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LANDMINES

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Abstract

Landmines are silent killers, maiming and killing during conflict as well as long after its termination. This paper is - to the best of our knowledge - the first to study the impact of landmines on child health, as well as the impact on household income in Angola by exploiting geographical variations in landmine intensity. We generate exogenous variation in the intensity of landmine contamination using the distance separating each commune from a set of rebel headquarters in the highly contentious Planalto (central highlands) region. As predicted, landmine intensity is found to be a decreasing function of the distance to the UNITA centre of gravity, an area of both offensive and defensive mining and shifting frontlines. This holds even after controlling for other geographical characteristics and war intensity that might also directly affect our response variables. Instrumental variables estimates, based on two different household surveys collected in 2000/2001 and the Landmines Impact Survey, indicate that Suspected Hazard Areas have large, significant and negative effects on weight-for-age (WAZ) and height-for-age (HAZ), as well as household income. We use these micro estimates in the context of humanitarian mine action, addressing the issue of the benefits, costs and priorities of landmine clearing, but also the implication of landmines in a larger development perspective in times of conflict and beyond.

1 Introduction

This paper is - to the best of our knowledge - the first to study the impact of landmines on child health, as well as the impact on household income in Angola by exploiting geographical variations in landmine intensity.[1] It also counts among the few studies exploring the impact of landmines outside of directly contaminated communities. Our identification strategy is based on the plausibly exogenous variation in landmine intensity induced by the geographic location of a commune with respect to the headquarters of the rebel group UNITA (Uniao Nacional para a Independencia Total de Angola. We use newly available data on landmine contamination in Angola (Landmines Impact Survey) and for robustness two different household surveys conducted during the last phase of conflict in 2000/2001.

During the long period of civil unrest, 1.5 million Angolans may have died, an estimated 20% of the population was displaced, and over 6 million landmines were said to be planted according to the UNHCR. While all Angolan provinces are affected by landmines, the within province variation in mine contamination is substantial. Until recently the precise extent of the mine challenge faced by communities across Angola was not known. According to the Landmines Impact Survey completed in 2007, which data we are using in the present paper, the number of impacted communities amounts to 8% of the 23,504 communities in Angola(Survey Action Center 2007). An estimated 2.4 million people live in landmine impacted communities, with 0.6 million living in high - or medium-impact communities. Overall, approximately 17% of all citizens are still living in mine-impacted communities in spite of Humanitarian Mine Action that has started in 1994 with the Lusaka Protocol. The Landmine Impact Survey design uses the Suspected Hazard Area as the main unit of observation, identifying 3,293 Suspected Hazardous Areas in Angola.[2]We use the georeferenced location of Suspected Hazardous Areas to build our landmine intensity variable. Angola is widely and heavily mined as Figure (4) underlines, depicting the location of Suspected Hazardous Areas.

Instrumental variables estimates indicate that Suspected Hazard Areas have large, significant and negative effects on weight-for-age (WAZ) and height-for-age (HAZ), as well as household income. We use these micro estimates in the context of humanitarian mine action, addressing the issue of the benefits, costs and priorities of landmine clearing, but also the implication of landmines in a larger development perspective in times of conflict and beyond.

The rest of this paper is organized as follows. Section 2 reviews the previous literature on household outcomes and landmines in Cambodia and Mozambique. Section 3 outlines some theoretical impacts of landmines on child health and income. In section 4, we present our basic empirical specification, and show why OLS-based estimates of the impact of Suspected Hazard Areas are likely to be biased. In section 5, we spell out our identification strategy. Section 6 discusses reduced form estimates. Section 7 presents baseline instrumen-

[1] The title of the paper is inspired by the 1998 documentary "Seeds of the Devil" on landmines victims in Angola.

[2] Our landmine intensity variable thus refers to the number of Suspected Hazardous Areas rather than the number of landmines per se. Further explanation about Landmine Impact Survey semantics, data design and the use of Landmine Impact Survey data is provided in the Annex

tal variables estimates of the impact of Suspected Hazard Areas on child anthropometrics and household expenditures per adult equivalent. Section 8 discusses the results with respect to landmine clearance. Section 9 concludes.

2 Previous Literature

This paper aims at contributing to the quickly expending literature on the socio-economic consequences of wars and conflicts.[3] With two exceptions, the impact of landmines on households has not been empirically investigated beyond the usual ad-hoc clearance analysis. In particular, we are the first to provide estimates of the impact of landmines in Angola and the impact on child health.

In the case of Mozambique Merrouche (2006) uses a dataset on landmine contamination intensity (National Demining Institute - IND) along with the 1996 household survey of the National Statistics Office of Mozambique. Using a difference-in-difference estimator to correct for selection in landmine placement and the distance to national borders as exclusion restriction, she finds large and statistically significant effects of landmine contamination on poverty and consumption per capita. The conclusion of the cost-benefit analysis is that despite the high cost of mine clearance positive returns can be expected to be generated.[4]

Using similar methods and instrumentation than in the paper on Mozambique, Merrouche (2008) looks into the effect of landmines contamination on returns to education in Cambodia. She uses two sources of variation in an individual's exposure to the conflict: age in 1970 due to the spread of landmines over time and landmine contamination intensity in the individuals' district of birth. The instrumental variable specification uses the distance to the Thai border as an exogenous source of variation in landmine contamination. Estimates indicate an education loss of 0.4 years at the mean and no visible effect on earnings. One obvious caveat of Merrouches identification story is both the strategic and economic significance of borders. Hence the exclusion restriction of borders is likely to be violated due to a direct effect on household welfare.

[3] A notable recent addition to this literature includes Miguel and Roland (2005) which evaluates the long term economic impact of US bombing in Vietnam. However, their results prove to be inconclusive. They do not find a robust negative impact of U.S. bombing on poverty rates, consumption levels, infrastructure, literacy or population density in the 1990s, which place their findings in line with the argument that institutions and geography are more important than initial stocks of physical and human capital for long run economic growth. In Angola, (Arcand and Wouabe 2009) study the impact of the Angolan civil war on household welfare using similar data and techniques akin to the ones in this paper.

[4] Mine action programs commonly contrast the US$3 cost of production of landmines to the estimated US$300-US$1,000 costs of clearance per landmine. In addition to loss of income and other socio-economic consequences, the life-time treatment of a surviving victim is estimated to cost US$5,000. One prosthesis costs between US$30 and $1,000 and children need a new one every six months as they grow(see UN Mine Action Program).

3 The Impact of Landmines on Households and Child Health

The impact of landmines on child health has been investigated with respect to direct physical injury, trauma, loss of earnings, cost of prosthetics and rehabilitative care. However there are potentially wider impacts on child health and households. As we cannot single out specific impacts, our results capture the sum and interaction of various channels.

Landmines are primarily used to deny access to land to enemy troops. They can effectively depopulate whole sections of a country, degrade land (Behre 2007), disrupt agriculture, increase costs of transportation, damage economic infrastructure and ultimately affect income and employment opportunities. Farming is particularly hard-hit, as well as any activity that depends crucially on transportation. In addition, farming activities may be forced to move to drought-prone and less fertile soils. During the conflict in Angola, the Mavinga Valley, once a fertile area in the southeast, was largely abandoned, and people pushed into drought-prone environments (Doswald-Beck, Herby, and Dorais-Slakmon 1995).

Another channel through which mines impact household welfare and child health is education. Children, mothers and household members are likely to have problems to access schooling. Local school premises may be mined and roads to more distant schools blocked. Also awareness raising campaigns usually carried out in schools (e.g. mine education, hygiene, HIV, etc.) will reach less into remote and landmine contaminated areas.

In terms of health, direct and indirects impact can be identified: First, landmine casualties often overwhelm medical infrastructure already weakened by conflicts. Mine victims require long-term stays in hospitals, multiple surgeries, and large quantities of blood. In Mozambique, landmine victims represented less than 4% of surgical admissions but their care mobilized 25% of hospital resources (Sheehan and Croll 1993). Incidentally, providing care and rehabilitation for landmine victims requires diverting resources away from vaccination, sanitation, nutrition, and vector-control programs (Center For Disease Control 1997); (Williams 1995); (Williams 1996);(Kakar, Bassani, Romer, and Gunn 1996). Second, landmines increase the cost of providing relief and health care to populations in need due to mined roads, bridges and infrastructure. For instance, while it cost US$80 to deliver one ton of relief supplies by road from Lobito to Huambo in 1980, it cost US$2,000 by air. But landmines along the delivery routes made land transportation unfeasible in Angola (UNICEF 1996). Also note that populations from conflict-impacted areas tend to have weakened immune systems. Here mine contamination may hinder medical treatment early on. This facilitates diffusion of diseases and pathogens across the population.

Finally, mines deny the use of soil and grazing lands. These abandoned mined lands can become havens for disease vectors. For instance, in Zimbabwe, minefields are said to have prevented the eradication of the tsetse fly and diseases, such as foot-and-mouth disease (Human Rights Watch 1997);(Rupiya 1998).

4 Landmine Clearance

Landmines have long been the pre-carré of humanitarian mine action with a more specific focus on direct safety rather than long term development. Our household estimates indicate that the field has underestimated benefit-cost ratios.

In 2008, Halo Trust estimated the cost of landmines removal at an average of US$499 per mine, or US$2.30 a square metre.[5] The cleared area is nowadays considered more relevant in socio-economic terms than the number of mines per se. Indeed, the clearance cost per hectare, and the benefit of clearance, are the same regardless of whether there is one mine or 100. Although with a higher mine density, the chance of an accident is greater.

