closes mining sites, following Orihuela et al. (2019, p.22).

Table 4.2
Sample composition

	Total sample	5km	5-100 km
Number of households	158,446	4,168	154,278
% of sample		2.6%	97.4%
Children under 5 for stunting, underweight and anemia analysis	89,787	2,453	87,334
Children under 5 for ARI analysis	92,855	2,561	90,294
Adults for mental health analysis	147,508	3,799	143,709
Distance to closest mine (mean)	38.8	2.6	39.8

[4] The initial sample consisted of 200,914 households from clusters located within a distance of 0,19 to 7,520 kilometres to the closest mine

	Total sample	5km	5-100 km
Mining units paired with households			
2014	76	11	74
2015	112	23	106
2016	119	21	116
2017	110	23	108
2018	116	31	109
2019	118	32	109

Source: Author's elaboration with ENDES data

The main descriptive statistics of the outcome, exogenous and control variables only for households within 100 km from the closest mine are shown in Table 4.3.

Table 4.3
Main descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Children					
Stunting (1=yes)	88,729	13.31%	0.34	0	1
Underweight (1=yes)	88,729	2.76%	0.16	0	1
Anemia (1=yes)	81,286	33.31%	0.47	0	1
Hemoglobin level adjusted by altitude (g/dl)	81,286	113.51	11.45	15	173
Height/age SD (according to WHO)	88,729	-86.22	103.94	-565	597
Weight/age SD (according to WHO)	88,729	-6.45	106.24	-537	493
Acute Respiratory Infection	92,855	4.70%	0.21	0	1
Age	91,914	2.06	1.39	0	5
Sex (1=male)	92,855	51.16%	0.50	0	1
Mother has anemia (1=yes)	88,959	21.37%	0.41	0	1
Mother's highest educational level					
No education	92,855	1.85%	0.13	0	1
Primary education incomplete	92,855	10.00%	0.30	0	1
Primary education complete	92,855	10.47%	0.31	0	1
Secondary education incomplete	92,855	29.82%	0.46	0	1
Secondary education complete	92,855	16.04%	0.37	0	1
Higher education	92,855	31.82%	0.47	0	1
Mother's age at birth	91,914	28.15	6.89	12	49
Adults (mental health)					
Depression index (0-27)	147,508	2.83	4.26	0	27
Presence of depression	147,508	7.47%	0.26	0	1
Sex (1=male)	147,508	42.94%	0.49	0	1
Age	147,508	40	17.32	15	97
Education					
No education	147,508	5.74%	0.23	0	1
Primary education incomplete	147,508	18.03%	0.38	0	1
Primary education complete	147,508	6.48%	0.25	0	1
Secondary education incomplete	147,508	16.07%	0.37	0	1
Secondary education complete	147,508	25.99%	0.44	0	1
Higher education	147,508	27.66%	0.45	0	1
Married or living together (1=yes)	147,508	65.06%	0.48	0	1
Person is head of household and female (1=yes)	147,508	15.32%	0.36	0	1

Variable	Observations	Mean	Std. Dev.	Min	Max
Household characteristics					
Size of households	158,446	4.1	1.9	1	21
Number of women	158,446	1	0.8	0	7
Number of children under 5	158,446	0.7	0.7	0	10
Ethnic Identity (2016-2019)					
Quechua	85,929	34.24%	0.47	0	1
Aymara	85,929	4.00%	0.20	0	1
Native from the Amazon	85,929	0.88%	0.09	0	1
Originary indigenous community	85,929	0.67%	0.08	0	1
Afro descendent	85,929	8.31%	0.28	0	1
White	85,929	13.25%	0.34	0	1
Mestizo	85,929	30.22%	0.46	0	1
Other	85,929	3.17%	0.18	0	1
Do not know	85,929	5.27%	0.22	0	1
Participates in any social program	158,436	33.53%	0.47	0	1
Any member has health insurance	158,446	74.70%	0.43	0	1
Wealth quintile					
q1=poorest	158,446	28.17%	0.45	0	1
q2=poorer	158,446	23.16%	0.42	0	1
q3=middle	158,446	19.04%	0.39	0	1
q4=richer	158,446	16.24%	0.37	0	1
q5=richest	158,446	13.39%	0.34	0	1
Separate room for kitchen	143,447	84.59%	0.36	0	1
Cooking fuel					
electricity	154,999	0.46%	0.07	0	1
lpg	154,999	67.55%	0.47	0	1
natural gas	154,999	3.06%	0.17	0	1
kerosene	154,999	0.03%	0.02	0	1
coal, lignite	154,999	0.07%	0.03	0	1
charcoal	154,999	0.38%	0.06	0	1
wood	154,999	25.59%	0.44	0	1
straw / shrubs / grass	154,999	0.44%	0.07	0	1
agricultural crop	154,999	0.02%	0.01	0	1
animal dung	154,999	2.34%	0.15	0	1
other	154,999	0.04%	0.02	0	1
Kitchen has a mechanism to eliminate smoke	64,047	40.88%	0.49	0	1
Anything done to water to make safe to drink	158,446	91.86%	0.27	0	1
Household location (1=urban; 0=rural)	158,446	65.79%	0.47	0	1
Cluster characteristics					
Located close to mine (5km)	158,446	2.63%	0.16	0.0	1.0
Cluster altitude	158,446	1,638	1,513	3	5,037
Closest mine is metal mining	158,446	0.61	0.5	0	1
District royalties from mining (PEN)	124,682	4,836,746	10,800,000	0	123,000,000

4.4.Empirical approach

This research will use a quantitative method to explore the health effects of mining in the context of minor environmental protection. The following econometric model is defined to relate health status variables to the exposure to mining activities:

$$Health\ status_{idt} = \alpha + \beta mining_{ct} + X'_{idt}\delta + D'_{ct}\gamma + \theta_d + \vartheta_t + \varepsilon_{idt} \qquad \text{(eq.1)}$$

Health status$_{idt}$ represents the outcome variable for every individual (child or adult) *i* in each district *d* for a given year *t.* The main variable is *mining*$_{ct}$ and refers to the exposure to mining activities, represented as the distance from each cluster of household *c* to the closest mining operations; this variable is defined as a dummy which takes the value of 1 if a cluster of households is located within 5 km to the closest mine. β represents the change in the health condition variables (stunting, underweight, being anemic or having an ARI, in the case of children or depression, in adults) in response to being close to mining activities.

Household and individual characteristics are controlled in the vector X'_{idt} and cluster characteristics, are represented by vector D'_{ct}. These variables are important to control for possible channels that can affect health such as sanitation or indoor pollution and should help address time-variant omitted variables that can influence the results on health. District fixed effects θ_d and time fixed effects ϑ_t are included to account for unobservable characteristics, and ε_{idt} is defined as the error term.

District fixed effects address the time invariant unobservables that can represent, for example, relations between municipalities and companies or institutions around extraction, like different perceptions towards the activity or the use of revenues by local governments. Also, following the considerations by Orihuela et al. (2019), fixed effects address the possibility of spatial correlation, due to the nature of geographical data. Since observations do not correspond to geographical units -i.e. provinces or regions- it is important to control for variation at the smallest geographical level (Orihuela et.al 2019, p.24). Although the data is grouped in clusters, cluster fixed effects could take away variation in the data; additionally, estimations show smaller standard errors when using district fixed effects.

A second specification is defined to account for additional mechanisms that can affect health. Since previous research highlights more severe health consequences from exposure to heavy metals, a variable that indicates whether the mine in question is metallic or non-metallic is included. Second, a variable reflecting the amount of mining royalties is added to the equation; this can result ambiguous because major revenues can imply better health services, but at the same time, major production could equate to higher levels of pollution.

$$Health\ status_{idt} = \alpha + \beta\ mining_{ct} + \partial\ metal_{ct} + \gamma\ royalties_{dt} + X'_{id}\delta + D'_{ct}\gamma + \theta_d + \vartheta_t + \varepsilon_{idt} \qquad \text{(eq.2)}$$

In equation 2, *metal*$_{ct}$ indicates whether the closest mine is of metallic operations and ∂ translates into the changes in health results when there are metallic operations, compared to non-metallic. The variable *royalties*$_{dt}$ refers to the income (in logarithms) received by local governments (districts) from the income tax generated by mining operations; these amounts are proportional to companies' production, therefore can indicate the intensity of mining in a given period. γ captures the effects of a 1 percent increase in mining royalties on the health indicators.

Finally, to identify possible differential effects related to ethnic identities, the second econometric specifications is broadened to include ethnic identity dummies. Given the variable availability, this is tested only for the period 2016-2019.

From the descriptive statistics in The main descriptive statistics of the outcome, exogenous and control variables only for households within 100 km from the closest mine are shown in Table 4.3.

Table 4.3, we can appreciate that the largest ethnic identity group within 100 kilometres from mining sites is *quechua,* followed by *mestizo* and white population. Unfortunately, most identity groups have very few observations and therefore are grouped into one category to see if there are differential effects across these minorities. The categories considered for this part of the analysis are: i) *quechua*; ii) *mestizo;* iii) white, and iv) others, which includes the identities defined as afro-descendent, *aymara, native from the Amazon, originary indigenous community* and others.

Recalling the research hypothesis, it is expected to find a significant relation between health indicators and a major exposure (minor distance) to mining activities, given higher chances to be faced with a more polluted environment. This departs from the contradiction found among policies which promote the expansion of extraction, while neglecting social and environmental standards and protection.

Chapter 5
Results

In this section we will have a look at the estimation results, regarding the effects of exposure to mining activities on health indicators. We start with the first specification results for the selected health variables for children -stunting, underweight, hemoglobin count, anemia and acute respiratory infections- and adults -depression incidence. Then we move to the second specification to see any changes if taking royalties and the presence of metallic mining into account. Following, the analysis focuses on the differential effects across ethnic identities for the last three years of the sample and finally, different statistics related to the presence of social conflicts are included to try to explore further concepts of health, related to the theoretical framework.

First, Figure 5.1, Figure 5.2 and Figure 5.3 show slightly lower incidence of stunting, underweight and anemia in children from households located within 5 kilometres from the closes mine, versus those further away. A similar inference can be mane from looking at Figure 5.4, where children in households close to mines have a somewhat higher incidence of ARI. These observations agree with the research hypothesis, however, the estimation results in Table 5.1 differ to some extent, since only two indicators show a significant relation between the dependent variables and exposure to mining.

Table 5.1
Distance effect on height to age, weight to age, hemoglobin level, anemia and acute respiratory infections (specification 1)

	(1) **Height to age**	(2) **Weight to age**	(3) **Hemoglobin**	(4) **Anemia**[(1)]	(5) **ARI**[(2)]
5 km to closest mine	-7.540**	-2.410	-0.890**	0.00959	0.0200
	(3.522)	(3.713)	(0.406)	(0.0112)	(0.0415)
10 km to closest mine	0.271	-3.422	0.178	0.271	0.0129
	(2.102)	(2.216)	(0.242)	(2.102)	(0.0250)
Observations	82,558	82,558	76,036	75,869	79,580
R-squared	0.057	0.032	0.175	0.112	0.0043
Number of districts	1,159	1,159	1,158		

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

[(1), (2)] Marginal effects

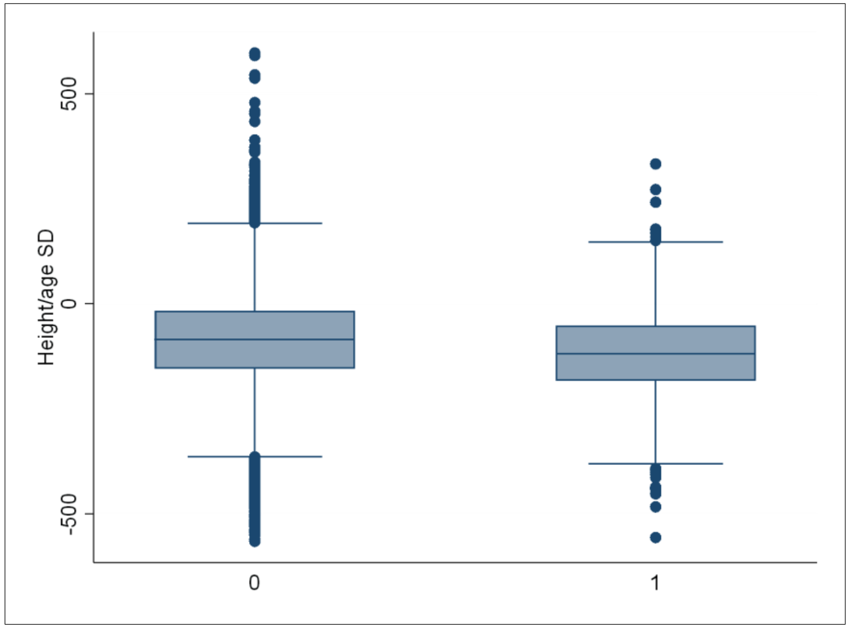
[(3)] Regressions have been controlled for: age and sex of children; mother's education, age at birth, and health status; size of household, beneficiaries of social programs and health insurance, wealth quintile, dwelling infrastructure related to indoor pollution, place of residence, altitude and year dummies (complete results are shown in the Appendix)

It is observed that children exposed to mining more directly have a height to age z-score of 0.075 SD[5] less than those located further away. In the case of hemoglobin count, children in households close to a mining site have an hemoglobin level 0.089 grams per decilitre (g/dl)[6], below households located beyond 5 km from mine sites. The model was also tested considering a larger distance (10 kilometres); however, the results are not statistically significant.

[5] Due to data format, height to age and weight to age must be divided by 100 for interpretation.

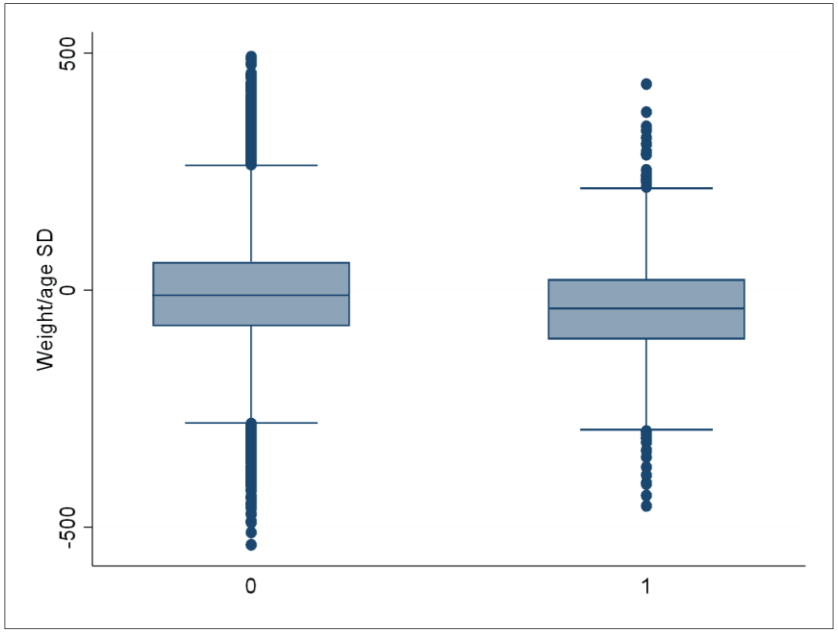
[6] The data presents the hemoglobin variable minus 1 decimal, for interpretation it is divided by 10

Figure 5.1
Height to age relative to distance from mines



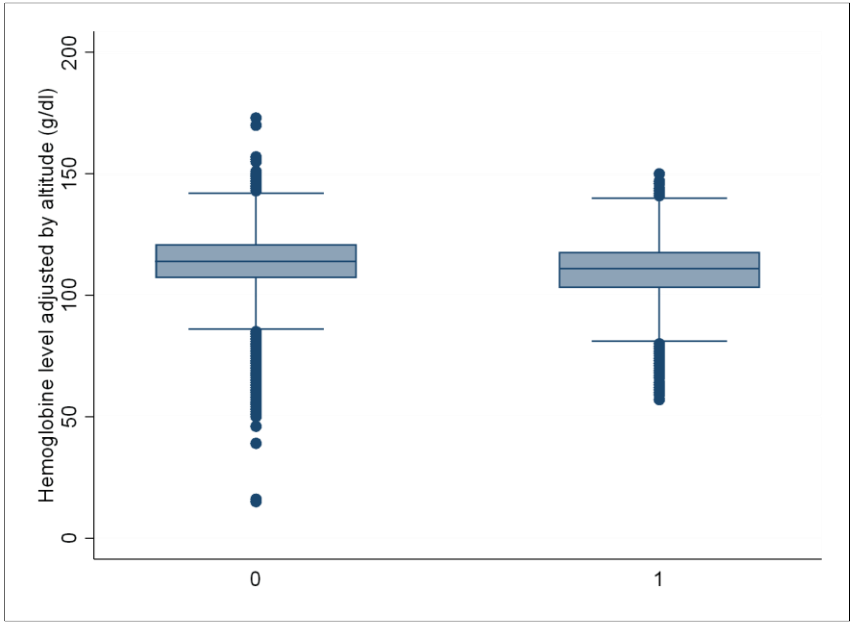
Source: Author's elaboration

Figure 5.2
Weight to age relative to distance from mines



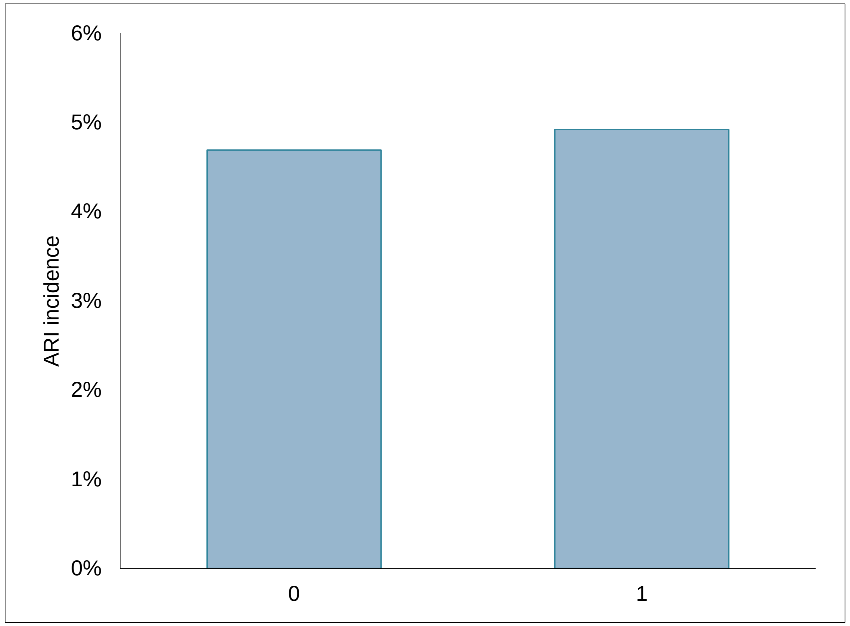
Source: Author's elaboration

Figure 5.3
Hemoglobin level relative to distance from mines



Source: Author's elaboration

Figure 5.4
ARI incidence relative to distance from mines



Source: Author's elaboration

For the second specification, results are similar, however show larger effects. Children more exposed to mining have a hemoglobin count of 0.116 g/dl below those who are further than 5km to the closest mining site. Having metallic operations and mining royalties do not have a significant effect on the hemoglobin count, which seems consistent with previous research, which has evidenced a clearer relation between pollution from heavy metals and lower hemoglobin levels in blood. In the case of this variable, it is found that possible alternative channels through which health could be affected by mining (major financial resources) have no statistical significance; in other words, mining financial resources are not necessarily compensating for health loses.

Table 5.2
Distance effect on height to age, weight to age, hemoglobin level, anemia and acute respiratory infections (specification 2)

Variables	(1) **Height to age**	(2) **Weight to age**	(3) **Hemoglobin**	(4) **Anemia**(1)	(5) **ARI**(2)
5 km to closest mine	-8.927**	-4.429	-1.158***	0.0162	-0.0119
	(3.734)	(3.936)	(0.436)	(0.0111)	(0.0454)
Metal mining	4.117***	4.774***	-0.0433	0.00483	0.00220
	(1.536)	(1.620)	(0.179)	(0.00475)	(0.0189)
District royalties (logarithm)	0.413	0.802*	0.0172	-0.000796	0.00514
	(0.437)	(0.460)	(0.0508)	(0.00120)	(0.00532)
10 km to closest mine	1.240	-1.844	-0.0881	0.00317	0.0237
	(2.399)	(2.529)	(0.280)	(0.00715)	(0.0282)
Metal mining	4.144***	4.746***	-0.0439	0.00488	0.00249
	(1.537)	(1.620)	(0.179)	(0.00475)	(0.0189)
District royalties (logarithm)	0.380	0.787*	0.0129	-0.000736	0.00500
	(0.437)	(0.460)	(0.0508)	(0.00120)	(0.00532)
Observations	63,502	63,502	58,478	58,296	60,343
R-squared	0.056	0.031	0.176	0.112	0. 004
Number of districts	1,041	1,041	1,040		

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

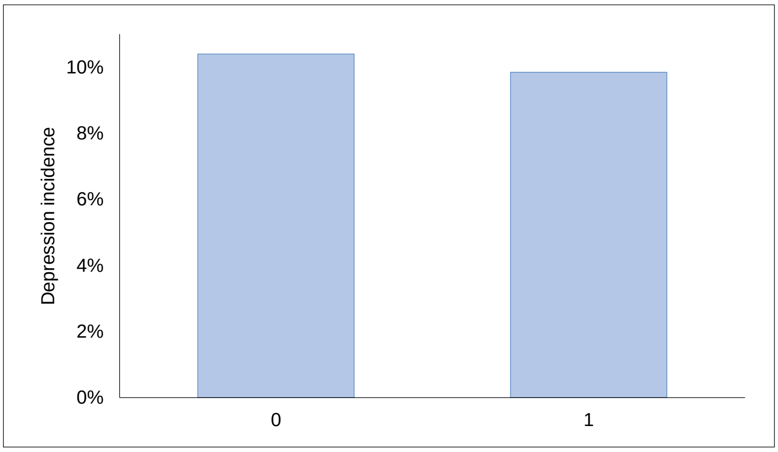
(1), (2) Marginal effects

(3) Regressions have been controlled for household and individual characteristics: age and sex of children, mother's education, mother's age at birth, mother's health status, size of household, beneficiaries of social programs and health insurance, wealth quintile, dwelling infrastructure related to indoor pollution, place of residence, altitude and year dummies (complete results are shown in the Appendix)

Results are also larger for the heigh to age variable; children more exposed to mining have a height to age z-score of 0.089 SD below those who are further than 5km to the closest mining site. Regarding the variables weight to age, anemia and ARI, the effects from direct exposure remains not significant, but underweight and stunting appear to have a positive relation with the presence of metallic mining. Results show that it generates a higher height to age and weight to age z-score by 0.041 and 0.047 SD, respectively, compared to non-metallic mining sites. Additionally, it is observed that a 1 percent increment in mining royalties improves growth conditions in children due to an increase of 0.008 SD in the weight to age z-score. These results could inform of a possible negative effect of mining for the stunting indicator, but metallic mining could also generate positive contributions for stunting and underweight indicators. Perhaps this relates to better behaviour from companies towards communities, unfortunately, necessary information to draw conclusions is not available in the data. At the same time, underweight is affected by royalties, which can indicate that the revenues from metallic mining are canalized for health investment. As it was mentioned, revenues from mining distributed to local districts are intended to improve service provision, hence it makes sense to find a positive relation among them.

For the case of depression incidence in adults, Figure 5.5 shows a higher prevalence in households located further away from mine sites, opposite to what was expected. This also agrees with the results in Table 5.3, since there is not a significant effect of distance on the chosen mental health indicator, when considering a 5 kilometre distance. However, testing a 10-kilometre distance from the closest mine, the results indicate that those directly exposed to mining have 3.41 percentage points less chances to have depression, compared to households locates further than 10 kilometres to the closes mine.

Figure 5.5
Depression incidence relative to distance from mines



Source: Author's elaboration

Table 5.3
Marginal effects of distance effects on depression incidence (specification 1)

	Distance to mine: 5 km		Distance to mine: 10 km	
	(1)	(2)	(3)	(4)
	Depression(1)	**Depression index**	**Depression(2)**	**Depression index**
Household is close to mine	0.0161	0.156	-0.0341**	-0.0889
	(0.0278)	(0.125)	(0.0161)	(0.0711)
Observations	131,116	133,912	131,116	133,912
R-squared	0.0679	0.069	0679	0.069
Number of districts		1,167		1,167

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

(1), (2) Marginal effects

(3) Regressions have been controlled for household and individual characteristics: age and sex of children, mother's education, mother's age at birth, mother's health status, size of household, beneficiaries of social programs and health insurance, wealth quintile, dwelling infrastructure related to indoor pollution, place of residence, altitude and year dummies (complete results are shown in the Appendix)

We can observe some changes in the results for the second specification. In principle, results show that being close to a mining site (within 5 kilometers) would increase the depression index by 0.26 points, meaning there are higher chances of a person reporting some depression symptoms. When looking at a distance of 10 kilometers, the decrease in depression is slightly higher, compared to the first specification; results indicate that for people who are more exposed to mining there is a depression incidence of 4.04 percentage points less than for those located further away.