Cost-benefit evaluations of landmines clearance are diverse. Harris (2000) estimates that removing landmines in Cambodia would produce benefits - in the form of saved lives, reduced injuries, lower medical costs, and greater farm output - that amount to 2% of costs. In Mozambique, the benefits are estimated to be 10% of costs (Elliot and Harris 2001). Mitchell (2004) argues that mine accidents, mine related population displacement and land degradation are not major impediments to national economic development in Bosnia-Herzegovina. Harris (2002) finds a positive net present value for mine clearance in Afghanistan. The value of saved lives and avoided disabilities is 35% of the total annual benefit of landmine clearance, with more benefits coming from saving dairy cattle. For Cambodia Gildestad (2005) finds that benefits outweigh costs of clearing irrigation systems, water supply, roads, bridges, school premises, health centers, historical sites and agricultural soil.

Commenting on such studies Paterson (2001) notes that the true economic benefits of landmine clearance are often underestimated. Because clearance operations usually concentrate on the most contaminated areas, rather than considering average contamination. This neglects a larger range of issues that would otherwise increase the average benefit-cost ratio of mine clearance[6]

Developed countries now use the value of statistical life (VSL), based on the surveys on the willingness to avoid risks or from market-based, revealed preference studies. While the theoretical superiority of VSL has been recognized in the landmine clearance literature before, the absence of estimates for countries with landmine problems has constrained researchers to use imperfect forgone earning methods (Harris 2000). Gibson, Barns, Cameron, Lim, Scrimgeour, and Tressler (2006) look into the value of statistical life (VSL) in rural Thailand using the continent-valuation (CV) method by Rosen (1988). The authors criticize the use of present values of lost income to value landmine injuries and premature deaths. Because it ignores risk aversion and thus underestimates the value of life. Their estimated VSL of US$ 250,000 is much larger than previously found.

[5] Authors' communication with Halo Trust Angola - December 2009

[6] The question of how those benefits are determined can clearly have a contentious dimension. In Cambodia regime officials favoured the clearance of lands they had a stake in. This caused subsequent tensions over land-grabbing (Landmine Monitor 2008)

Gibson, Barns, Cameron, Lim, Scrimgeour, and Tressler (2006) present the argument that while economists may underestimate the value of lives saved from landmine clearance, mine clearance agencies may overestimate and subsequently spend excessive amounts of time and money on risk reduction. Elliot and Harris (2001) have suggested that donors project their own standards and expectations.[7] Over-valuing saved lives could explain why landmine clearance standards are so strict, requiring 100% removal of mines (United Nations Mine Action Service 2009). The implication is manual clearance, as machines are not yet able to find every single mine. Howeve, strictly economically speaking, it would be more efficient to reduce the risk of landmines to the point where marginal costs equal marginal benefits.

Cost-benefit evaluations have yet to provide a final answer on landmine clearance. This research offers the opportunity to bring forth a worthwhile debate on the funding priorities in post-conflict countries. Our estimates indicate that cost-benefit studies have neglected wider impacts of landmines on households.

5 The Strategic Use of Landmines

Landmines have been coined the ”poor man’s weapon.” They have the deadly characteristic of being versatile in their strategic usage, costing as little as US$1 to produce and requiring little technical skill to use. Consequently, they have been heavily used in combat settings in developing countries such as Angola.[8]

All actors who took part in the Angolan conflict used landmines. The government and Cuban forces laid extensive minefields around their bases in and around towns. Mines were also laid extensively around infrastructures such as airports, pylons, water sources and bridges. This strategy is still visible in the geographical distribution of Suspected Hazardous Areas today. After the Cold War and the end of international support to both UNITA and the government, landmines became a weapon of choice, particularly for increasingly cash-strained UNITA. The strategic value of landmines as “force multiplier” further increased with UNITA’s change of military strategy from semi-conventional warfare to mobile guerilla and the movement’s loss of its historical strongholds Bailundo, Andulo and Jamba in 1999.

As the conflict in Angola was not a positional war, limited to specific militarized areas, almost every part of the country is now affected by landmines. During the course of the war, positions radically shifted back and forth from one side to the other. Landmines were laid at each stage for protection and to “undermine” the enemy. Mines were used in permanent

[7] This appeal to donors’ empathy, which is used by the United Nations in its advocacy for Mine Action. For instance campaigns us the image of young girls playing a soccer match in what would seem like a typical western setting when a landmine goes off. The phrase ”if there were landmines here, would you stand for them anywhere” is then displayed. http://www.stoplandmines.org/slm/index.html (last accessed September 15, 2009)

[8] Improvised Explosive Devices (IED), or handmade landmines, are extensions of those versatile uses and have become the weapon of choice of non-State actors in Pakistan, Iraq or Chechnya. IED, however, were not widely used in Angola. Both sides received weapons from their foreign allies and were able to accumulate substantial stocks that lasted beyond the end of the Cold War(Geneva Call 2004).

military position or before withdrawing from locations. Because of the front mobility, the disruption of land communications was a major aim of UNITA. And thus mining of roads, paths and bridges was a deliberate strategy.[9]

Outside of its base area in the southeast (Kuando Kubango), UNITA consolidated and administered few areas. Beyond these areas the wide dissemination of landmines was used to deny the government the use of territory (Human Rights Watch 1993). Therefore, UNITA's use of landmines can be said to have been primarily offensive, reflecting their rebel status in the civil conflict equation.[10] On the other side, the government, the FAA and the Cuban forces mined to protect their military positions, bridges, pylon lines, and dams. The government also used landmines to deny access to agricultural land in order to cut food supplies of the opponent (Heynen, Unruh, and Hossler 2003). All sides' strategically used mines for social and economic disruption.

Unfortunately, the Landmine Impact Survey has no information on the type and origins of landmines, and hence of which side planted them. Demining operators in Angola found more than 40 different types of mines from 15 countries.[11] More information regarding landmines types is provided in the Annex.

One can classify the strategic usages of landmines to better understand their impact(see Human Rights Watch (1993) and McGrath (2000)).

-Route denial: This strategy primarily uses anti-tank and anti-vehicle devices in order to deny the use of roads and tracks to the opposing forces. In some cases, anti-tank mines are combined with anti-personnel mines to discourage clearance.[12] Both UNITA and the government's forces mined in this way. One of the principal NGOs involved in humanitarian mine action, HALO Trust reckons anti-tank mines on roads constitute a bigger problem than in any other mine-affected country.

-Ambush: Ambushes were a common tactic throughout all phases of the Angolan conflict. The range of devices employed was dictated by the nature of the target, i.e. whether dealing with a vehicle convoy, an armored column or a foot patrol. Ambushes have been the primary use of directional devices such as the infamous M18A1 (Claymore) and MON-50 and MON-100.[13] However, those anti-personnel mines are theoretically less problematic, as the

[9] Che Guevarra underlined in his essay "La Guerra de Guerrillas" (1961) that "explosions of mines in roads and the destruction of bridges are very important methods to be taken into account"(Osanka 1962). Savimbi's biographer, Fred Bridgland, noted pointed out his interest for the tactics of Che Guevara (Bridgland 1987).

[10] Non-state-actors in general rely primarily on landmines for offensive purposes (Geneva Call 2004)

[11] In Angola, it was estimated in 1994 that landmines "reduced food production in the areas around Malange and other besieged cities by more than 25%" See the Secretary-General 1994 Report to the General Assembly on Assistance in Mine Clearance, A/49/357.

[12] Originally, anti-personnel landmines were invented to protect anti-tank mines.

[13] The M18A1 Claymore is a type of directional anti-personnel mine used by the U.S. military that fires shrapnels, in the form of steel balls, out to about 100 meters across a 60 arc in front of the device. The MON-50 and MON-100 are the Soviet version of anti-personnel mines. This dimension also plays in the strategic value of landmines along the DMZ line separating North and South Korea. It should be noted that

combatants can remove their remote detonators. Still, cases where tripwire or booby-traps were used to activate those mines have been found. Since many ambushes were set at key sites, such as wells, river crossings, or track junctions, the incidence of remote devices at these locations is high. Few records have been kept of such mine-laying.

-Bridgehead Mining: All combatant groups in Angola have commonly mined bridgeheads. This now presents not only a danger to civilians, but a serious obstacle to economic and social rehabilitation. Bridgehead mining has taken two forms. The first is the defensive mining of standing bridges. The second is mining to prevent the repair or reconstruction of destroyed bridges by mining the damaged bridges, approach routes and adjacent river banks. Bridgehead mining has been a particularly serious problem in southern Angola and in the Province of Moxico.

-Defensive Mining of Key Structures and Facilities: this was used primarily by the government(FAPLA) to deter insurgent action against key economic installations and strategic locations. This tactic is well-illustrated by the use of anti-personnel mines at the base of electricity pylons. Major roads, railroads, dams, oil installations, diamond mines and water pipelines were also protected in this manner. FAPLA also laid protective and nuisance minefields around the perimeters of towns and municipal centers where UNITA attacks were expected. In addition, FAPLA laid large defensive minefields around the towns of Cuito Cuanavale and Cassinga to counter UNITA advances in these areas. This defensive use of minefields against conventional ground assaults was in accordance with the Soviet military doctrine. At least some of these minefields appear to have been recorded.

-Random Dissemination: the random dissemination of land mines can have an immediate military purpose, i.e. to deter infantry attack and reconnaissance patrols. It can also have the purpose of terrorizing civilian communities. However, after so many years of war, it is impossible to determine whether the randomly disseminated mines in a particular area were originally deployed for one purpose or the other. In the post-combat era, any such distinction is not even relevant.

Another key dimension of landmines strategy is fear and terror. The psychological dimension of landmines has been exploited strategically. It is also one of the dimension that extends most beyond the end of hostilities. It denies access to areas that may or may not be mined. The simple suspicion of an area being mined can have socio-economic consequences in the long run.[14]

While acknowledging the complexity of mining strategies, we will assume that the government used mines primarily defensively (including over larger perimeter than the immediate protected target), while UNITA mined offensively. Those differentiated strategic uses mean that defensive mining was more intensive than offensive mining. It only takes a couple of

the United States position regarding anti-personnel mines is heavily dictated by the situation between North and South Korea.

[14] For this reason trust from the concerned community in demining activities is essential.

mines to block a road, but hundreds or even thousands of mines are required to protect a city.

6 Empirical Specification

We aim to quantify the impact of landmines as proxied by Suspected Hazard Areas on household income and child health. In particular child anthropometrics can be expected to be directly and indirectly affected by landmines. In contrast to income, anthropometrics are a particularly reliable proxy of household welfare. The long term indicator height-for-age z-score (HAZ) may indicate retardation in growth resulting from a poor diet over a prolonged period of time. In addition we use the more short term responsive weight-for-age z-score (WAZ).

Let i denote children, h households, c communes, and N the sample size. The basic structural equation that we are seeking to estimate is given by:

$$Y_{ihc} = x_{ihc}\,\alpha + w_c\beta + \varepsilon_{ihc} \tag{1}$$

where Y_{ihc} is the N x1 vector associated with the outcome of interest (such as child health), x_{ihc} is a matrix of child, household and commune control variables, w_c is the number of Suspected Hazardous Areas in a certain radius around the centre of a commune, and ε_{ihc} is a disturbance term. Our purpose is to consistently estimate the impact of Suspected Hazardous Areas on our outcome variable.

We decompose the disturbance term into two components:

$$\varepsilon_{ihc} = \lambda_c + \eta_{ihc} \tag{2}$$

where λ_c represents commune-level unobservables that affect the outcome, while η_{ihc} are child- or household-level unobservables.

There is a danger that OLS estimates of (1) will lead to an inconsistent estimate of β, since the number of landmines is likely to be correlated with commune-level unobservables λ_c. For example, the decision of rebels or government forces to engage in military operations in an area are probably correlated with commune characteristics that are not adequately captured by the household- and commune-level observables that are included in x_{ihc}. Estimating (1) with commune-specific fixed effects solves this problem, but variables such as w_c can then no longer be identified. As a result, we decide to include fixed effects at the hierarchically higher province level and thus estimate within provinces. In particular, the provincial dummies should explain a sizeable bulk of the variance of Suspected Hazardous Areas and mob up province-level endogeneity. Commune-specific random effects are not feasible either, because the likely endogeneity of landmines implies that it will be correlated with the random effects. Consequently, the only solution is instrumental variables. We base our identification strategy on the history of the conflict and the strategic use of landmines.

7 Identification Strategy

The idea behind our identification strategy is informed by the nature of the guerrilla warfare that characterized the larger part of the Angolan conflict. We use the distance to the centre of gravity of UNITA's headquarters in the Planalto (Central Highland) region as exclusion restriction. This region had been intensively mined for both offensive and defensive purposes by both sides. Our hypothesis is that communities closer to UNITA are likely to be more mined.

The Planalto, Angola's geographical heartland, was the centre of UNITA's influence. UNITA aimed to keep the government away from these provinces. The ethnic majority in these provinces is Ovimbundu, Savimbi's own ethnic group. The region initially supported UNITA, seduced by the professed self-sufficiency rhetoric of the movement. In 1992, the region voted for Savimbi in the presidential elections that were lost by UNITA at the national level.[15]

UNITA's attachment to the Planalto region is thus mainly based on historical ethnic support. Unlike other ethnic groups in Angola the Ovimbundus did not come into contact with the Portuguese until the 18^{th} century. They were organized into several powerful kingdoms - Bié, Andulo, Huambo and Bailundo - of which Bailundo was dominant. Only at the turn of the 20^{th} century, after the Bailundo Revolt (1902), the Ovimbundu kingdoms were subdued.[16] The construction of the Benguela railway line between 1903 and 1929 allowed the spread of Ovimbundu settlements into the interior of the province of Moxico (Cornwell 2000).

The main headquarters constituting our instrument, N'Harea, Mungo, Bailundo, Cuemba and Andulo are all located in Ovimbundu heartland. While those localities are historically important and relevant for UNITA's identity, they are small peri-urban settlements. After UNITA had set-up headquarters in those locations, they preserved their geographical remoteness as a strategic asset and did not attempt to develop those areas.[17] Finally, note that little direct fighting clashes occurred in this area until the fall of those headquarters in late 1999. The big battles notably occurred around the cities of Huambo, Kuito and Malanje, but which are remote from these Planalto headquarters.[18]

Our instrument is based on the centre of gravity of the Planalto headquarters. Figure(1) gives a satellite overview of the UNITA headquarters and their center of gravity. Due to

[15] Savimbi based his rejection of the national elections on the support he received from this region and promptly marched towards the cities of Huambo and Kuito. This led to the sieges of the two cities, which did not welcome UNITA with open arms as the movement had expected. UNITA imposed a particularly ruthless siege on Kuito, which lasted for over nine months. Fighting resulted in the direct and indirect death of an estimated 30,000 people, notably from starvation

[16] Jonas Savimbi's grandfather, Sakaita, fought in this revolt/war.

[17] "Although of questionable strategic significance, Bailundo, a shabby town in the central highlands, is the traditional capital of Mr Savimbi's Ovimbundu people. It was the seat of the king, and also the starting point of the 1902 Ovimbundu rebellion against Portugal, the colonial power. It is, therefore, of great symbolic importance" The Economist , Battling in the rain, Oct 7th 1999

[18] The distance between these cities and the closest UNITA Planalto headquarter is: 200 km for Malanje, 70 km for Huambo and 97 km for Kuito.

the relatively small geographical distances between, the average latitude and longitude is a good proxy to the centre of gravity. Using the distance to the nearest UNITA headquarter gives us similar results. However we prefer the use of the centre of gravity as it reflects the aggregated contentiousness of the areas, while being located in an area unlikely to be a source of endogeneity. The map in Figure (4) gives the center of gravity and the locations of Suspected Hazard Areas , as well as communes in our sample.

Our instrument must satisfy two conditions. First, conditional on the child-, household- and commune-level covariates included in x_{ihc} , the distance to UNITA headquarters must be a statistically significant determinant of the intensity of Suspected Hazardous Areas facing commune c. Second, it must, conditional on x_{ihc} , be orthogonal with respect to λ_c.

Several potential confounding factors that are correlated with the outcome and instrumental variable are included in the empirical models. As previously mentioned, the location constituting our instrument is fairly remote. The distance of a given commune to the UNITA headquarters might be inversely related to the commune's remoteness, which itself might well be correlated with household and commune-level unobservables that affect the response variable(s). Therefore, we include, amongst the covariates, variables that will control for remoteness, such as the distance of communes to Luanda and to their respective provincial capital (economic remoteness).

We use a rich set of war intensity proxies. We control for the distance of communes to the Benguela railway. This was a de facto frontline between the government and UNITA during the conflict; even as the nature of the war evolved to guerrilla warfare. The railway runs from the port city of Benguela (Benguela province) to the border town of Luau (Moxico province), connecting with the Zambian and Congolese (DRC) railway networks[19] . It covers a distance of 1,344 km and crosses four provinces (Benguela, Huambo, Biè and Moxico). Save for a brief period in 1980 the line was closed for the duration of the civil war following Angola's independence in 1975. A complementary variable to indicate on which side of the Benguela railway the commune is located is also included. Finally, a conflict intensity variable representing the number of casualties in an appropriate radius over the period of civil war (1975-2000) is included in our specification.

One of the data limitations is the absence of disaggregated population density estimates. Instead we argue that the total of length of roads(picadas) in the commune is a close proxy of population density, remoteness, infrastructure level and thus propensity to Suspected Hazardous Areas contamination. In addition, our road measure controls for the strategic mining of roads and public infrastructure, which may be correlated with our instrument, Suspected Hazardous Areas and our outcome variables.

It is well known that Angola is rich in natural resources. In particular oil and diamond mines are related to a plethora of variables such as infrastructure, income, and conflict

[19] In 1931, when the Benguela Railway was completed, the Belgians extended their line from the important junction of Tenke to meet it near Dilolo.

intensity. Diamonds were important to UNITA, while oil proved to be critical for the government's funding. Thanks to the mostly offshore nature of oil exploitation in Angola, the production was never interrupted during the war, insuring a steady flow of resources to the government. Although UNITA briefly controlled Cabinda,[20] the government kept control over oil production there. To account for these factors we control for the number of diamonds mines and oil fields in appropriate radii around each commune.

Last but not least, household-level control variables such as whether the household was displaced during the war, and whether infants and heads were born in the province of residence also contribute to our accounting of potential omitted variables. A rural dummy accounts for the localization of the household in an urban/rural area.

To summarize our identification strategy: Suspected Hazardous Areas intensity is a decreasing function of the distance to the center of gravity of UNITA headquarters. Letting z_c^{UNITA} denote this distance to each commune, our identification story suggests that the underlying first-stage reduced form that corresponds to the structural equation specified in (2) should be given by:

$$w_c = x_{ihc}\gamma + z_c^{UNITA}\pi_1 + v_{ihc} \quad (3)$$

with $\pi_1 < 0$. Whether or not z_c^{UNITA} does provide any modicum of identification can be explicitly tested by examining the statistical significance of π_1.

8 Data

The robustness of our estimates owes to the use of two different household surveys conducted in 2000/2001: the Inquerito aos agregados familiares sobre despesas e receitas (national household survey on expenditures and incomes, henceforth referred to as IDR) and the Multiple Indicator Cluster Survey (MICS).

The IDR was conducted in 1999-2000 in the provinces of Cabinda, Luanda, Lunda Norte, Benguela, Namibe, Huila and Cunene. Given the unstable security situation at the time, the survey is roughly representative of areas of Angola under effective government control and has a strong urban component, caveats that should be kept in mind in interpreting our results. Angola is made up of 18 provinces. The survey was carried out by the Gabinete de monitarizao das condies de vida da populao, Instituto nacional de estatstica (INE), Ministerio do planeamento (MINPLAN). The IDR 2000 includes information on household composition, expenditures, education, health and fertility behavior. It uses a stratified sampling design in which 12 households were surveyed in a random fashion in 226 aldeias (villages) in rural areas and bairros (neighborhoods) in urban areas, in 50 communes. While language cannot be exactly equated with ethnicity, it remains a good proxy in the case of Angola. In the IDR

[20] In 1993, UNITA captured the onshore oil city of Soyo in Cabinda. The government responded by hiring the South African mercenary firm Executive Outcome which managed to secure the entire oil producing region. The government further extended EO contract to train the national army.

we can control for the language spoken by the household head. Summary statistics for the IDR 2000 data are presented in Table (3).