Table 5.4
Marginal effects of distance effects on depression incidence (specification 2)

	Distance to mine: 5 km		Distance to mine: 10 km	
	(1)	(2)	(3)	(4)
	Depression[(1)]	**Depression index**	**Depression**[(2)]	**Depression index**
Household is close to mine	0.0216	0.256*	-0.0404**	-0.0889
	(0.0297)	(0.134)	(0.0183)	(0.0820)
Metal mining	-0.0101	-0.0304	-0.0113	-0.0334
	(0.0116)	(0.0518)	(0.0115)	(0.0518)
District royalties (logarithm)	-0.000357	-0.0212	-0.000324	-0.0205
	(0.00324)	(0.0154)	(0.00323)	(0.0154)
Observations	101,814	104,098	101,814	104,098
R-squared	0. 0696	0.072	0.0697	0.072
Number of districts		1,052		1,052

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[(1), (2)] Marginal effects

[(3)] Regressions have been controlled for household and individual characteristics: age and sex of children, mother's education, mother's age at birth, mother's health status, size of household, beneficiaries of social programs and health insurance, wealth quintile, dwelling infrastructure related to indoor pollution, place of residence, altitude and year dummies (complete results are shown in the Appendix)

It could be speculated that an improvement in mental health responds to a perception of major opportunities from being closer to a mine unit; it is difficult to confirm this because there is no significant relation to the amount of revenues received at a district level, but one possible way to understand the results is that depression incidence can be related to expectations, but not to material benefits linked to major resources necessarily.

Some challenges in this case are that we have no information on household mobility; perhaps this type of variables could give validation to the argument that moving close to a mining sites is motivated by expectations. Additionally, the depression index is constructed with variables that refer to symptoms in the two weeks previous to the interview, and it could be that this does not capture other components of mental health of individuals but also of communities as a whole. Recalling some of the literature regarding the conceptions of health, it is important to acknowledge that the data under analysis is constructed under traditional scientific ways and that it is necessary to interpret it in a culturally focus way.

Now, regarding the second research question on differences across ethnic identities, when including ethnic dummies into the model, there are slight changes in the results. The reference category is the *mestizo* identity because it is one of the largest group and we are interest in seeing whether there are differential effects with respect to indigenous population, including the *quechua* identity. The indicators of stunting and hemoglobin levels in blood maintain a negative relation with the exposure variable and confirm that children in households which are closer to mining sites have slightly worse health indicators.

Table 5.5
Distance effect on height to age, weight to age, hemoglobin level, anemia and acute respiratory infections across ethnic identities

	(1) Height to age	(2) Weight to age	(3) Hemoglobin	(4) Anemia[(1)]	(5) ARI[(2)]
Household is close to mine (5 km)	-7.880*	-4.270	-0.883*	0.0144	-0.0237
	(4.296)	(4.525)	(0.498)	(0.0130)	(0.0519)
Quechua identity	1.157	1.577	0.127	-0.00864**	0.0433***
	(1.273)	(1.341)	(0.146)	(0.00403)	(0.0161)
Identifies as white	0.762	-1.196	0.318*	-0.00452	0.00728
	(1.549)	(1.631)	(0.179)	(0.00475)	(0.0190)
Other identity	-0.222	0.112	-0.168	0.00207	0.00519
	(1.349)	(1.421)	(0.155)	(0.00413)	(0.0173)
Metal mining	4.695**	4.800**	-0.0290	0.00843	0.00288
	(2.011)	(2.118)	(0.231)	(0.00646)	(0.0254)
District royalties (logarithm)	-0.373	-0.0659	0.0708	-0.00164	0.00307
	(0.533)	(0.562)	(0.0614)	(0.00144)	(0.00675)
Observations	49,757	49,757	45,965	45,792	45,912
R-squared	0.054	0.030	0.175	0.110	0.0055
Number of districts	939	939	939		

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[(1), (2)] Marginal effects

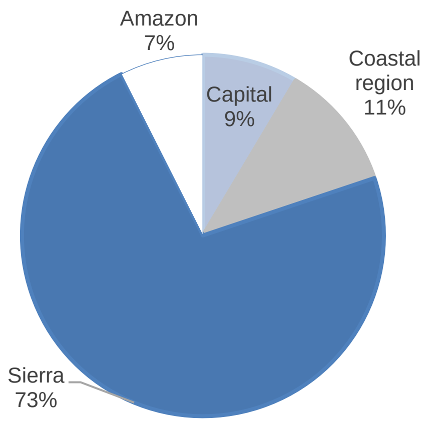
[(3)] Regressions have been controlled for household and individual characteristics: age and sex of children, mother's education, mother's age at birth, mother's health status, size of household, beneficiaries of social programs and health insurance, wealth quintile, dwelling infrastructure related to indoor pollution, place of residence, altitude and year dummies (complete results are shown in the Appendix)

Some new information found is that in a mining context (i.e. households located within 100 km from mine sites), children from households which identify as white have a higher hemoglobin count by 0031 g/dl, in comparison to *mestizos*. Second, although there is no statistical significance for the effects of exposure on ARI and anemia, we find that in a mining contexts, children with a *quechua* identity have a lower probability of having anemia than *mestizos* by 0.86 percentage points, but a higher probability of respiratory infections by 4.33 percentage points, compared to the same reference group.

Among the factors that could explain the *quechua* groups to have less chances of having anemia, the data shows that for them, there is a higher proportion of households being beneficiaries of social programs (55% compared to 25% in the case of *mestizos*), factor which could be implicated in efforts to reduce anemia. Also, households with a *quechua* identity are located closer to metallic mining sites, compared to *mestizos*. Perhaps the resources generated by companies in charge of these projects allow for the implementation of programs that also address problems such as anemia.

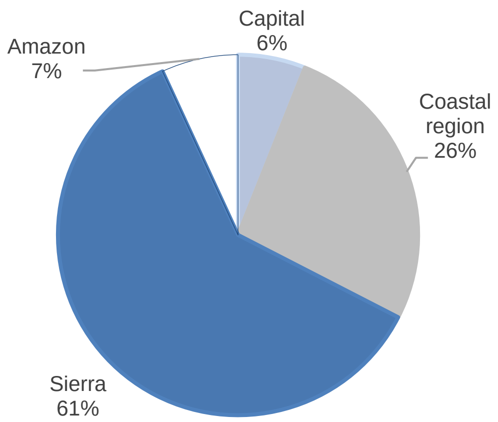
A similar explanation can be considered in observing a major incidence of respiratory infections in the case of *quechua* identities. As it was mentioned in the previous paragraph and as it is seen below, households with this identity are more exposed to metallic mining, as compared to the rest, because most of the metallic mining units are located in the *sierra* region (in the Andes). Additionally, households with a *quechua* identity have a significantly higher presence in the Andes (around 73%), while for the rest of identity categories, there is usually a larger group in coastal regions outside of the capital, but not a big majority like in the case of *quechua* in the Andes.

Figure 5.6
Location of quechua identity



Source: Author's elaboration with ENDES data

Figure 5.7
Location of metallic mining units



Source: Author's elaboration with ENDES data

With respect to the last variable of interest and considering a 5-kilometre distance as being close to a mining site, we still do not find a statistically significant effect on the incidence of depression. Nonetheless, the presence of depression is 3.14 percentage points higher for people identifying as white, compared to *mestizos*.

Table 5.6
Marginal effects of distance effects on depression incidence across ethnic identities

	Marginal effects	Standard errors
Household is close to mine (5 km)	0.0471	(0.0341)
Quechua identity	-0.00143	(0.00997)
Identifies as white	0.0314**	(0.0157)
Other identity	-0.00339	(0.0135)
Metal mining	-0.00512	(0.0148)
District royalties (logarithm)	-0.00339	(0.00364)
Observations	76,328	
Pseudo R-squared	0.0714	

*** p<0.01, ** p<0.05, * p<0.1

(1) Regressions have been controlled for household and individual characteristics: age and sex of children, mother's education, mother's age at birth, mother's health status, size of household, beneficiaries of social programs and health insurance, wealth quintile, dwelling infrastructure related to indoor pollution, place of residence, altitude and year dummies (complete results are shown in the Appendix)

It was expected to find significant results on the incidence of depression for less dominant groups, such as indigenous or *quechua*, but since the results do not envision that, it raises the question of why this is the case. We can consider two possible ways of understanding.

First, we can think about expectations, which was already mentioned. The data shows that the mean amount of royalties, if the sample is divided by depression incidence, is higher when there is no reported depression (4,578,431.70 versus 3,545,678.80 Peruvian soles in the case of reported depression), which could indicate that mining also generates a sense of opportunities and this could be related to minor depression. In this context, it is worth recalling the definition of "extractive imperative" (Arsel, Hogenboom and Pellegrini, 2016) to make sense of the hypothesis of associating a larger amount of extraction to higher expectations of development.

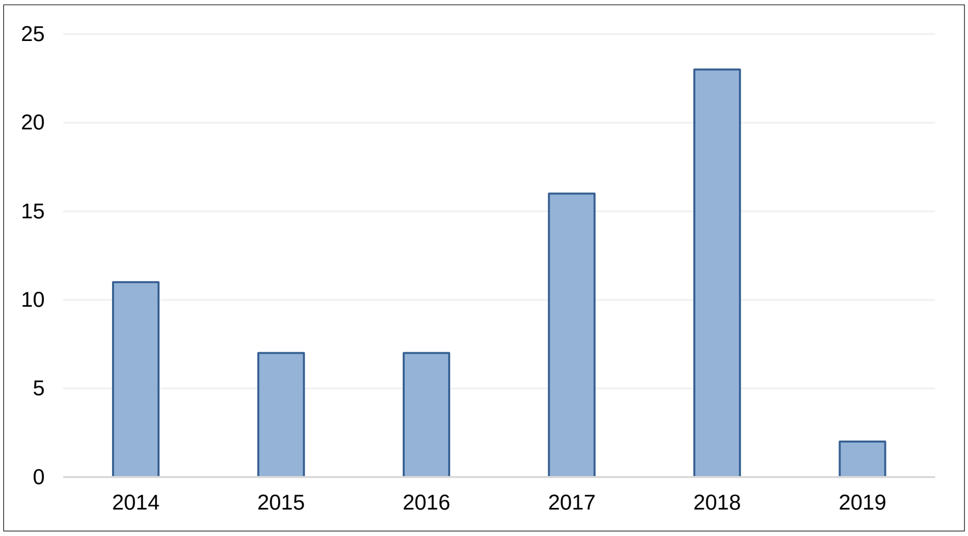
From another point of view, however, the results on depression incidence can make us wonder, whether this is a case of slow violence, and there are certain health conditions which are no longer visible. Integrating the contributions by Nixon (2011) we could acknowledge that depression and mental health in general could become disregarded if certain problems associated with mining have been understood as normal for certain groups of people (identities in this case). This is a question which would require more information to be answered, however we can look at previous research regarding inequalities related to ethnicity to justify this need. For example, following the work of Acemoglu et al. (2002), Barrón (2008) argues that racial inequality in Peru is a persistent result of historical inequality and exclusion which played in benefit of elites (composed mostly of white and mixed population – *mestizos*). According to this thesis, places like Peru, which were densely populated by indigenous communities were prompt to the settlement of extractive institutions, which resulted into forced labour of indigenous population, resource grabbing, migrations towards mining activities in replacement of agriculture and exclusion from provision of basic services (Barrón, 2008, pp. 52-54). If we agree with this argument, we could conclude that health disparities now, also respond to a historical inequality, in which mostly *quechua* population has being more exposed to mining activities, and therefore it is expected to observe that health status differs for *quechua* identities, but that disparities might be somehow invisible.

All things considered, it results challenging to associate health results with respect to ethnic identities and one should be cautious to generalize around them. For one thing, there is hardly a unique representation of them within geographic levels, despite observing majorities in certain regions, but most importantly, ethnic identification in Peru has a complex background of class, race, status, among other intersections. For instance, Sulmont (2011) and Thorp, Caumartin and Gray-Molina (2006), when studying social mobilizations across Latin America realized that in the case of Peru social struggles are mostly class based, rather than founded on ethnicity, partly due to the erasure of cultural identities and the pressure of assimilation; in other words, as indigenous identities have been associated with backwardness, coming out of poverty has also meant abandoning original cultural expressions and ethnic identity as a strategic decision to avoid discrimination, therefore identity can be thought as fluid rather than a fixed notion. Accordingly, when the 2017 national census included the variable of self-identification, there was a lot of discussion regarding the best way to address this question, since it was necessary to acknowledge the still prevalent rejection of the category "indigenous", given its links to exclusion and discrimination, despite the existence of strong cultural identities (Sanchez Velasquez, 2016).

Up until now, results have been mixed, however to some extend have coincided with the research hypothesis, since there are certain health indicators that related negatively to exposure to mining. In spite of that, seeing that many variables of interest do not related significantly to mining, it is challenging to attribute direct impacts to the expansion of activities in Peru. This also responds to different channel through which mining can be affecting communities. While this research tried to focus on the effects that can come from an exposure to negative externalities, these do not happen isolated from the effects that can come from major revenues for local governments, a more or less direct relation between companies and communities, as well as the reaction towards it based on a positive or negative background of the sector in particular places.

With that premise, it is pertinent to also acknowledge the limitations of the data for telling us what there is to know about health. It has been mentioned in the document that conflicts could inform further understandings of health and they could be particularly useful to explore the mental health dimension. To illustrate this idea, it was found that in the period of analysis, there were 66 environmental fines related to mining in the country, and their change in number goes along the legislation changes mentioned in Chapter 2; there was a decrease during 2015 and 2016 and an increase again[7], which confirms the existence environmental risks and the relevance of protection measures.

Figure 5.8
Environmental fines in the period 2014-2019



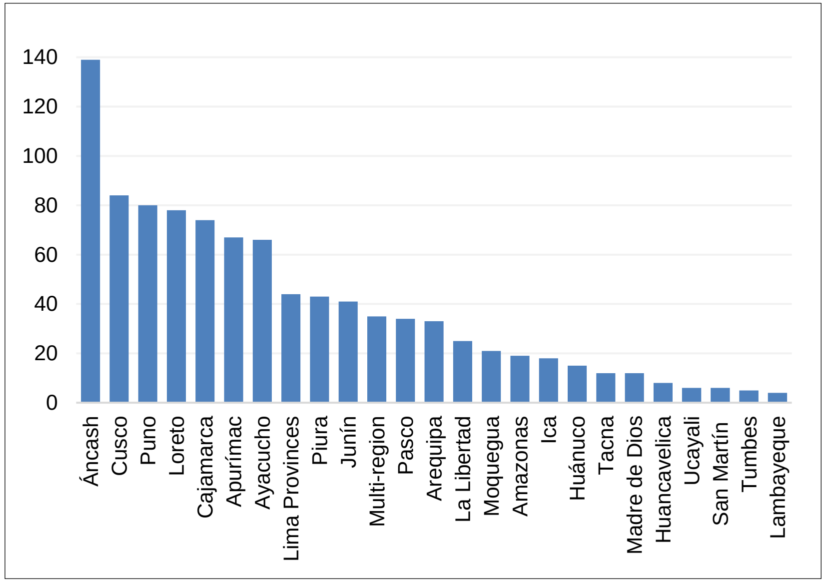
Source: Author's elaboration with OEFA (2020) data

At least for the three regions with the highest number and amount of environmental fines (La Libertad had 10; Pasco, 12, and Cajamarca, 8)[8], there is also a high incidence of social conflicts. Figure 5.9 and Figure 5.10 show that one region has a significant number of them compared to the rest, however, in perspective, for at least 50% of the regions, socio-environmental conflicts constitute more than 70% of total registered conflicts. On that note, for the top 5 regions with the highest intensity of mining activity (Cajamarca, La Libertad, Áncash, Moquegua and Arequipa), the socio-environmental conflicts as a percentage of total conflicts is at least above 60%; however some regions with less production have very high level of environmental conflicts, as well.

The figures bellow coincide with the claim that a major intensity of mining activities, could also bring higher chances of pollution and number of social conflicts, especially if there is a less strict environmental control.

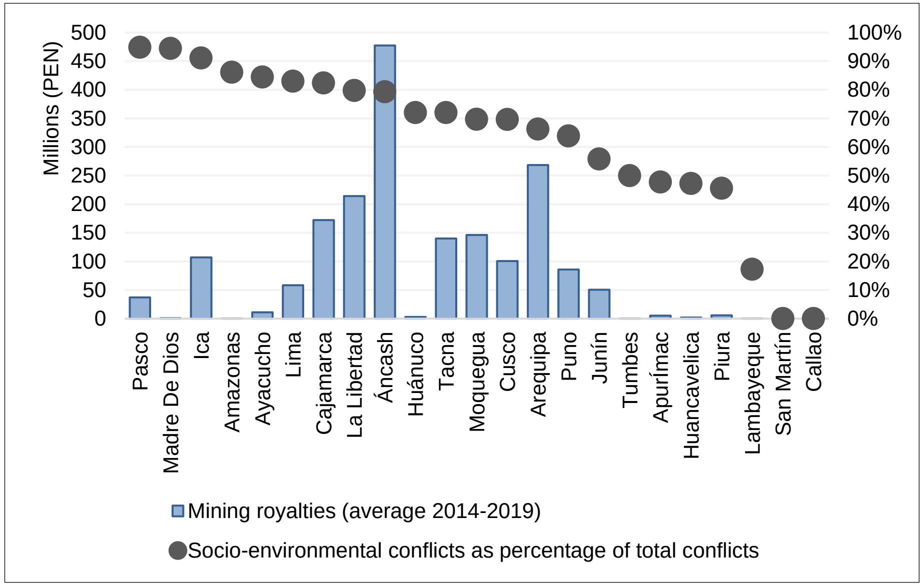
[7] The fines correspond to processes of environmental control which started in the years indicated. These processes can take years, therefore numbers in 2019, for example, could become higher.
[8] See Appendix 9 for the complete list of number and sum of environmental fines, per region

Figure 5.9
Total number of social conflicts per region in the period 2014-2019



Source: Defensoría del Pueblo (2015b,2016, 2017, 2018, 2019b, 2020)

Figure 5.10
Mining royalties and social conflicts per region in the period 2014-2019

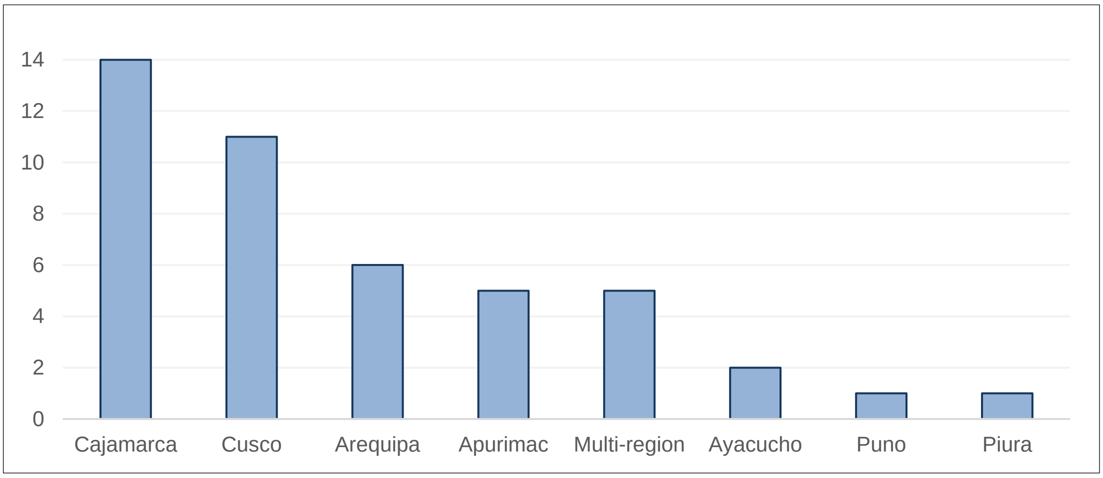


Source: Defensoría del Pueblo (2015b,2016, 2017, 2018, 2019b, 2020)

Our interest in looking at social conflicts is because they reflect the existence of eco-risks and factors which can contribute to health status, going beyond formal notions of health and illness, recalling Cartwrights (2016) and Nixon (2011). For instance, the statistics from the Latin American Observatory of Mining Conflicts (OCMLA) show that in the period 2014-2019, there have been 45 cases of criminalization of protests which the platform has registered. Most of them are in Cajamarca and Cusco, two regions which are in the top five of total number of conflicts, as well as a considerable amount of mining revenues.

Criminalization of protest is considered to be one type of attack which can influence health status -consider mental health due to uncertainty and fear. Some cases of protest criminalization include actions as arbitrary detentions and direct attacks toward people protesting, however they also include the declaration of states of emergency which can imply having constant vigilance from armed forced and higher risk of detentions.

Figure 5.11
Cases of criminalization of protest in the period 2014-2019



Source: Observatorio de Conflictos Mineros de América Latina (n.d.)

Nevertheless, even if the cases shown in Figure 5.11 are regions with a high incidence of depression, it is not possible to correlate the mental health status with the conflict statistics. But they are an invitation to wonder what the possible consequences of protest criminalization for health are, and in general, of having a negative connotation towards conflicts arising because on mining activities. Unfortunately, the amount of information and lack of systematized data does not allow to include these variables in the econometric specifications.

Chapter 6
Conclusions

This research has presented a quantitative analysis on the relation between health status and proximity to mining, as a proxy for exposure to pollution generated by the sector. This research is situated in the context of policy changes in Peru during the last decade, which promoted major investment at the stake of weakening environmental protection. The results have shown that being directly exposed to mining activities can be related to worse growth indicators, specifically stunting and a lower hemoglobin count in children. A statistically significant correlation between respiratory illnesses in children was not found and mixed results regarding incidence of depression in adults were observed.

To address the research questions, this document has explored a pooled cross section data for the period 2014-2019, which integrated health indicators found in the Demographic and Health Survey from Peru (ENDES) and information on the location of producing mining units in Peru during the same years. The mining information only registered formal operations of both metallic and non-metallic mining units, and did not provide information on the production amount of each, however this was covered by including data on the royalties received by each district municipality, which to some extend reflects the amount of production per year. Both sources of data were match using information on geographic location to capture the distance from household clusters and the closest mining unit. The empirical approach consisted of a fixed effect model which related indicators of stunting (height to age), underweight (weight to age), hemoglobin count, anemia and respiratory infections in children and mental health status in adults to being close to a mining unit.

The study found a clear correlation between hemoglobin levels in blood of children and exposure to mining, which agrees with previous studies on the consequences of exposure to mining pollution, especially heavy metals (Amnesty International, 2017; Astete et al., 2009; Asociación Civil Centro de Cultura Popular Labor, 2018; Von der Goltz and Barnwal, 2019). This relation was confirmed when considering variables of financial revenues at a local level, because there was not a significant relation between major economic resources and hemoglobin levels, which could inform that effects on hemoglobin level are only coming from possible exposure to pollution; in fact, when accounting for this factors the effects were larger (from 0.08 g/dl to 0.12 g/dl less than households located further away) and the statistical significance also was major (from 10% to a 1% level of significance).

On the other hand, the results have shown that there are multiple channels through which mining can have an effect in health, and that increases the challenge of generating evidence of the effects that mining can have in human and environmental health. For instance, a highly statistically significant and positive relation between the presence of metal mining and growth indicators -heigh and weight to age- was found, as well as small but positive effects of mining royalties on the weight to age indicator. This shows the possibility of material and economic benefits being translated into services which can cover health needs. For example, in the case of the first indicator, we can find a contrast in the results, because while there is a negative effect on stunting from proximity to mining, when the closest mine is of metallic operation, the effects is positive, however lower (about half). This could inform of cases in which companies intervene directly in communities through investment sin health.

Furthermore, on an attempt to illustrate eco-risks (Cartwright, 2016) as broader concepts of health, a variable indicating depression incidence in adults was used, to see whether the development of mining activities was harming mental health of those who are more exposed to mining activities and risks. This type of variable had not been explored by previous research which had employed the ENDES survey. Nevertheless, results did not show a clear relation between proximity to mining and a major incidence of depression in adults when considering a 5 km distance as being close to mining. When testing the model considering a 10km distance, results indicated that depression incidence was actually less for those closer to a mine site by 3.41 percentage points and, 4.04 when taking royalties and the presence of metallic mining into account in the model . One hypothesis to explain this relation is the possible association with mining and positive expectations.

Moving forward to the second research question, it was found that there are certain disparities in health indicators across ethnic identities in mining contexts. The most statistically significant differences were found for *quechua* identity and for households identifying as white. Perhaps the most striking result is that for children with a *quechua* identity, the probability of having an acute respiratory infection was highly significant and higher than in the case of *mestizos* by 4.33 percentage points. Accordingly, the sample showed that the location of *quechua* identities coincides with the location of most metal mining units. As it was mentioned, the clearer evidence on the links between mining and health have been defined between respiratory illnesses and metal pollution, just as well, throughout the document, a series of examples have been mentioned regarding specific cases in which communities have provided epidemiological prove of how affected they are by mining pollution and in this case, the results could reinforce those types of claims. This could be a reason to justify the need, from a policy side, to identify more actively major risks for health in specific areas and communities.

Lastly results are unclear regarding the relation with depression. These show a significant higher incidence of depression in adults identified as white, in comparison to *mestizo* identities, however there was no evidence found regarding differences across other ethnic identities. Since the data also shows a correlation between higher royalties and less incidence of depression, this result is associated with mining creating positive expectations, like better job opportunities or a better provision of services. This positive association reminds us of the existence of an extractive imperative (Arsel, Hogenboom and Pellegrini, 2016), which is not just a posture from policy, but it translates into communities' imaginaries of progress. In the case of Peru, the redistribution scheme of mining revenues has created a sense of dependence towards the activity given the large amounts of resources local governments can access to. And while it is possible that mining increases a negative exposure to externalities, it can also create material possibilities.

However, it is also considered relevant to point out and recall the literature proposed by Nixon (2011) on slow violence, since we have not found significant differential results for groups who are in larger proportion more exposed to mining. It is worth acknowledging that the information available does not necessarily allow to identify other possibilities of health and mental health problems, such as eco-risks. In the text, it has been commented that *quechua* communities have historically been subject to the expansion of mining which has allowed for the emergence and persistence of inequalities, and the data coincide with the facts that regions with higher presence of mining also have larger proportions *quechua* identities; however, results on any differential impact on health according to ethnicity, in this study are not considered enough to be generalized. Ethnic identification in Peru is a much too complex topic and it has even been characterized as a dynamic factor. On that note it is still a challenge to find a more adequate approach to investigate health inequalities with respect to social positionality.