The MICS was conducted in 2001 (April-October) by the National Institute of Statistics (INE) and the United Nations Children's Fund (UNICEF). It covers 6,252 households in all 18 provinces. The MICS reviews 42 indicators specifically designed by UNICEF to assess the situation of children under five years of age and women 15 to 49 years old in health, nutrition, water, sanitation, hygiene, education and child protection. Although most communes were under effective government control, many had previously been under UNITA influence. However relatively more households were surveyed in urban areas than in IDR. In MICS ethnicity or language questions have been omitted. Summary statistics for the MICS data are presented in Table (2).

For the landmines we use the 2007 Landmines Impact Survey. It was coordinated by the Survey Action Network in the 18 provinces of Angola from 2004 to 2007. The Landmine Impact Survey is a complete countrywide survey with all but 19 of the 556 communes visited and 383 of them found to be impacted. A total of 28,000 people took part in community interviews in the 1,988 impacted communities; an additional 10,000 took part in interviews. The Landmine Impact Survey provides different sets of information like the number of recent victims (last two years) and non-recent victims, level of impact, number of Suspected Hazardous Areas and types of socio-economic blockages. The main data we decide to use in this research are the locations of Suspected Hazard Areas . This allows us to address the issue of contamination beyond the directly impacted community. At this level, the Landmine Impact Survey allows for a distinction between the different types of landmines (anti-personnel, anti-tank and unexploded ordnances). The Landmine Impact Survey identified 3,293 Suspected Hazardous Areas, with Moxico and Bié representing 30% (965) of all Suspected Hazardous Areas in the country. If the number of Suspected Hazardous Areas of Uge and Kuando Kubango are also added, these fours provinces represent 50% of the Suspected Hazardous Areas in Angola. 60% of impacted communities 'only' have one Suspected Hazardous Areas and 85% have one or two Suspected Hazardous Areas. The Landmine Impact Survey indicates that 58% of impacted communities (and 62% of the Suspected Hazardous Areas) have one type of mine. The number of Suspected Hazardous Areas reported to have anti-tank mines is 952 and the number reported to have anti-personnel mines is 2,723.[21]

All the Landmine Impact Survey data is geo-referenced. Using a world gazetteer[22] we geo-referenced both our IDR and MICS datasets with the communal capital, the lowest level

[21] The Landmine Impact Survey also provides data specific to recent landmines victims. The survey identifies 341 casualties in the 24 months preceding the survey, of which 79% were men, with 75% of those between the ages of 15 and 44 years of age. The province of Moxico represent one third of the total number of casualties. The survivor rate of 50% in Angola is lower than most affected mine-affected country. The rate is usually closer to 60% and sometimes as high as 70%. While this level of data provides information on the 'profile' and characteristics of the victims, it should be noted that a significant portion of those killed were in fact traveling outside of their own community. They were therefore not 'known' to the impacted community and subsequently classified as 'unknown'.

[22] Such as the website: www.fallingrain.com

possible. We calculate the number of mines within various radii of these. For two reasons we concentrate on relatively large radii between 50 and 150 km. First, we want to show that landmines have an impact that goes beyond the directly affected communities. Second, one caveat is that the size of the commune varies substantially. For instance, in IDR the mean area is 20070 km^2 with a standard deviation of 25102 km^2. The chosen radii cover well the varying degree of commune sizes. Radii too small may over- or underestimate the number of mines for households far off the communal capital.

Our conflict intensity variable is based on the extensive work of Ziemke (2007). She used archives, libraries and news agency files (a total of 186 sources from over 20 countries were involved) to construct a database of individual battle and massacre events that took place in the Angolan war over a 41 year period (1961-2002). We construct a conflict intensity variable with the number of casualties in various radii over the period 1975-2000. Again we chose relatively large radii to match the communal area and to at least match or overlap the Suspected Hazardous Areas radius. In the baseline results we use the number of casualties in a 150 km radius. Results are qualitatively similar with larger or smaller radii.

Diamonds and oil played a major role in the Angolan conflict, funding respectively UNITA and the government. We rely on DIADATA, a dataset compiled by researchers from the Peace Research Institute Oslo that identifies the sites of diamond mines across Angola. DIADATA consists of 1175 entries for diamond occurrences in 53 countries. There are 52 entries for Angola. Distances and radius between the FAS communes and the different diamond mines have been computed to account for the strategic importance of diamonds in Angola. Angola's diamonds are of particularly high quality and value (gem quality). Due to their alluvial nature they are easy to loot from the rivers where they can be found and then smuggled across borders (small weight and size, easy marketability, indestructibility). This would indicate the perfect case for the implementation of the resource curse scenario.[23] Furthermore, diamonds constituted the main source of revenue for UNITA, far more substantial than what the movement was receiving from the United States and South Africa prior to the Bicesse Accords in 1991.[24] Industry sources put UNITA's cumulative net revenue in 1992-1998 at around US$ 2 billion (Hodges 2003). However, in terms of the relation between war violence and diamonds, Ziemke (2007) finds in her research on war violence in Angola from 1961-2002 (i.e. the full forty years of the war, including the pre-independence conflict with Portugal) that diamond regions in Angola experienced in fact fewer battles and massacres than other regions, even when controlling for populations. Another important dimension of diamonds is that after UNITA lost its western backing at the end of the Cold War, Savimbi's movement was able to supply its military needs in buying weapons from former soviet countries (notably the Ukraine), trading in diamonds. We calculate the number of diamond mines in a 150 km radius around each commune. To create our oil variable we

[23] (Le Billion 2000),p.6 described Angola as "a land cursed by its wealth"

[24] As referenced by Hodges (2003) at the height of its power in the mining areas (principally Lunda Norte and Lunda Sul, in Lunda-Chokwe territories) in 1994-1997, UNITA was estimated to be marketing on average about US$600 million worth of diamonds annually. In fact, during the five years that it controlled most of the Cuango valley (1992-1997), UNITA supplied between 8-10% of the world supply of rough diamonds, even threatening to undermine the market stability fostered by De Beers' CSO

use the petroleum datasets provided by the Centre for the Study of Civil War at the Peace Research Institute Oslo(PRIO). The petroleum dataset contains information on all known on-shore and oil and gas deposits throughout the world. Two datasets are available: one for on-shore deposits and another for off-shore deposits. We use the number of oil deposits in a 150 km radius around the commune.

We include in our covariates a number of distances using ArcGis and spatial tools in R. Those include the distance to the capital Luanda, to the corresponding provincial capital and the Benguela railway. We also calculate the total length of secondary roads (picadas) per commune.

9 Reduced Form Estimates

Results for the reduced form in equation (3) are presented in Table (4) for MICS and Table (5) for IDR. The dependent variable is given by the total number of Suspected Hazardous Areas within various radii of the commune. To understand the meaning of Suspected Hazardous Areas, consider the simple correlation between the number of Suspected Hazardous Areas and recent mine victims across 15 provinces in Figure (3). An additional Suspected Hazardous Area leads to 0.77 additional fatal victims. One could interpret this finding that it takes about one victim to discover a Suspected Hazardous Area. Also consider Figure (4) that depicts the location of Suspected Hazardous Areas, the center of gravity of UNITA, communal and provincial borders, and the surveyed communes in IDR and MICS.

The reduced forms correspond to the instrumental variables results presented below for the child health response variables in MICS and income for IDR. Virtually identical results are obtained when we consider the reduced forms of the child health model in the IDR dataset. All specifications include a rich set of child, household and communal covariates, listed in the summary statistics in Table (2) for MICS and Table (3) for IDR.[25] Due to the different design of the two surveys, covariates differ slightly for the MICS and IDR regressions. IDR provides information on languages spoken (a proxy for ethnicity), while MICS features more health-related information on children like vaccinations. In addition, we include provincial fixed effects. Standard errors are clustered at the commune level in order to account for common shocks affecting all observations within a given commune.

The negative relationship between the distance to the UNITA center of gravity and Suspected Hazardous Areas is significant and robust across radii and both datasets. Consider the column with the number of Suspected Hazardous Areas in a 150 km radius. The marginal effect of moving away an additional kilometer from the center of gravity of UNITA is to reduce total Suspected Hazardous Areas by -0.53 in MICS. In IDR an additional kilometer leads to a decrease of -1.25 in Suspected Hazardous Areas. The robustness of our instrument should be convincing, given the use of two datasets, the rich set of controls, clustered stan-

[25] The same covariates are included in the structural equation to avoid what Heckman calls a "forbidden regression." Also note that we exclude the highly endogeneous income from the child health models in IDR. This exclusion is reasonable, as we argue that our instrument is exogeneous to income

dard errors and the province fixed effects. In particular, the latter capture a considerable part of the variance in Suspected Hazardous Area intensity. This tough specification should safeguard us against any remaining sources of endogeneity.

Due to their possible impact on landmine intensity, we also report commune-level covariates in Table (4) for MICS and Table (5) for IDR.[26] When interpreting these results one should keep in mind the substantially different coverage of both surveys and the endogeneity of some covariates. In MICS we find some positive relationship between Suspected Hazardous Areas and the distance to Luanda (for 100 km, 75 km, 50 km), as well as to the provincial capital (for 100 km, 75 km). In IDR these distances are not statistically different from zero. In MICS we find a positive and significant relationship between casualties and Suspected Hazardous Areas for the 150 km radius, and a negative and signifcant one for 75km. This relationship is negative and significant in the IDR model for 100 km,75km and 50 km. A 1000 additional casualties decrease the number of Suspected Hazardous Areas within 100 km by six. In MICS there is a positive, but not significant correlation of Suspected Hazardous Areas with the distance to the Benguela frontline. In IDR we do find a large, positive and significant correlation with this frontline. As one moves away from the frontline, the number of Supsected Hazard Areas increases.