Unfortunately, in this case the research was not able to explore the link between conflict, as a practice to achieve justice, with the prevalence of illness and health status. Even though information available from the Ombudsman Office in Peru, the OCMLA and OEFA about environmental fines, social conflicts and criminalization, was revised in the analysis, no conclusion can really be drawn regarding any possible relation. In that sense, it is still a pending task to further investigate this link. This would be pertinent, given that there is evidence at a micro level of how collective action from affected communities correlates with the existence of epidemiological evidence of impacts. These, according to authors like Cartwright (2016) and Nixon (2011) could very well be examples of eco-risks and slow violence, which without enough attention become invisible and not accounted for in policy agendas. Also, relating our results with epidemiological studies which have taken place in highly conflicted communities in Peru, such as Cerro de Pasco or Espinar, it is pertinent to question the type of data with which policy decisions can be made to, for instance, promote major economic activities by diminishing environmental protection efforts. One challenge in that sense is to look for ways to integrate this type of information into methods which usually inform causal relations between extractive industries and their impacts.

The main limitation in the research lied in the availability of data to respond to the objectives. For one thing, the data provided by ENDES is representative at a national level and does not result fully useful if we wanted to look at case specific examples of mining pollution. It is considered also that having systematized information on mining conflicts could be a starting point to direct further research on the effects of mining on mental health and that would allow to have a more contextual analysis of the mechanisms in which this activity can have different impacts. The results drawn in this research are also an invitation to broaden the definitions of health and illness, engaging with literature found within the environmental justice movement, as well as definitions found in medical anthropology. Given the weight attributed to the mining sector for Peruvian development, researching its impacts from different approaches is a known topic, however, it is considered relevant to insist on the need to provide additional evidence which can integrate an environmental justice lens to the policy evaluation criteria in order to increase the perception of urgency towards risks posed on the environment and communities health.

Appendix

Appendix 1
Measures and potential effects of Law 30230

Law 30230	Before	Potential effects
Sanctions due to environmental infractions become exceptional, only apply for cases of severe environmental damage. In case of environmental fines, the amounts to be paid can only go up to 50% of the real fine. The use of administrative mechanisms such as paralyzing operations are encouraged instead, as preventive measures	The use of sanctions and administrative mechanisms were complimentary, as stated in the legal framework in Peru. Sanctions' objective was to have a dissuasive power and encourage compliance; while administrative measures were an instrument to avoid or halt environmental damage.	These underrate the importance of complying with environmental protection and increase probability of infractions. Also, environmental fines lose dissuasive effect for correcting company's behaviour towards regulation. Under this assumption, there are greater probabilities of environmental damage and increasing health risks without a corresponding punishment and obligation to compensate them.
Repeating an infraction is no longer consider as such after 6 months. Committing an infraction when there is no repetitive conduct in the legal period can give access to discounts on fines.	Previously the period to consider repetition of infraction was 4 years, in which it was less likely to repeat an infraction twice or more, given the consequences reflected in the sanctions	Repeating an undesired conduct related to environmental protection is less punishable, therefore can increase probability of them occurring. This could increase the risk of deteriorating ecosystems slowly and exposing people to cumulative pollution, whiteout acknowledging its existence.
Reduction in time for the evaluation of Environmental Impact Assessment (EIA), a compulsory planning instrument that identifies potential environmental and social damage beforehand and serves as base line for environmental inspections during operations.	The time of evaluation for EIA was proportional to its type: 40 days for less complex EIA and 50 days for larger EIA. The changes did not consider the availability of resources for this task to be carried out in the corresponding instances.	Alongside these measures, there are punishment for official who do not comply with the period, thus generating risks in approving instruments without a thorough evaluation of potential dangers for environment and people.
The functions of stablishing environmental standards -Environmental Quality Standards (EQS) and Maximum Permissible Limits (MPL)- becomes a function of the Minister Council, which involves the participation of many sectors.	Before, the environmental authority – MINAM – was the only instance responsible for proposing and approving the EQS and MPL, through a participatory process.	This can create a conflict of interest, because decisions on environmental standards could potentially respond to criteria other than health risks. Instead, Law 30230 encourages economic evaluation of them, which could undermine negative impacts, crucial for guaranteeing a healthy environmental and low levels of risks for health.

Source: based on the report prepared by ANC et al

Appendix 2

Effects of distance to mining on stunting, underweight and anemia (specification 1)

	Distance to mine: 5 km				Distance to mine: 10 km			
	(1) **Height to age**	(2) **Weight to age**	(3) **Hemoglobin**	(4) **Anemia (a)**	(5) **Height to age**	(6) **Weight to age**	(7) **Hemoglobin**	(8) **Anemia (a)**
Household is close to mine	-7.540**	-2.410	-0.890**	0.00959	0.271	-3.422	0.178	-0.00421
	(3.522)	(3.713)	(0.406)	(0.0112)	(2.102)	(2.216)	(0.242)	(0.00679)
Age in years	-0.0688***	-0.237***	0.271***	-0.00603***	-0.0688***	-0.237***	0.271***	-0.00601***
	(0.0188)	(0.0199)	(0.00235)	(0.000618)	(0.0189)	(0.0199)	(0.00235)	(0.000619)
Sex	-0.898	2.695***	-0.960***	0.0226***	-0.895	2.697***	-0.960***	0.0225***
	(0.632)	(0.667)	(0.0727)	(0.00316)	(0.632)	(0.667)	(0.0727)	(0.00316)
Mother's education: primary	13.64***	6.385**	0.840***	-0.0222***	13.60***	6.368**	0.835***	-0.0221***
	(2.588)	(2.729)	(0.294)	(0.00746)	(2.588)	(2.728)	(0.294)	(0.00744)
Mother's education: secondary	34.85***	20.81***	1.296***	-0.0376***	34.81***	20.79***	1.290***	-0.0374***
	(2.622)	(2.765)	(0.298)	(0.00754)	(2.622)	(2.765)	(0.298)	(0.00752)
Mother's education: higher	48.08***	32.29***	2.542***	-0.0655***	48.03***	32.27***	2.535***	-0.0652***
	(2.800)	(2.952)	(0.319)	(0.00903)	(2.800)	(2.952)	(0.319)	(0.00901)
Mother's age at birth	0.390***	0.356***	0.0689***	-0.00144***	0.390***	0.356***	0.0688***	-0.00143***
	(0.0490)	(0.0516)	(0.00563)	(0.000193)	(0.0490)	(0.0516)	(0.00563)	(0.000193)
Mother has anemia	-1.541*	-2.033**	-2.993***	0.0632***	-1.542*	-2.054**	-2.992***	0.0630***
	(0.787)	(0.829)	(0.0919)	(0.00698)	(0.787)	(0.830)	(0.0919)	(0.00698)
Size of household	-3.648***	-2.603***	-0.199***	0.00364***	-3.651***	-2.604***	-0.199***	0.00363***
	(0.176)	(0.186)	(0.0204)	(0.000718)	(0.176)	(0.186)	(0.0204)	(0.000718)
Social programs beneficiary	-7.020***	-2.958***	-0.213**	0.00666**	-6.995***	-2.964***	-0.209**	0.00659**
	(0.822)	(0.867)	(0.0945)	(0.00269)	(0.822)	(0.867)	(0.0945)	(0.00269)
Any medical insurance	-2.671***	-1.095	0.425***	-0.0110***	-2.666***	-1.100	0.426***	-0.0109***
	(0.965)	(1.018)	(0.112)	(0.00326)	(0.965)	(1.018)	(0.112)	(0.00325)
Wealth quintile: poorer	17.19***	12.94***	0.392**	-0.00694*	17.15***	12.97***	0.386**	-0.00685*
	(1.333)	(1.405)	(0.153)	(0.00410)	(1.333)	(1.405)	(0.153)	(0.00408)
Wealth quintile	28.90***	21.96***	1.059***	-0.0211***	28.90***	21.99***	1.058***	-0.0210***
	(1.580)	(1.666)	(0.181)	(0.00514)	(1.580)	(1.666)	(0.181)	(0.00513)
Wealth quintile	39.98***	31.02***	1.852***	-0.0375***	40.00***	31.05***	1.854***	-0.0374***
	(1.709)	(1.801)	(0.196)	(0.00630)	(1.709)	(1.801)	(0.196)	(0.00629)
Wealth quintile: richest	51.08***	40.75***	2.683***	-0.0584***	51.11***	40.77***	2.686***	-0.0582***
	(1.887)	(1.989)	(0.217)	(0.00817)	(1.887)	(1.989)	(0.217)	(0.00816)
Does something to water to make it safe	7.053***	4.883***	0.298*	-0.00241	7.019***	4.879***	0.293*	-0.00233
	(1.363)	(1.438)	(0.157)	(0.00434)	(1.363)	(1.437)	(0.157)	(0.00433)
Separate room for kitchen	4.991***	6.145***	0.245**	-0.00615**	4.999***	6.142***	0.246**	-0.00616**
	(0.906)	(0.956)	(0.104)	(0.00291)	(0.907)	(0.956)	(0.104)	(0.00291)
Cooking fuel: LPG	2.223	5.028	-0.246	-0.0174	2.481	5.046	-0.209	-0.0179
	(5.480)	(5.777)	(0.646)	(0.0170)	(5.479)	(5.776)	(0.646)	(0.0169)
Cooking fuel: Natural gas	5.636	11.62*	0.110	-0.0187	5.897	11.68*	0.146	-0.0192
	(5.797)	(6.111)	(0.682)	(0.0180)	(5.796)	(6.110)	(0.682)	(0.0179)
Cooking fuel: Kerosene	44.34**	41.79**	-0.377	-0.0326	44.63**	41.79**	-0.335	-0.0331
	(20.06)	(21.15)	(2.324)	(0.0693)	(20.06)	(21.15)	(2.324)	(0.0691)

Cooking fuel: Coal, lignite	-3.949	-3.820	0.117	-0.0400	-3.833	-3.886	0.144	-0.0400
	(17.84)	(18.81)	(2.037)	(0.0550)	(17.84)	(18.81)	(2.037)	(0.0549)
Cooking fuel: Charcoal	-2.326	-5.427	0.882	-0.0430*	-2.042	-5.433	0.924	-0.0435**
	(7.402)	(7.804)	(0.860)	(0.0220)	(7.401)	(7.803)	(0.860)	(0.0219)
Cooking fuel: Wood	-0.224	3.919	-0.246	-0.0194	0.0809	3.947	-0.202	-0.0199
	(5.623)	(5.928)	(0.662)	(0.0173)	(5.622)	(5.926)	(0.662)	(0.0172)
Cooking fuel: Straw / shrubs / grass	2.263	-0.333	-0.0864	-0.0356	2.434	-0.410	-0.0690	-0.0358
	(9.302)	(9.807)	(1.072)	(0.0278)	(9.302)	(9.807)	(1.072)	(0.0277)
Cooking fuel: Agricultural crop	-4.242	-72.17*	4.929	-0.256	-4.032	-72.56*	4.982	-0.256
	(37.51)	(39.55)	(4.144)	(0.157)	(37.51)	(39.55)	(4.144)	(0.157)
Cooking fuel: Animal dung	-0.958	6.372	0.958	-0.0481**	-0.605	6.451	1.006	-0.0486**
	(6.909)	(7.285)	(0.806)	(0.0197)	(6.908)	(7.282)	(0.806)	(0.0196)
Cooking fuel: Other	18.95	1.575	-4.251	-0.00861	20.16	1.321	-4.026	-0.0116
	(24.59)	(25.93)	(3.146)	(0.0816)	(24.59)	(25.92)	(3.145)	(0.0815)
Rural	-5.866***	-2.439	-0.534***	0.0112**	-5.786***	-2.418	-0.526***	0.0111**
	(1.511)	(1.593)	(0.174)	(0.00494)	(1.511)	(1.592)	(0.174)	(0.00492)
Altitude	-0.0234***	-0.0190***	-0.00206***	4.51e-05***	-0.0234***	-0.0190***	-0.00206***	4.49e-05***
	(0.00197)	(0.00207)	(0.000225)	(9.01e-06)	(0.00197)	(0.00207)	(0.000225)	(9.00e-06)
2015	-1.754	-4.422**	0.786***	-0.0163***	-1.844	-4.183**	0.765***	-0.0159***
	(1.769)	(1.866)	(0.206)	(0.00562)	(1.776)	(1.873)	(0.207)	(0.00562)
2016	-1.366	-4.064**	0.564***	-0.00923*	-1.437	-3.800**	0.545***	-0.00880
	(1.750)	(1.845)	(0.203)	(0.00549)	(1.758)	(1.854)	(0.204)	(0.00551)
2017	1.729	-1.301	0.750***	-0.0127**	1.637	-1.014	0.727***	-0.0122**
	(1.751)	(1.846)	(0.204)	(0.00551)	(1.761)	(1.857)	(0.205)	(0.00553)
2018	3.733**	1.633	0.172	-0.0127**	3.611**	1.912	0.146	-0.0122**
	(1.740)	(1.835)	(0.202)	(0.00549)	(1.750)	(1.845)	(0.203)	(0.00551)
2019	4.457**	1.683	1.140***	-0.0335***	4.320**	2.024	1.109***	-0.0328***
	(1.756)	(1.852)	(0.204)	(0.00606)	(1.771)	(1.867)	(0.205)	(0.00607)
Constant	-102.5***	-15.94**	104.6***		-102.8***	-15.88**	104.5***	
	(7.419)	(7.821)	(0.866)		(7.418)	(7.821)	(0.866)	
Observations	82,558	82,558	76,036	75,869	82,558	82,558	76,036	75,869
R-squared	0.057	0.032	0.175	0.112	0.057	0.032	0.175	0.112
Number of districts	1,159	1,159	1,158		1,159	1,159	1,158	