10 Empirical Results

Baseline linear instrumental variables results for child height-for-age (HAZ) z-scores are presented in Table (6) for MICS and Table (7) for IDR, weight-for-age (WAZ) z-scores in Table (8) for MICS and Table (9) for IDR, log household expenditures per adult equivalent in Table (10) for IDR. Corresponding OLS estimates and Hausman tests of exogeneity are reported below the IV estimates.

In both datasets we find a large, negative and statistically significant impact of Suspected Hazardous Areas on height-for-age. Consider the number of Suspected Hazardous Areas in a 150 km radius in Table (7) and (6); an additional 100 Suspected Hazardous Areas reduce HAZ z-scores by 0.65 in MICS and 0.45 in IDR. Similarly, for the 50 km radius an additional 100 Suspected Hazardous Areas lead to a reduction of 0.89 in MICS and 1.00 in IDR. If we compare a commune with zero Suspected Hazardous Areas within 50 km to a commune with 43.05 Suspected Hazardous Areas in MICS (i.e. the sample standard deviation), we find a difference of 0.39 (i.e. -0.00897 x 43.05) in height-for-age. This is 24% of the sample standard deviation in HAZ z-scores. Furthermore, the Hausman test of exogeneity indicates that the OLS estimates for 100 km, 75 km and 50 km are downward biased. For instance, using the OLS estimate for 50 km in MICS, the difference would be -0.068 (i.e. -0.00157 x 43.05). This amounts to a mere 4% rather than 24% of the sample standard deviation. Repeating the exercise for IDR and the 50 km radius; a commune that moves from zero to 12.3 Suspected Hazardous Areas, suffers from a reduction in HAZ z-scores of -0.12 (i.e. -0.01004 x 12.3), which corresponds to 8% of the sample standard deviation. Note that OLS

[26] We do not report household and individual level covariates in the reduced form as they have no meaning effect on landmine intensity.

and IV results for IDR are statistically equivalent, as we fail to reject the tests of exogeneity under the assumption that our identification strategy is valid.

Results for short-term child health are equally striking, but not robust across surveys. As shown in Table (8) and (9), the marginal impact of Suspected Hazardous Areas on weight-for-age z-scores is as expected negative. The effect is statistically different from zero at 5% across all radii for MICS, while we find negative, but not significant effects in IDR. An additional 100 Suspected Hazardous Areas within 150 km reduce WAZ z-scores by 0.405 in MICS and 0.195 in IDR. If we compare a commune with zero Suspected Hazardous Areas within 75 km to a commune with 60.7 Suspected Hazardous Areas in MICS (i.e. the sample standard deviation), we find a difference of 0.25 (-0.00405 x 60.7) in weight-for-age. This is 20% of the sample standard deviation in WAZ z-scores. For MICS, OLS results are significantly downward biased for 100 km, 75 km and 50 km. Note that we fail to reject the Hausman tests of exogeneity for IDR, which suggests that OLS and IV are statistically equivalent.

A few remarks are in order to interpret the different results between IDR and MICS. The mean mine intensity and variance is substantially higher in MICS than in IDR. Two reasons can be pointed out. First, roughly 8% of households in the IDR sample are in rural areas, compared to 33% in MICS. Second, the MICS survey spans across 61 communes across all 18 provinces. Some of these communes had previously been under UNITA influence, while the IDR surveyed 50 communes in the seven provinces that were solidly under government control. And children under five years have on average lower height and weight for age in MICS than in IDR.

As for household expenditures per adult equivalent in the IDR sample, Suspected Hazardous Areas have a large, negative and significant impact. Consider the 150 km radius in Table (10); an additional 10 Suspected Hazardous Areas within 150 km, lead to a 4.5% reduction in household income. Comparing a household in a commune free of Suspected Hazardous Areas within 150 km with a household in a commune with 62.44 Suspected Hazardous Areas (the sample standard deviation), the difference in income is 28% (62.44 x 0.45).

11 Implications for Landmine Clearance

Having identified a large and negative impact of Suspected Hazardous Areas viz. landmines on child health and income, we now reconsider the issue of mine clearance. While removing landmines is a fairly straightforward technical undertaking, it is embedded in a larger political context.[27] According to the United Nations Office of Humanitarian Affairs (OCHA) and the Financial Tracking System, over US$52 million were committed to mine action activities in Angola since 2000.[28] However, international funding for mine action has decreased by 60% in 2007 compared with the previous year (Landmine Monitor 2008).

[27] Other sensitive land clearance settings include Afghanistan. See Bolton (2008) on the commercialization of demining, a situation also found in Angola to a lesser degree.

[28] The Financial Tracking Service (FTS) is a global, real-time database which records all reported international humanitarian aid, including NGOs, the Red Cross, bilateral aid, in-kind aid, and private donations.

Donors' fledging commitment to demining in Angola can be explained by four factors. First, the traditional 'donor fatigue' five years after the end of the war has started. Second, some donors prefer funding mine education programs over mine removal. While mine education can decrease the risk of accident, it does not permanently remove the mine risk and help long term development. Third, while sharing the same goal of a 'world free of landmines', and being now placed under the common "mine action" umbrella[29] , there is an increasing divide between the mine-ban lobby and demining actors. This divide has emerged since the push for the Ottawa Treaty (which only covers anti-personnel mines). Indeed, mine-ban proponents have been accused of overplaying the size of landmine contamination worldwide. Due to the lack of reliable data for most countries, the number of landmines was indeed greatly inflated as no country wanted to be held responsible of torpedoing the Treaty signing. The success of the mine-ban lobby has grave, unintended consequences. There is a misguided perception amongst some donors that 100% mine removal is an endless task. Still it remains that the only definitive solution to removing landmine threat is demining.[30] Finally, Angola is in the unusual position to fund its own demining program due to its oil revenue. Angola has over 40 accredited commercial demining companies and six international NGOs operating in mine clearing. International donors fund NGOs and the government funds the commercials, INAD and Angolan Armed Forces.[31]

How do the results presented in this paper fit in this context? 100% mine removal may not be feasible for a country like Angola (if only for lack of national and international political interest). The NGO HALO Trust, which was in charge of four provinces[32] for the Angolan Landmine Impact Survey estimates that on average only one-quarter of the suspected areas requires physical clearance. This means that either the Suspected Hazardous Area is not mined, or that it is located in an area where demining is not necessary.

Our results indicate the existence of a larger scope of mine impact than traditionally envisioned in mine action. Thusfar the impact on child health and household income has not been factored into cost effectiveness analysis of landmine removal. These findings have three implications: (1) The cost effectiveness of mine removal in comparison to other forms of mine action (e.g. mine risk actions) has been underestimated. (2) The Landmine Impact Survey calculates an impact score, indicating the severity of contamination in a commune. This score is based on the number of recent victims, the number of different types of socioeconomic and institutional blockages, and the type of munition (landmines and/or unexploded ordnances.[33] This calculation overweighs recent victims in the final score. A complementary

[29] see Electronic Mine Action Network : http://www.mineaction.org/

[30] See Halo Trust speech at the five-year point of the Ottawa Treaty (2004) Landmines and Sex available at: http://www.halotrust.org/landminesandsex.html.

[31] The European Union, the United Nations, Canada, Norway and Germany, among others, have heavily contributed to clearing mines since 1994.

[32] Benguela, Huambo, Bié and Kuando Kubango

[33] (0-5 points = low impact; 6-10 points = medium impact; and 11 or more points = high impact). In the case of Angola, the Landmine Impact Survey identifies 40 impacted communities (2%) as high-impact, 455 (23%) as medium impact, and 1,493 (75%) as low-impact

calculation could include the landmine impact on child health and household income.(3) Reliable data is key to assess the impact and clearance of landmines. Furthermore, as noted by Harpviken (2003), the impact assessment ought to be conceptualised not as a one-off event, but as a process that forms a integral part of the whole project cycle, meaning that data ought to be kept relevant.

12 Concluding Remarks

This paper has explored the impact of landmines on child health and household income in the last years of the Angolan conflict. Our instrumental variable uses the exogenous variation in landmines intensity generated by the distance separating the communes of our sample from UNITA Planalto headquarters.

Linear instrumental variable estimates, based on two sets of household survey data collected in 2000/2001 (IDR and MICS) indicate that landmines lower height-for-age, weight-for-age and household income beyond the immediately affected communities. These results confirm the far-reaching and lasting consequences of landmines for households in times of conflict and beyond. This suggest a higher cost-effectiveness of mine clearance, as usually assumed.

Furthermore, this paper argues that landmines issues should be placed in the larger scope of development. Unlike other scourges afflicting countries emerging from conflict, landmines are a finite problem, once removed, they do not come back. This requires political will and pragmatism rather than idealism. After the Second World War, France was heavily mined. 13 million landmines and unexploded ordnances were spread over 500,000 hectares of land, about 1% of the country's territory. Demining was acknowledged as a prerequisite to reconstruction. Hence a demining direction was created in February 1945. At the end of 1947, demining operations were considered for the most part completed.[34] This example highlights the critical dimension of political will in the mitigation and removal of landmines. A Better understanding of the impact of landmines on child health and household welfare underlines the importance of mine action in development. In the ten years since Ottawa Treaty, there is still only one effective long term way of removing the threat caused by landmines: demining (Survey Action Center 2009).

[34] This prompt demining is the also the result of the initial over-estimation of the number of mines (55 million), as well as the important means allocated to the task including media campaign (press, boards, radio). In violation of the Geneva Convention (1929, art.31), prisoners of war were also used along with young unemployed Frenchmen. In spite of the training and caution taken, 2,300 deaths occurred in this process (1,800 German and 500 French). Unexploded ordnances are still regularly found in the north-eastern part of France, but accidents have been extremely rare since the end of the war (Voldman 2005).