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; (a) Marginal effects

Appendix 3

Effects of distance to mining on stunting, underweight and anemia (specification 2)

	Distance to mine: 5 km				Distance to mine: 10 km			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**Height to age**	**Weight to age**	**Hemoglobin**	**Anemia (marginal effects)**	**Height to age**	**Weight to age**	**Hemoglobin**	**Anemia (marginal effects)**
Household is close to mine	-8.927**	-4.429	-1.158***	0.0162	1.240	-1.844	-0.0881	0.00317
	(3.734)	(3.936)	(0.436)	(0.0111)	(2.399)	(2.529)	(0.280)	(0.00715)
Metal mining	4.117***	4.774***	-0.0433	0.00483	4.144***	4.746***	-0.0439	0.00488
	(1.536)	(1.620)	(0.179)	(0.00475)	(1.537)	(1.620)	(0.179)	(0.00475)

District royalties (logarithm)	0.413	0.802*	0.0172	-0.000796	0.380	0.787*	0.0129	-0.000736
	(0.437)	(0.460)	(0.0508)	(0.00120)	(0.437)	(0.460)	(0.0508)	(0.00120)
Age in months	-0.0752***	-0.234***	0.274***	-0.00544***	-0.0752***	-0.234***	0.274***	-0.00545***
	(0.0215)	(0.0226)	(0.00271)	(0.000910)	(0.0215)	(0.0226)	(0.00271)	(0.000912)
Sex	-0.734	2.925***	-1.017***	0.0215***	-0.728	2.926***	-1.016***	0.0215***
	(0.719)	(0.758)	(0.0835)	(0.00424)	(0.719)	(0.758)	(0.0836)	(0.00424)
Mother’s education: primary	12.17***	5.062	0.551	-0.0183**	12.12***	5.033	0.543	-0.0182**
	(2.956)	(3.116)	(0.339)	(0.00800)	(2.956)	(3.116)	(0.339)	(0.00801)
Mother’s education: secondary	33.73***	19.09***	1.007***	-0.0321***	33.68***	19.05***	0.998***	-0.0320***
	(2.993)	(3.155)	(0.344)	(0.00855)	(2.993)	(3.155)	(0.344)	(0.00855)
Mother’s education: higher	47.41***	30.13***	2.374***	-0.0588***	47.34***	30.08***	2.363***	-0.0587***
	(3.190)	(3.363)	(0.367)	(0.0115)	(3.190)	(3.363)	(0.367)	(0.0115)
Mother’s age at birth	0.423***	0.378***	0.0711***	-0.00128***	0.423***	0.378***	0.0711***	-0.00128***
	(0.0557)	(0.0587)	(0.00648)	(0.000248)	(0.0557)	(0.0587)	(0.00648)	(0.000249)
Mother has anemia	-1.669*	-2.084**	-3.015***	0.0577***	-1.665*	-2.095**	-3.016***	0.0577***
	(0.889)	(0.937)	(0.105)	(0.0100)	(0.889)	(0.937)	(0.105)	(0.0100)
Size of household	-3.952***	-2.688***	-0.212***	0.00324***	-3.958***	-2.690***	-0.212***	0.00325***
	(0.203)	(0.214)	(0.0238)	(0.000844)	(0.203)	(0.214)	(0.0238)	(0.000846)
Beneficiary of social program	-6.205***	-2.845***	-0.185*	0.00625**	-6.163***	-2.837***	-0.180*	0.00620**
	(0.928)	(0.978)	(0.108)	(0.00288)	(0.928)	(0.978)	(0.108)	(0.00288)
Any medical insurance	-3.553***	-1.796	0.471***	-0.0110***	-3.542***	-1.794	0.472***	-0.0110***
	(1.073)	(1.131)	(0.126)	(0.00358)	(1.073)	(1.131)	(0.126)	(0.00358)
Wealth: poorer	18.36***	13.46***	0.516***	-0.0105**	18.31***	13.44***	0.510***	-0.0104**
	(1.526)	(1.609)	(0.177)	(0.00446)	(1.526)	(1.609)	(0.177)	(0.00446)
Wealth: middle	29.19***	21.75***	1.063***	-0.0215***	29.18***	21.76***	1.062***	-0.0216***
	(1.801)	(1.898)	(0.209)	(0.00596)	(1.801)	(1.898)	(0.209)	(0.00597)
Wealth: richer	39.90***	30.22***	1.836***	-0.0375***	39.91***	30.23***	1.839***	-0.0376***
	(1.946)	(2.051)	(0.226)	(0.00805)	(1.946)	(2.051)	(0.226)	(0.00807)
Wealth: richest	50.48***	38.39***	2.599***	-0.0543***	50.51***	38.41***	2.603***	-0.0545***
	(2.149)	(2.265)	(0.249)	(0.0107)	(2.149)	(2.265)	(0.249)	(0.0107)
Does something to water to make it safe	7.385***	5.866***	0.350*	-0.00307	7.346***	5.846***	0.344*	-0.00300
	(1.616)	(1.704)	(0.189)	(0.00470)	(1.616)	(1.704)	(0.189)	(0.00470)
Separate room for kitchen	5.512***	6.989***	0.258**	-0.00609*	5.520***	6.991***	0.259**	-0.00612*
	(1.053)	(1.110)	(0.123)	(0.00317)	(1.053)	(1.110)	(0.123)	(0.00317)
Cooking fuel: LPG	9.344	12.14*	0.190	-0.0254	9.819	12.29*	0.251	-0.0264
	(6.511)	(6.864)	(0.785)	(0.0174)	(6.509)	(6.862)	(0.785)	(0.0173)
Cooking fuel: Natural gas	14.81**	20.72***	0.562	-0.0295	15.30**	20.87***	0.623	-0.0305*
	(6.866)	(7.238)	(0.825)	(0.0183)	(6.864)	(7.236)	(0.825)	(0.0183)
Cooking fuel: Kerosene	50.06**	38.06	0.143	-0.0445	50.60**	38.22	0.211	-0.0456
	(22.29)	(23.49)	(2.640)	(0.0707)	(22.29)	(23.49)	(2.640)	(0.0707)
Cooking fuel: Coal, lignite	7.464	9.700	0.341	-0.0552	7.840	9.760	0.391	-0.0557
	(19.04)	(20.07)	(2.195)	(0.0524)	(19.04)	(20.07)	(2.195)	(0.0524)
Cooking fuel: Charcoal	7.663	-2.964	0.458	-0.0366	8.179	-2.802	0.522	-0.0375
	(9.238)	(9.738)	(1.089)	(0.0252)	(9.237)	(9.736)	(1.089)	(0.0251)
Cooking fuel: Wood	8.804	12.42*	0.301	-0.0302*	9.345	12.60*	0.370	-0.0312*

	(6.670)	(7.031)	(0.803)	(0.0175)	(6.668)	(7.029)	(0.802)	(0.0174)
Cooking fuel: Straw / shrubs / grass	15.99	12.49	0.166	-0.0406	16.38	12.54	0.197	-0.0411
	(10.24)	(10.79)	(1.203)	(0.0276)	(10.24)	(10.79)	(1.203)	(0.0276)
Cooking fuel: Agricultural crop	4.075	-64.81	5.410	-0.246*	4.599	-64.92	5.452	-0.247*
	(37.53)	(39.56)	(4.195)	(0.146)	(37.53)	(39.56)	(4.195)	(0.147)
Cooking fuel: Animal dung	8.648	15.15*	1.438	-0.0523***	9.238	15.36*	1.514	-0.0535***
	(7.861)	(8.287)	(0.935)	(0.0200)	(7.859)	(8.284)	(0.935)	(0.0200)
Cooking fuel: Other	30.61	19.30	-3.623	-0.0432	32.56	19.70	-3.371	-0.0465
	(26.36)	(27.79)	(3.344)	(0.0794)	(26.36)	(27.78)	(3.344)	(0.0796)
Rural	-6.559***	-3.268*	-0.906***	0.0174***	-6.475***	-3.206*	-0.895***	0.0172***
	(1.718)	(1.811)	(0.200)	(0.00579)	(1.718)	(1.811)	(0.200)	(0.00578)
Altitude	-0.0257***	-0.0250***	-0.00174***	3.41e-05***	-0.0258***	-0.0250***	-0.00175***	3.44e-05***
	(0.00242)	(0.00255)	(0.000281)	(1.05e-05)	(0.00242)	(0.00255)	(0.000281)	(1.06e-05)
2015	0.113	-2.658	0.685***	-0.0123**	-0.0407	-2.581	0.680***	-0.0123**
	(1.987)	(2.095)	(0.234)	(0.00574)	(1.993)	(2.101)	(0.234)	(0.00576)
2016	0.370	-1.850	0.643***	-0.00882	0.237	-1.736	0.644***	-0.00898
	(1.980)	(2.087)	(0.232)	(0.00562)	(1.987)	(2.095)	(0.233)	(0.00565)
2017	2.734	0.739	0.757***	-0.0116**	2.555	0.830	0.752***	-0.0117**
	(1.989)	(2.096)	(0.233)	(0.00567)	(1.996)	(2.104)	(0.234)	(0.00570)
2018	5.280***	3.208	0.219	-0.0105*	5.064**	3.274	0.209	-0.0105*
	(1.968)	(2.075)	(0.231)	(0.00570)	(1.975)	(2.082)	(0.232)	(0.00573)
2019	6.345***	4.958**	1.074***	-0.0274***	6.083***	5.062**	1.064***	-0.0274***
	(2.017)	(2.126)	(0.236)	(0.00679)	(2.029)	(2.139)	(0.238)	(0.00683)
Constant	-111.6***	-25.30**	103.7***		-111.7***	-25.09**	103.7***	
	(10.84)	(11.42)	(1.278)		(10.84)	(11.43)	(1.278)	
Observations	63,502	63,502	58,478	58,296	63,502	63,502	58,478	58,296
R-squared	0.056	0.031	0.176		0.056	0.031	0.176	
Number of districts	1,041	1,041	1,040		1,041	1,041	1,040	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 4
Effects of distance to mining on ARI: marginal effects

	Specification 1				Specification 2			
	Distance to mine: 5 km		Distance: 10 km		Distance to mine: 5 km		Distance: 10 km	
	(1)		(2)		(3)		(4)	
	ARI	**Standard errors**	**ARI**	**Standard errors**	**ARI**	**Standard errors**	**ARI**	**Standard errors**
Household is close to mine	0.0200	(0.0415)	0.0129	(0.0250)	-0.0119	(0.0454)	0.0237	(0.0282)
Metal mining					0.00220	(0.0189)	0.00249	(0.0189)
District royalties (logarithm)					0.00514	(0.00532)	0.00500	(0.00532)
Age in years	0.00273	(0.00289)	0.00272	(0.00288)	0.00304	(0.00323)	0.00303	(0.00323)
Sex	0.0268***	(0.00802)	0.0268***	(0.00802)	0.0247***	(0.00912)	0.0247***	(0.00911)
Mother’s education: primary complete	-0.0186	(0.0339)	-0.0185	(0.0339)	-0.0627*	(0.0376)	-0.0627*	(0.0376)
Mother’s education: primary incomplete	0.00320	(0.0331)	0.00333	(0.0331)	-0.0365	(0.0361)	-0.0364	(0.0360)
Mother’s education: secondary complete	-0.0183	(0.0332)	-0.0182	(0.0331)	-0.0516	(0.0363)	-0.0516	(0.0363)
Mother’s education: secondary incomplete	-0.0213	(0.0335)	-0.0212	(0.0335)	-0.0534	(0.0368)	-0.0533	(0.0368)
Mother’s education: higher	-0.0418	(0.0340)	-0.0417	(0.0340)	-0.0691*	(0.0376)	-0.0691*	(0.0375)
Mother’s age at birth	-0.00260***	(0.000641)	-0.00260***	(0.000641)	-0.00224***	(0.000745)	-0.00224***	(0.000745)
Female head of household	0.0408***	(0.0126)	0.0407***	(0.0126)	0.0347**	(0.0142)	0.0346**	(0.0142)
Size of household	-0.00111	(0.00224)	-0.00110	(0.00224)	-0.00260	(0.00257)	-0.00260	(0.00257)
Social programs beneficiary	0.0154	(0.0102)	0.0154	(0.0102)	0.0202*	(0.0114)	0.0204*	(0.0114)
Any medical insurance	0.0164	(0.0113)	0.0164	(0.0113)	0.0249**	(0.0126)	0.0249**	(0.0126)
Wealth quintile: poorer	-0.00109	(0.0168)	-0.00114	(0.0168)	0.00231	(0.0190)	0.00210	(0.0189)
Wealth quintile	-0.0146	(0.0200)	-0.0148	(0.0200)	-0.0126	(0.0225)	-0.0128	(0.0225)
Wealth quintile	-0.0395*	(0.0220)	-0.0397*	(0.0220)	-0.0342	(0.0249)	-0.0342	(0.0248)
Wealth quintile: richest	-0.0397	(0.0243)	-0.0399	(0.0243)	-0.0354	(0.0274)	-0.0353	(0.0274)
Does something to water to make it safe	0.0243	(0.0168)	0.0244	(0.0168)	0.0169	(0.0193)	0.0168	(0.0192)
Separate room for kitchen	-0.0153	(0.0112)	-0.0153	(0.0112)	-0.0153	(0.0128)	-0.0152	(0.0128)
Cooking fuel: LPG	0.0930	(0.0824)	0.0930	(0.0824)	0.0479	(0.0923)	0.0484	(0.0921)

Cooking fuel: Natural gas	0.0888	(0.0857)	0.0887	(0.0857)	0.0514	(0.0957)	0.0519	(0.0955)
Cooking fuel: Kerosene	0.257	(0.200)	0.257	(0.200)	0.0660	(0.268)	0.0668	(0.267)
Cooking fuel: Coal, lignite	0.146	(0.269)	0.146	(0.269)	0.119	(0.269)	0.118	(0.269)
Cooking fuel: Charcoal	0.0524	(0.106)	0.0525	(0.106)	0.0633	(0.119)	0.0640	(0.119)
Cooking fuel: Wood	0.105	(0.0837)	0.105	(0.0836)	0.0574	(0.0935)	0.0581	(0.0933)
Cooking fuel: Straw / shrubs / grass	0.219*	(0.117)	0.219*	(0.117)	0.157	(0.127)	0.159	(0.127)
Cooking fuel: Agricultural crop	-2.596	(139.4)	-2.842	(231.1)	-2.449	(99.90)	-2.449	(100.8)
Cooking fuel: Animal dung	0.134	(0.101)	0.134	(0.101)	0.0898	(0.109)	0.0909	(0.109)
Cooking fuel: Other	0.175	(0.278)	0.174	(0.278)	0.182	(0.280)	0.187	(0.279)
Urban	0.0191	(0.0191)	0.0193	(0.0191)	0.0299	(0.0215)	0.0303	(0.0215)
Altitude	9.57e-06	(2.40e-05)	9.92e-06	(2.40e-05)	1.46e-05	(2.93e-05)	1.51e-05	(2.92e-05)
2015	-0.00950	(0.0212)	-0.0105	(0.0213)	0.00818	(0.0242)	0.00627	(0.0243)
2016	0.0113	(0.0208)	0.0101	(0.0209)	0.0265	(0.0238)	0.0242	(0.0239)
2017	-0.0364*	(0.0213)	-0.0376*	(0.0215)	-0.0110	(0.0248)	-0.0133	(0.0249)
2018	-0.0350*	(0.0211)	-0.0362*	(0.0213)	-0.0196	(0.0247)	-0.0218	(0.0248)
2019	-0.0569***	(0.0216)	-0.0583***	(0.0218)	-0.0427	(0.0260)	-0.0453*	(0.0262)
Observations	79,580		79,580		60,343		60,343	
Pseudo R-square	0.0043		0.0043		0.004		0.004	

*** p<0.01, ** p<0.05, * p<0.1

Appendix 5

Effects of distance to mining on mental health

	Specification 1				Specification 2			
	Distance to mine: 5 km		Distance to mine: 10 km		Distance to mine: 5 km		Distance to mine: 10 km	
	(1) **Depression[(a)]**	(2) **Depression index**	(3) **Depression[(a)]**	(4) **Depression index**	(5) **Depression[(a)]**	(6) **Depression index**	(7) **Depression[(a)]**	(8) **Depression index**
Household is close to mine	0.0161	0.156	-0.0341**	-0.0889	0.0216	0.256*	-0.0404**	-0.0889
	(0.0278)	(0.125)	(0.0161)	(0.0711)	(0.0297)	(0.134)	(0.0183)	(0.0820)
Metal mining					-0.0101	-0.0304	-0.0113	-0.0334
					(0.0116)	(0.0518)	(0.0115)	(0.0518)
District royalties (logarithm)					-0.000357	-0.0212	-0.000324	-0.0205
					(0.00324)	(0.0154)	(0.00323)	(0.0154)
Age in years	0.00493***	0.0308***	0.00491***	0.0308***	0.00501***	0.0326***	0.00499***	0.0326***
	(0.000292)	(0.000843)	(0.000294)	(0.000843)	(0.000351)	(0.000979)	(0.000362)	(0.000979)
Sex	-0.162***	-1.034***	-0.161***	-1.034***	-0.156***	-1.034***	-0.155***	-1.034***
	(0.00859)	(0.0244)	(0.00867)	(0.0244)	(0.0103)	(0.0282)	(0.0106)	(0.0282)
Education: primary complete	-0.00951	-0.527***	-0.00945	-0.527***	-0.0160	-0.612***	-0.0159	-0.612***
	(0.00872)	(0.0561)	(0.00870)	(0.0561)	(0.00976)	(0.0638)	(0.00970)	(0.0638)
Education: primary incom-	-0.0726***	-1.153***	-0.0723***	-1.153***	-0.0716***	-1.218***	-0.0711***	-1.219***
plete	(0.0136)	(0.0702)	(0.0135)	(0.0702)	(0.0155)	(0.0809)	(0.0155)	(0.0809)
Education: secondary com-	-0.0401***	-0.869***	-0.0399***	-0.869***	-0.0496***	-0.969***	-0.0493***	-0.968***
plete	(0.0112)	(0.0635)	(0.0111)	(0.0635)	(0.0127)	(0.0726)	(0.0127)	(0.0726)
Education: secondary in-	-0.0728***	-1.148***	-0.0725***	-1.148***	-0.0791***	-1.234***	-0.0786***	-1.234***
complete	(0.0109)	(0.0618)	(0.0109)	(0.0618)	(0.0126)	(0.0706)	(0.0125)	(0.0706)
Education: higher	-0.119***	-1.483***	-0.119***	-1.483***	-0.124***	-1.576***	-0.124***	-1.576***
	(0.0119)	(0.0639)	(0.0119)	(0.0639)	(0.0140)	(0.0729)	(0.0140)	(0.0729)
Female head of household	0.0232***	0.336***	0.0230***	0.337***	0.0284***	0.345***	0.0282***	0.345***
	(0.00717)	(0.0371)	(0.00715)	(0.0371)	(0.00813)	(0.0424)	(0.00811)	(0.0424)
Married	-0.0551***	-0.507***	-0.0551***	-0.507***	-0.0583***	-0.523***	-0.0582***	-0.523***
	(0.00593)	(0.0254)	(0.00593)	(0.0254)	(0.00692)	(0.0293)	(0.00696)	(0.0293)
Size of household	-0.000555	-0.0165**	-0.000536	-0.0164**	-0.000824	-0.0205***	-0.000794	-0.0203***
	(0.00143)	(0.00649)	(0.00142)	(0.00649)	(0.00163)	(0.00756)	(0.00162)	(0.00756)
Social programs beneficiary	-0.00239	0.0661**	-0.00253	0.0658**	-0.00560	0.0621*	-0.00582	0.0615*
	(0.00611)	(0.0290)	(0.00609)	(0.0290)	(0.00692)	(0.0332)	(0.00688)	(0.0333)
Any medical insurance	0.00747	0.0183	0.00740	0.0183	0.00747	0.0167	0.00735	0.0166
	(0.00619)	(0.0266)	(0.00618)	(0.0266)	(0.00691)	(0.0303)	(0.00688)	(0.0303)
Wealth quintile: poorer	-0.00142	-0.0359	-0.00114	-0.0343	-0.00275	-0.0523	-0.00251	-0.0503
	(0.00939)	(0.0459)	(0.00936)	(0.0459)	(0.0106)	(0.0527)	(0.0106)	(0.0527)
Wealth quintile	-0.0262**	-0.190***	-0.0259**	-0.189***	-0.0234*	-0.193***	-0.0231*	-0.191***
	(0.0118)	(0.0559)	(0.0117)	(0.0559)	(0.0133)	(0.0641)	(0.0133)	(0.0641)
Wealth quintile	-0.0533***	-0.410***	-0.0533***	-0.410***	-0.0516***	-0.428***	-0.0515***	-0.428***
	(0.0131)	(0.0602)	(0.0130)	(0.0602)	(0.0149)	(0.0691)	(0.0148)	(0.0691)
Wealth quintile: richest	-0.104***	-0.711***	-0.104***	-0.711***	-0.0937***	-0.714***	-0.0935***	-0.715***
	(0.0152)	(0.0653)	(0.0152)	(0.0653)	(0.0173)	(0.0750)	(0.0172)	(0.0750)
	-0.0516***	-0.364***	-0.0515***	-0.364***	-0.0582***	-0.429***	-0.0580***	-0.429***

Does something to water to make it safe	(0.00906)	(0.0450)	(0.00904)	(0.0450)	(0.0106)	(0.0535)	(0.0106)	(0.0535)
Separate room for kitchen	-0.0354***	-0.229***	-0.0355***	-0.229***	-0.0432***	-0.261***	-0.0432***	-0.262***
	(0.00686)	(0.0324)	(0.00685)	(0.0324)	(0.00798)	(0.0379)	(0.00797)	(0.0379)
Cooking fuel: LPG	0.00460	0.208	0.00403	0.203	0.0541	0.423**	0.0531	0.413**
	(0.0394)	(0.158)	(0.0393)	(0.158)	(0.0530)	(0.197)	(0.0528)	(0.197)
Cooking fuel: Natural gas	-0.0121	0.100	-0.0123	0.0965	0.0433	0.341	0.0423	0.331
	(0.0420)	(0.171)	(0.0419)	(0.171)	(0.0558)	(0.211)	(0.0556)	(0.211)
Cooking fuel: Kerosene	-0.170	-0.649	-0.170	-0.655	-0.0918	-0.573	-0.0918	-0.586
	(0.164)	(0.602)	(0.163)	(0.602)	(0.171)	(0.668)	(0.170)	(0.668)
Cooking fuel: Coal, lignite	-0.0823	-0.750	-0.0818	-0.743	-0.00359	-0.368	-0.00331	-0.357
	(0.165)	(0.546)	(0.164)	(0.546)	(0.172)	(0.605)	(0.171)	(0.605)
Cooking fuel: Charcoal	0.0616	0.306	0.0607	0.302	0.120	0.596*	0.118	0.586*
	(0.0562)	(0.240)	(0.0561)	(0.240)	(0.0734)	(0.310)	(0.0732)	(0.310)
Cooking fuel: Wood	0.0155	0.271*	0.0147	0.266	0.0767	0.514**	0.0753	0.502**
	(0.0406)	(0.164)	(0.0405)	(0.164)	(0.0546)	(0.203)	(0.0544)	(0.203)
Cooking fuel: Straw / shrubs / grass	0.123**	1.053***	0.121**	1.039***	0.195***	1.228***	0.192***	1.203***
	(0.0549)	(0.260)	(0.0547)	(0.260)	(0.0687)	(0.297)	(0.0686)	(0.297)
Cooking fuel: Agricultural crop	-0.0313	-1.137	-0.0297	-1.138	0.0933	-0.827	0.0952	-0.830
	(0.174)	(0.907)	(0.173)	(0.907)	(0.181)	(1.001)	(0.181)	(1.001)
Cooking fuel: Animal dung	0.0212	0.453**	0.0203	0.445**	0.0695	0.622***	0.0681	0.606**
	(0.0446)	(0.200)	(0.0445)	(0.200)	(0.0575)	(0.236)	(0.0573)	(0.236)
Cooking fuel: Other	0.118	1.437**	0.116	1.428**	0.177*	1.735***	0.174*	1.718***
	(0.0973)	(0.597)	(0.0970)	(0.597)	(0.106)	(0.640)	(0.106)	(0.640)
Urban	0.0259**	0.243***	0.0261**	0.246***	0.0260**	0.254***	0.0260**	0.259***
	(0.0113)	(0.0520)	(0.0113)	(0.0520)	(0.0127)	(0.0593)	(0.0127)	(0.0593)
Altitude	-3.04e-05**	-0.000310***	-3.07e-05**	-0.000310***	-2.96e-05*	-0.000311***	-3.01e-05**	-0.000309***
	(1.28e-05)	(6.44e-05)	(1.28e-05)	(6.44e-05)	(1.53e-05)	(7.80e-05)	(1.52e-05)	(7.80e-05)
2015	0.0201*	0.131***	0.0222**	0.138***	0.0172	0.150***	0.0190	0.156***
	(0.0110)	(0.0492)	(0.0110)	(0.0494)	(0.0128)	(0.0579)	(0.0128)	(0.0581)
2016	0.0188*	0.136***	0.0210**	0.143***	0.0146	0.132**	0.0166	0.138**
	(0.0104)	(0.0473)	(0.0105)	(0.0476)	(0.0122)	(0.0561)	(0.0122)	(0.0563)
2017	0.00338	-0.0522	0.00588	-0.0445	-0.00837	-0.0898	-0.00610	-0.0835
	(0.0104)	(0.0472)	(0.0104)	(0.0475)	(0.0120)	(0.0564)	(0.0120)	(0.0566)
2018	-0.00977	-0.170***	-0.00702	-0.161***	-0.0156	-0.201***	-0.0131	-0.194***
	(0.0104)	(0.0469)	(0.0104)	(0.0473)	(0.0120)	(0.0556)	(0.0119)	(0.0557)
2019	0.000474	-0.141***	0.00345	-0.131***	-0.00727	-0.183***	-0.00447	-0.173***
	(0.0104)	(0.0472)	(0.0104)	(0.0476)	(0.0121)	(0.0569)	(0.0121)	(0.0572)
Constant		4.189***		4.197***		4.555***		4.563***
		(0.217)		(0.217)		(0.346)		(0.347)
Observations	131,116	133,912	131,116	133,912	101,814	104,098	101,814	104,098
R-squared	0.0679	0.069	0.0679	0.069	0. 0696	0.072	0.0697	0.072
Number of districts		1,167		1,167		1,052		1,052