References

Arcand, J.-L., and E. Wouabe (2009): "Households in a Time of War:Instrumental Variables Evidence for Angola," .

Behre, A. (2007): "The contribution of Landmines to Land Degradation," Land Degradation and Development, 18, 1–15.

Bolton, M. (2008): "Goldmine? A Critical Look at the Commercialization of Demining in Afghanistan," Report for the Center for the Study of Global Governance, London School of Economics (LSE), 1.

Bridgland, F. (1987): Jonas Savimbi : A Key to Africa. Mainstream Publishing, Edinburgh, 1th edn.

Center For Disease Control (1997): "Landmine Related Injuries," MMWR, 46(31), 724–726.

Cornwell, R. (2000): "The War for Independence," in Angola's War Economy, ed. by J. Cillier, and C. Dietrich, Pretoria, South Africa. ISS Monograph.

Doswald-Beck, L., P. Herby, and J. Dorais-Slakmon (1995): "Basic Facts: the human cost of landmines," www.icrc.org.

Elliot, G., and G. Harris (2001): "A cost-benefit analysis of landmine clearance in Mozambique," Development Southern Africa, 18(5), 625–633.

Geneva Call (2004): "The Involvement of Armed Non State Actors in the Landmine Problem," Geneva Call Reports, http://sekhon.berkeley.edu/papers/MatchingJSS.pdf.

Gibson, J., S. Barns, M. Cameron, S. Lim, F. Scrimgeour, and J. Tressler (2006): "The Value of Statistical Life and the Economics of Landmine Clearance in Developing Countries," World Development, 35(3), 512–531.

Gildestad, B. (2005): Cost-benefit analysis of mine clearance operations in Cambodia. Nordic Consulting Group, for the Cambodian Mine Action Authority (CMAA) and UNDP.

Harjai, M., D. Agarwal, P. Dave, S. Jogg, and P. Arora (2005): "Mine Blast Injuries," Medical Journal Armed Forces India, 61, 143–147.

Harris, G. (2000): "The economics of landmine clearance: case study of Cambodia," Journal of International Development, 12(2), 219–225.

——— (2002): "The economics of landmine clearance in Afghanistan," Disasters, 26(1), 49–54.

Heynen, N., J. D. Unruh, and P. Hossler (2003): "The Political Ecology of Recovery from Armed Conflict: the case of landmines in Mozambique," Political Geography, 22(1), 841–861.

Hodges, T. (2003): Angola : Anatomy of and Oil State. Indiana University Press, 601 North Morton Street, Bloomington, IN, 1th edn.

Human Rights Watch (1993): Land Mines in Angola. Africa Watch.

——— (1997): Human Rights Watch Arms Report: Still Killing- Landmines in Southern Africa. Human Rights Watch, New York.

Kakar, F., F. Bassani, C. Romer, and S. Gunn (1996): "The Consequences of Land Mines on Public Health," Prehospital and Disaster Medicine, 11, 2–10.

Landmine Monitor (2008): "Landmine Monitor Angola 2008," .

Le Billion, P. (2000): "The political economy of resource wars," in Angola's War Economy, ed. by J. Cilliers, and C. Dietrich, Pretoria, South Africa. ISS Monograph.

McGrath, R. (2000): Landmines and Unexploded Ordnance: A Resource Book. Pluto Press, London, 1th edn.

Merrouche, O. (2006): "The Human Capital Cost of Landmine Contamination in Cambodia," Household in Conflict Network (HiCN) Working Paper, (25).

——— (2008): "Landmines and Poverty: IV evidence from Mozambique," Peace Economics, Peace Science and Public Policy, 14(1), 145–164.

Miguel, E., and G. Roland (2005): "The long-run impact of bombing Vietnam," Berkeley mimeo.

Mitchell, S. (2004): "Death, Disability, Displaced Persons and Development: The Case of Landmines in Bosnia and Herzegovina," World Development, 32(12), 2105–2120.

National Research council (2001): "Alternative technologies to replace anti-personnel landmines," .

Osanka, F. (1962): Modern Guerilla Warfare-Fighting Communist Guerilla Movements 1941-1961. The Free Press of Glencoe, Illinois, 1th edn.

Paterson, T. (2001): "Commentary on "the economics of landmines clearance: case study of Cambodia"," Journal of International Development, 13(3).

Rosen, S. (1988): "The value of changes in life expectancy," Journal of Risk and Uncertainty, 1(3), 285–304.

Rupiya, M. R. (1998): Landmines in Zimbabwe:A Deadly Legacy. SAPES Books, Harare.

Sheehan, E., and M. Croll (1993): Landmine Casualties in Mozambique. HALO Trust, Maputo.

Survey Action Center (2007): "Landmine Impact Survey of Angola," .

——— (2009): Integration Mine Action with Development: Enhancing Use of Landmine.

UNICEF (1996): The State of the World's Children. Oxford University Press, Oxford.

United Nations Mine Action Service (2009): "Mine Action," .

Voldman, D. (2005): "Le Deminage de la France apres 1945," Les Chemins de la Memoire, 153, 7–10.

Williams, J. (1995): "Landmines: A Global Socioeconomic Crisis," Social Justice: A Journal of Crime, Conflict and World Order, 22(4), 97–114.

——— (1996): "Landmines: A Deadly Legacy," Armed Forces and Society, 22(2), 305–307.

Ziemke, J. (2007): From Battles to Massacres: An Analysis of Changing Conflict Patterns in Angola: 1961-2002. University of Wisconsin-Madison, Madison, WI.

A Technical Notes on Landmine Impact Surveys

Humanitarian Mine Action (HMA) uses surveys to assess the scope of landmines and unexploded ordnances contamination. Examples of those surveys include Landmine Impact Surveys, emergency surveys and standards surveys. Of these, the Landmine Impact Survey has now become the standard approach.

All of these methods collect data on areas of risk to the population-a risk caused by landmines or unexploded ordnances. Information on the risk areas, called Suspected Hazard Areas , is based on data already available, data collected by visual inspection from a safe viewing point and by using information volunteered by key informants from the community. A wide range of mine action activities, such as impact assessments, national strategies, clearance and marking operations planning and conduct, mine risk education (MRE), and victim assistance depend on the Suspected Hazardous Area data as the key data entity.

However, it should be noted that no mechanical investigation is deployed in order to confirm or discard the information, or to objectively assess the reliability and completeness of the information. Incidentally, cases where the Suspected Hazardous Area is actually smaller or less contaminated than initially thought can occur upon the demining of this area. This can have some implications in terms of demining cost and budgeting, but the surveying of every mine is a much more time and money consuming approach which explains the preference for the Landmine Impact Survey approach. Some HMA organizations have however expressed concerned about the coarse nature of some of the data (i.e. the survey is sub-contracted to NGOs operating in the different provinces) which is heavily reliant on the expertise and meticulousness of the surveying partner. Since no one wants to take the risk of overlooking a potentially mined area, there may be a risk with such survey of overestimating the number of Suspected Hazardous Areas in a given province.

For the purpose of the present study, this potential overestimating of the Suspected Hazardous Areas size and to a lesser degree their number cannot be investigated further. However, since the survey serves as the basis for demining activity, using the data made available by the Landmine Impact Survey constitute in and of itself a valid argument. But choosing the number of Suspected Hazardous Areas minimizes the overestimation risk.

B Technical Notes on Landmines

A mine is not supposed to explode unless is has been armed.[35] Once armed, mines can be activated in four ways. (1)Pressure can activate the device when a load is placed on it (e.g. walking or driving directly over the mine). (2) The release of pressure can set off a mine (e.g. when a pressure release anti-handling firing device attached to the underside is lifted). (3) Seismic activity can activate the device when a sensor detects vibrations or movement within the search range. (4) Trip wires or break wires can activate a mine, if they are disturbed. Trip wires may be either taut or slack. (4) Command detonated mines are activated by a person when he/she detects an enemy in the mine's lethal area. Radio or hard wire sends the signal to fire.

In the case of anti-personnel mines, two types of kill mechanisms are used. (1) Blast mines are typically exploded by the pressure of a footstep. They can be put in place by hand but many are also 'scatterable.' Scatterable mines can be launched from ground-based systems or dropped from fixed wing aircrafts or helicopters. When detonated, the blast waves of the mine push upwards deep into the tissue of the leg, driving with it 'secondary fragmentation'. Fragments of the mine casing, earth, grass, parts of the casualty's footwear, bone and flesh from the foot and ankle are all driven high into the wound. Traumatic amputation of the lower leg is common. Subsequent surgical amputation is normally required from a higher site in the limb to ensure that blast and fragmentation-affected tissue and bone are excised. Secondary injuries can be very severe. Blindness and serious facial, chest or abdominal injuries are common with blast mines. (2) Fragmentation typically explode when a trip-wire is pulled or when the mine is disturbed directly. The mine contains a packing of fragments; usually metal, or a segmented outer casing that breaks into fragments on detonation. When dispersed by the explosive force of the mine, these fragments, acting as missiles, are the prime cause of injuries sustained by victims. The fragmentation effect drives metal fragments into the mine victim. These fragments rip through tissue, organs, bone and where velocity is sufficiently maintained, they can cause large lacerated exit wounds. Survivors may suffer multiple amputations, blindness, and secondary effects caused by damage to internal organs. Fragmentation mines can kill and injure multiple victims in a single incident.

Anti-tank mines contain enough explosives to stop or destroy an armoured vehicle. An anti-tank mine usually requires a substantial amount of pressure to be applied in order to explode. It requires about 180kg to detonate. This means that anti-tank mines are not normally capable of being detonated by a person standing on them. However, civilian vehicles or people ploughing fields can activate anti-tank mines. An estimated 5% of explosive ordnances fail to explode on impact. When large quantities of munitions are fired into an area (unexploded ordnances), they are at risk to detonate at any time due to erosion.