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
(a) Marginal effects

Appendix 6

Effects of distance to mining on stunting, underweight and anemia across ethnic identities

	(1) **Height to age**	(2) **Weight to age**	(3) **Hemoglobin**	(4) **Anemia (a)**
Household is close to mine (5 km)	-7.880*	-4.270	-0.883*	0.0144
	(4.296)	(4.525)	(0.498)	(0.0130)
Quechua identity	1.157	1.577	0.127	-0.00864**
	(1.273)	(1.341)	(0.146)	(0.00403)
Identifies as white	0.762	-1.196	0.318*	-0.00452
	(1.549)	(1.631)	(0.179)	(0.00475)
Other identity	-0.222	0.112	-0.168	0.00207
	(1.349)	(1.421)	(0.155)	(0.00413)
Metal mining	4.695**	4.800**	-0.0290	0.00843
	(2.011)	(2.118)	(0.231)	(0.00646)
District royalties (logarithm)	-0.373	-0.0659	0.0708	-0.00164
	(0.533)	(0.562)	(0.0614)	(0.00144)
Age in years	-0.0152	-0.239***	0.270***	-0.00548***
	(0.0243)	(0.0256)	(0.00303)	(0.00101)
Sex	-0.611	3.535***	-1.001***	0.0227***
	(0.811)	(0.855)	(0.0934)	(0.00491)
Mother’s education: primary	10.74***	2.561	0.323	-0.0144
	(3.300)	(3.476)	(0.377)	(0.00914)
Mother’s education: secondary	32.08***	16.13***	0.936**	-0.0325***
	(3.342)	(3.520)	(0.381)	(0.00975)
Mother’s education: higher	46.35***	26.95***	2.230***	-0.0594***
	(3.566)	(3.756)	(0.407)	(0.0129)
Mother’s age at birth	0.449***	0.357***	0.0726***	-0.00140***
	(0.0630)	(0.0664)	(0.00726)	(0.000294)
Mother has anemia	-1.469	-1.479	-3.030***	0.0601***
	(1.009)	(1.063)	(0.118)	(0.0115)
Size of household	-3.784***	-2.566***	-0.212***	0.00357***
	(0.232)	(0.245)	(0.0270)	(0.00100)
Social programs beneficiary	-5.803***	-2.490**	-0.118	0.00682**
	(1.050)	(1.105)	(0.121)	(0.00337)
Any medical insurance	-4.337***	-2.739**	0.347**	-0.00975**
	(1.290)	(1.358)	(0.149)	(0.00420)
Wealth quintile: poorer	17.34***	13.11***	0.370*	-0.00790
	(1.684)	(1.774)	(0.194)	(0.00494)
Wealth quintile	26.73***	20.57***	0.793***	-0.0167***
	(2.004)	(2.111)	(0.231)	(0.00636)
Wealth quintile	37.31***	29.41***	1.612***	-0.0357***
	(2.177)	(2.293)	(0.251)	(0.00882)
Wealth quintile: richest	46.36***	36.79***	2.344***	-0.0530***
	(2.426)	(2.555)	(0.279)	(0.0118)
Does something to water to make it safe	10.11***	7.843***	0.237	0.00204
	(1.856)	(1.955)	(0.215)	(0.00567)
Separate room for kitchen	5.192***	6.448***	0.280**	-0.00733**
	(1.194)	(1.258)	(0.138)	(0.00372)
Cooking fuel: LPG	8.053	12.76*	0.171	-0.0350*
	(7.300)	(7.689)	(0.868)	(0.0191)
Cooking fuel: Natural gas	15.04*	21.91***	0.620	-0.0443**
	(7.688)	(8.097)	(0.911)	(0.0201)

Cooking fuel: Kerosene	45.91*	44.74*	0.321	-0.0600
	(23.71)	(24.98)	(2.806)	(0.0796)
Cooking fuel: Coal, lignite	19.30	22.24	-1.282	-0.0177
	(22.33)	(23.52)	(2.571)	(0.0624)
Cooking fuel: Charcoal	3.177	-9.236	0.723	-0.0592**
	(10.32)	(10.87)	(1.202)	(0.0284)
Cooking fuel: Wood	6.452	11.44	0.138	-0.0361*
	(7.467)	(7.865)	(0.886)	(0.0195)
Cooking fuel: Straw / shrubs / grass	8.661	7.438	-0.0993	-0.0629**
	(11.65)	(12.27)	(1.353)	(0.0315)
Cooking fuel: Agricultural crop	4.000	-63.17	5.482	-0.285*
	(37.69)	(39.69)	(4.183)	(0.160)
Cooking fuel: Animal dung	6.071	14.16	1.399	-0.0636***
	(8.661)	(9.122)	(1.019)	(0.0224)
Cooking fuel: Other	13.97	15.52	-7.332**	0.0477
	(28.80)	(30.34)	(3.725)	(0.0961)
Rural	-5.718***	-2.538	-0.820***	0.0143**
	(1.940)	(2.044)	(0.224)	(0.00632)
Altitude	-0.0302***	-0.0286***	-0.00178***	3.81e-05***
	(0.00283)	(0.00298)	(0.000325)	(1.29e-05)
2017	2.391*	2.133	0.163	-0.00338
	(1.326)	(1.397)	(0.153)	(0.00393)
2018	5.293***	4.818***	-0.331**	-0.00305
	(1.376)	(1.449)	(0.158)	(0.00414)
2019	6.270***	6.556***	0.526***	-0.0202***
	(1.411)	(1.486)	(0.162)	(0.00562)
Constant	-94.43***	-7.633	104.2***	
	(12.34)	(13.00)	(1.436)	
Observations	49,757	49,757	45,965	45,792
R-squared	0.054	0.030	0.175	0.110
Number of districts	939	939	939	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

(a) Marginal effects

Appendix 7

Effects of distance to mining on ARI across ethnic identities

	Marginal effects	Standard errors
Household is close to mine	-0.0237	(0.0519)
Quechua identity	0.0433***	(0.0161)
Identifies as white	0.00728	(0.0190)
Other identity	0.00519	(0.0173)
Metal mining	0.00288	(0.0254)
District royalties (logarithm)	0.00307	(0.00675)
Age in years	0.00142	(0.00374)
Sex	0.0257**	(0.0104)
Mother's education: primary complete	-0.0833**	(0.0399)
Mother's education: primary incomplete	-0.0620	(0.0391)
Mother's education: secondary complete	-0.0683*	(0.0389)
Mother's education: secondary incomplete	-0.0831**	(0.0393)
Mother's education: higher	-0.0684*	(0.0397)
Mother's age at birth	-0.00192**	(0.000805)
Female head of household	0.0356**	(0.0158)
Size of household	-0.00474	(0.00298)
Social programs beneficiary	0.0248*	(0.0131)
Any medical insurance	0.0133	(0.0145)
Wealth quintile: poorer	0.0102	(0.0213)
Wealth quintile	-0.0217	(0.0256)
Wealth quintile	-0.0405	(0.0281)
Wealth quintile: richest	-0.0474	(0.0313)
Does something to water to make it safe	0.0235	(0.0226)
Separate room for kitchen	-0.0202	(0.0146)
Cooking fuel: LPG	0.0150	(0.104)
Cooking fuel: Natural gas	0.0183	(0.108)
Cooking fuel: Kerosene	0.0296	(0.276)
Cooking fuel: Coal, lignite	0.164	(0.283)
Cooking fuel: Charcoal	-0.00838	(0.137)
Cooking fuel: Wood	0.0464	(0.106)
Cooking fuel: Straw / shrubs / grass	0.171	(0.143)
Cooking fuel: Agricultural crop	-2.609	(112.5)
Cooking fuel: Animal dung	0.0697	(0.123)
Cooking fuel: Other	0.204	(0.295)
Urban	0.0521**	(0.0253)
Altitude	1.12e-05	(3.63e-05)
2017	-0.0374**	(0.0162)
2018	-0.0489***	(0.0171)
2019	-0.0712***	(0.0179)
Observations	45,912	
Pseudo R-squared	0.0055	

*** p<0.01, ** p<0.05, * p<0.1

Appendix 8

Effects of distance to mining on mental health across ethnic identities

	Marginal effects	Standard errors
Household is close to mine	0.0471	(0.0341)
Quechua identity	-0.00143	(0.00997)
Identifies as white	0.0314**	(0.0157)
Other identity	-0.00339	(0.0135)
Metal mining	-0.00512	(0.0148)
District royalties (logarithm)	-0.00339	(0.00364)
Age in years	0.00496***	(0.000611)
Sex	-0.140***	(0.0166)
Education: primary complete	-0.0135	(0.0105)
Education: primary incomplete	-0.0565***	(0.0171)
Education: secondary complete	-0.0446***	(0.0141)
Education: secondary incomplete	-0.0673***	(0.0144)
Education: higher	-0.120***	(0.0180)
Female head of household	0.0228**	(0.00899)
Married	-0.0573***	(0.00903)
Size of household	-0.000303	(0.00176)
Social programs beneficiary	-0.00879	(0.00742)
Any medical insurance	0.00716	(0.00768)
Wealth quintile: poorer	0.00116	(0.0113)
Wealth quintile	-0.0257*	(0.0144)
Wealth quintile	-0.0505***	(0.0167)
Wealth quintile: richest	-0.0788***	(0.0199)
Does something to water to make it safe	-0.0616***	(0.0124)
Separate room for kitchen	-0.0398***	(0.00929)
Cooking fuel: LPG	0.0422	(0.0603)
Cooking fuel: Natural gas	0.0363	(0.0631)
Cooking fuel: Kerosene	-0.0585	(0.222)
Cooking fuel: Coal, lignite	0.121	(0.170)
Cooking fuel: Charcoal	0.0948	(0.0816)
Cooking fuel: Wood	0.0679	(0.0630)
Cooking fuel: Straw / shrubs / grass	0.171**	(0.0798)
Cooking fuel: Agricultural crop	0.0759	(0.176)
Cooking fuel: Animal dung	0.0529	(0.0646)
Cooking fuel: Other	0.173	(0.115)
Urban	0.0231*	(0.0139)
Altitude	-3.49e-05**	(1.69e-05)
2017	-0.0174**	(0.00886)
2018	-0.0262***	(0.00998)
2019	-0.0172*	(0.00972)
Observations	76,328	
Pseudo R-squared	0.0714	

*** p<0.01, ** p<0.05, * p<0.1

Appendix 9

Environmental fines per region in the period 2014-2019

Region	Total environmental fines	Sum of Infractions amount (UIT) (1)
La Libertad	10	27,326.42
Cajamarca	8	5,733.96
Pasco	12	942.59
Apurímac	2	394.92
Puno	3	288.08
Ancash	2	260.78
Junin	6	237.37
Piura	2	151.83
Cusco	2	136.29
Multi-Region	1	124.60
Arequipa	5	122.29
Huancavelica	2	91.17
Ica	3	45.66
Lima	4	31.72
Ayacucho	1	12.66
Tacna	1	8.23
Moquegua	2	4.59
Total	**66**	**35,913.14**

(1) UIT = Peruvian Tax Unit, on average equals 4,000.00 Peruvian Soles (PEN)

Source: OEFA (2020)

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