[35] This section draws on National Research council (2001) and Harjai, Agarwal, Dave, Jogg, and Arora (2005)

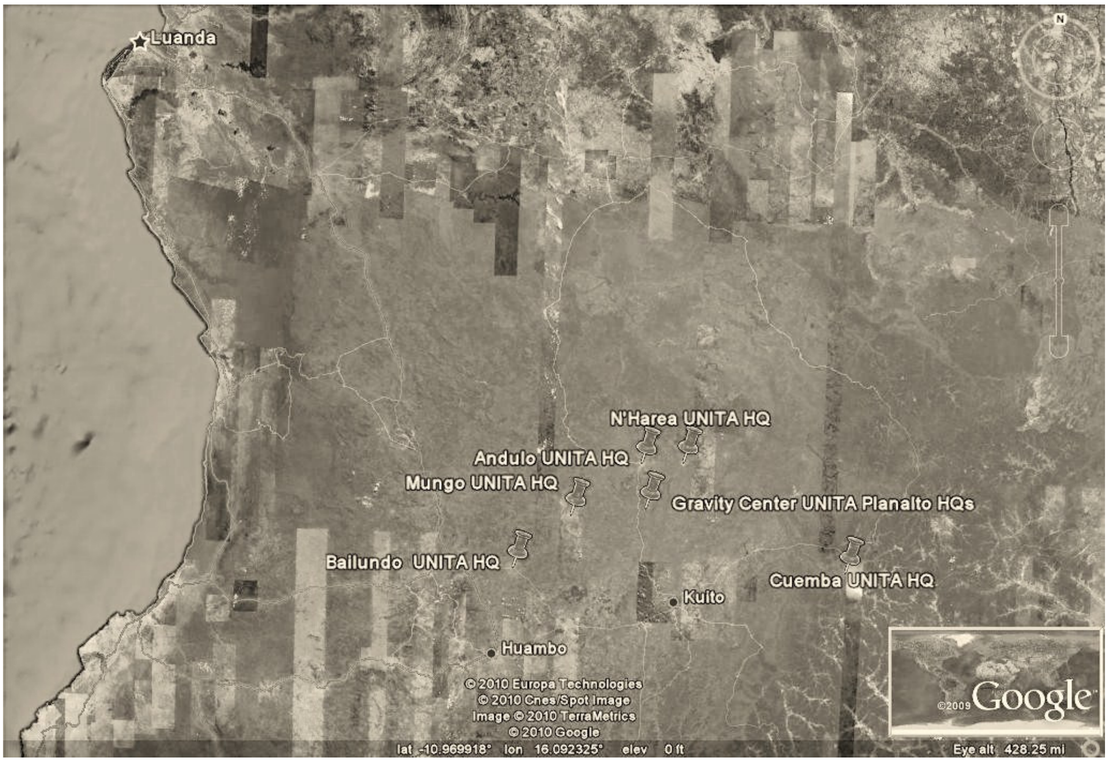

Figure 1: UNITA Headquarters and their centre of gravity

Figure 2: Map of Angola

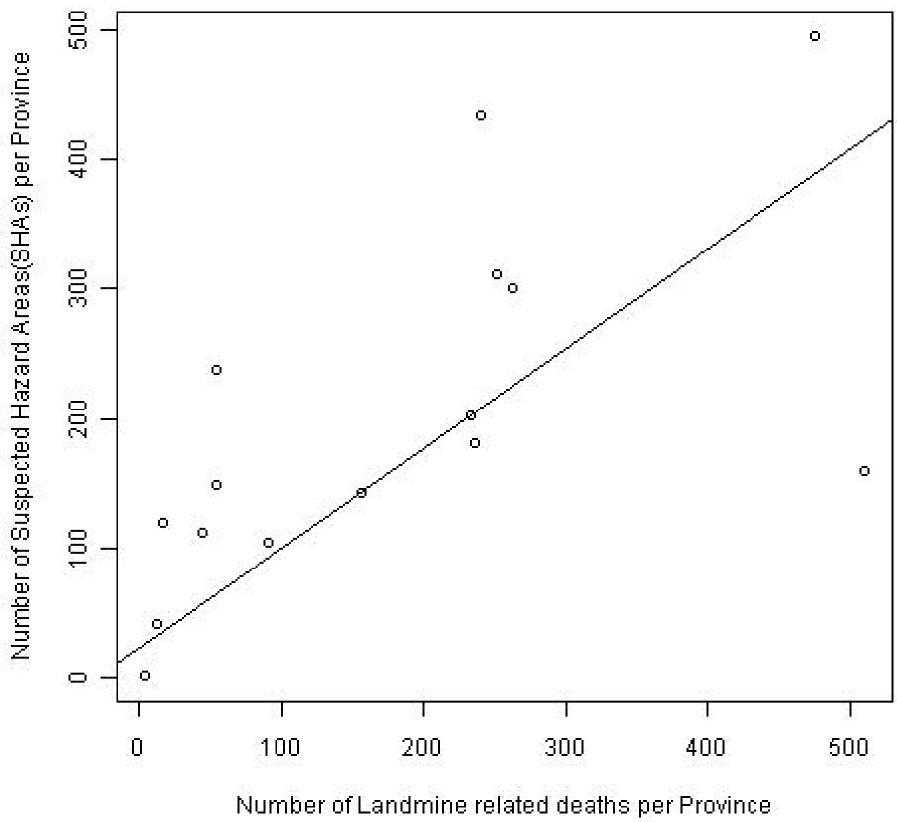

Figure 3: Simple Correlation between the number of landmine-related deaths from 1975 to 2001 and the number of Suspected Hazard Areas across 15 provinces (β = 0.7685; s.e. = 0.2464)

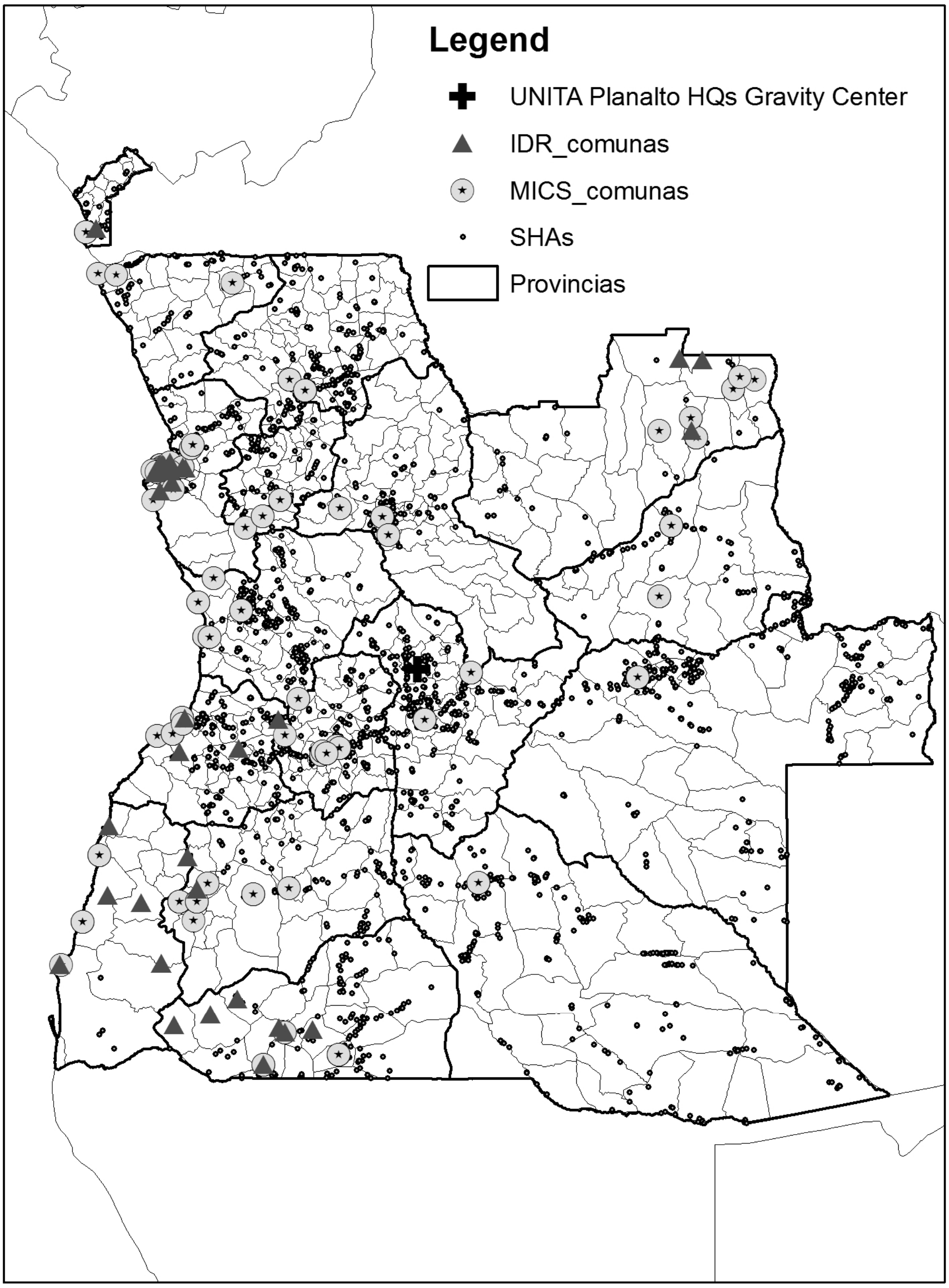

Figure 4: ArcGis Map of Angola with Suspected Hazard Areas , Surveyed communes in MICS and IDR, and the UNITA center of gravity

Province	Total Communities	Impacted Communities	% of Impacted Communities
Moxico	1,698	290	17%
Bi	2,825	282	10%
Uge	2,208	172	8%
Kuando Kubango	886	171	19%
Kwanza Sul	1,997	169	8%
Huambo	2,938	153	5%
Benguela	1,807	127	7%
Kunene	426	126	30%
Malanje	1,868	87	5%
Bengo	543	74	14%
Lunda Sul	736	73	10%
Hula	1,863	72	4%
Zaire	741	66	9%
Kwanza Norte	815	64	8%
Lunda Norte	1,059	30	3%
Cabinda	387	27	7%
Namibe	420	3	1%
Luanda	291	2	1%
TOTAL	23, 508	1, 988	8%

Table 1: Prevalence of Suspected Hazardous Areas by Province in the Landmine Impact Survey

Variables	mean	median	sd	min	max
Child Specific Variables					
Weight-for-Age Z-Score (0-5 yrs)	-1.324	-1.38	1.223	-4.94	4.97
Height-for-Age Z-Score (0-5 yrs)	-1.66	-1.77	1.619	-5	4.94
Age in Months	27.94	27	16.96	0	59
Child is Male	0.4993	0	0.5001	0	1
Child is Born in Province	0.9496	1	0.2188	0	1
Breastfed Child	0.9714	1	0.1666	0	1
Child has Vaccination Card	0.6495	1	0.4772	0	1
Polio Vaccination	0.83	1	0.3757	0	1
Diphtheria Vaccination	0.5225	1	0.4995	0	1
Measles Vaccination	0.494	0	0.5	0	1
BCG Vaccination	0.6651	1	0.472	0	1
Diarrhea	0.2358	0	0.4246	0	1
Accute Respitory Infection in the Past	0.07854	0	0.269	0	1
Iodized Salt	0.3465	0	0.4759	0	1
Household Specific Variables					
Sex of Head	0.7898	1	0.4075	0	1
Age of Head	37.64	36	11.1	15	70
Married Head	0.8025	1	0.3981	0	1
Head without Schooling	0.2111	0	0.4081	0	1
Head with Primary Schooling	0.6896	1	0.4627	0	1
Head with Secondary Schooling	0.09482	0	0.293	0	1
Literate Head	0.6316	1	0.4824	0	1
War-Displaced Head	0.1698	0	0.3755	0	1
Head Born in Province	0.4418	0	0.4967	0	1
Wealth Quintile	3.103	3	1.398	1	5
Household Size	6.327	6	2.713	2	21
Access to Water in the House	0.0299	0	0.1703	0	1
Cement Walls	0.02544	0	0.1575	0	1
Electricity	0.2477	0	0.4317	0	1
Rural Area	0.3322	0	0.4711	0	1
Commune Specific Variables					
Distance to UNITA Centre of Gravity	428.7	463.9	161.1	73.94	849
Suspected Hazardous Areas in 150 km radius	194	181	135.5	3	532
Suspected Hazardous Areas in 100 km radius	109.2	81	83.81	1	325
Suspected Hazardous Areas in 75 km radius	73.92	55.00	60.71	0.00	237.00
Suspected Hazardous Areas in 50 km radius	46.33	31	43.05	0	165
Distance to Luanda	510.9	515.5	277.5	1.02	953.5
Distance to Provincial Capital	29.18	2.076	51.6	0	255
Casualties in 150 km radius	6085	4443	460	327	19930
Distance to Benguela Frontline	261.7	222.7	200.1	0.2343	771.2
North of the Benguela Frontline	0.6629	1	0.4728	0	1
Length of Communal Roads(m)	121700	58440	180900	0	920500
Oilfields in 150 km Radius	3.352	0	6.368	0	25
Diamond Mines in 150 km Radius	0.4634	0	0.9092	0	4

Table 2: Summary statistics for the MICS survey, 4482 observations, selected categories for categorical variables

Variables	mean	median	sd	min	max
Child Specific Variables					
Weight-for-Age Z-Score (0-5 yrs)	-1.202	-1.26	1.176	-4.99	4.69
Height-for-Age Z-Score (0-5 yrs)	-1.58	-1.62	1.43	-4.99	2.97
Age in Months	28.1	28	17.08	0	59
Child is Male	0.5112	1	0.4999	0	1
Baby Born in Province	0.9477	1	0.2227	0	1
Household Specific Variables					
Log Income Per Adult Equivalent	5.698	5.724	1.055	0.281	8.923
Sex of Head	0.7798	1	0.4144	0	1
Age Group of Head	5.427	5	2.371	1	11
Married Head	0.5815	1	0.4933	0	1
Years of Education of Head	4.51	5	2.143	0	8
Literate Head	0.8144	1	0.3888	0	1
Head Speaks Portugese	0.221	0	0.415	0	1
Head Speaks Umbundo	0.2599	0	0.4386	0	1
Unemployed Household Head	0.02693	0	0.1619	0	1
War-Displaced Head	0.5088	1	0.5	0	1
Head Born in Province	0.5086	1	0.5	0	1
Household Size	5.816	5	3.032	1	30
Ratio of Dependents vs. Non-Dependents	1.143	1	0.9366	0	8
Access to Water in the House	0.1438	0	0.3509	0	1
Cement Walls	0.3713	0	0.4832	0	1
Electricity	0.5666	1	0.4956	0	1
Rural Area	0.08309	0	0.276	0	1
Commune Specific Variables					
Distance to UNITA Centre of Gravity	558.20	500	141.70	282.70	845.10
Suspected Hazardous Areas in 150 km radius	93.92	77	62.44	3	278
Suspected Hazardous Areas in 100 km radius	43.67	49	33.89	1	204
Suspected Hazardous Areas in 75 km radius	30.29	35	24.17	0	140
Suspected Hazardous Areas in 50 km radius	13.2	5	12.3	0	67
Distance to Luanda	480.7	444.9	330.1	0	953.5
Distance to Provincial Capital	44.21	30.58	54.74	0	638.1
Casualties in 150 km radius	5345	4492	2788	136	10720
Distance to Benguela Frontline	351	393.40	211.20	1.77	774
North of the Benguela Frontline	0.5696	1	0.4952	0	1
Length of Communal Roads(m)	155700	65420	264800	0	920500
Oil Fields in 150 km Radius	0.800	0	1.01	0	3
Diamond Mines in 150 km Radius	2.014	0	5.658	0	18

Table 3: Summary statistics for the IDR survey, 9171 Observations in the household income model, 7684 Observations in the anthroprometric models, selected categories for categorical variables intensities

Dependent Variable: Number of Suspected Hazardous Areas				
	150km	100km	75km	50km
Exclusion Restriction:				
Distance to Centre of Gravity of UNITA	-0.52821	-0.23635	-0.39262	-0.38139
	0.16234	0.07390	0.10951	0.12503
Selected Covariates:				
Distance to Luanda	0.05128	0.16004	0.33184	0.40254
	0.19634	0.06853	0.09249	0.10174
Distance to Provincial Capital	0.01802	0.02827	0.03007	-0.01559
	0.08033	0.04411	0.05104	0.04690
Casualties in 150km radius	0.00989	-0.00027	-0.00141	-0.00063
	0.00206	0.00072	0.00057	0.00096
Distance to Benguela Frontline	0.14475	0.08701	0.23081	0.20582
	0.13005	0.06522	0.13593	0.13017
North of Benguela Frontline	15.65693	15.08552	4.48970	-2.43224
	11.04594	4.15461	4.66979	5.49835
Length of Communal Roads	0.00000	0.00002	-0.00002	-0.00004
	0.00003	0.00001	0.00002	0.00002
Diamond Mines in 150km radius	-5.22286	-0.45640	-0.39370	-1.22988
	1.51194	0.60484	1.37352	1.10479
Oil Field in 150km radius	5.58410	-8.06115	2.92031	9.15549
	5.78057	2.24418	2.92125	3.58419

Table 4: First-stage reduced forms of the determinants of total number of Suspected Hazardous Areas for various radii in the anthroprometric models for the MICS survey. 4482 observations, child-specific, household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=61) below estimates.

Dependent Variable: Number of Suspected Hazardous Areas				
	150km	100km	75km	50km
Exclusion Restriction:				
Distance to Centre of Gravity of UNITA	-1.25093	-1.37331	-0.95528	-0.48506
	0.16088	0.16701	0.12118	0.04744
Selected Covariates:				
Distance to Luanda	-0.05054	0.07651	0.02142	0.02002
	0.05031	0.04689	0.02654	0.01394
Distance to Provincial Capital	-0.05271	0.04566	-0.00664	0.00334
	0.05588	0.05535	0.03185	0.01465
Casualties in 150km radius	0.00090	-0.00540	-0.00499	-0.00236
	0.00298	0.00215	0.00172	0.00096
Distance to Benguela Frontline	1.04440	1.10951	0.83497	0.38993
	0.16217	0.14892	0.09011	0.04620
North of Benguela Frontline	-2.12067	-20.35406	-3.34341	5.89500
	11.44744	11.28704	6.99748	3.68577
Length of Communal Roads(m)	0.00014	0.00005	0.00003	0.00002
	0.00011	0.00010	0.00006	0.00004
Diamond Mines in 150km radius	4.58338	-1.00164	-8.40326	5.09150
	10.92932	3.73916	2.29850	2.31324
Oil Field in 150km radius	-54.76691	9.38604	13.50405	3.06677
	82.25747	73.43410	43.23391	25.59207

Table 5: First-stage reduced forms of the determinants of total number of landmines for various radii in log income per adult equivalent models for IDR. Results for the anthroprometric regressions are qualitatively very similar. 9171 observations, child-specific (anthroprometric model only), household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=50) below estimates.

Dependent Variable: Child HAZ in 2001 (MICS)				
	150km	100km	75km	50km
beta-IV	-0.00648	-0.01447	-0.00871	-0.00897
	0.00255	0.00595	0.00372	0.00378
beta-OLS	-0.00326	-0.00449	-0.00108	-0.00157
	0.00157	0.00379	0.00206	0.00233
Test of exogeneity: p-value	0.14681	0.05209	0.01684	0.01834

Table 6: Instrumental variables estimates of the effect of Suspected Hazardous Areas across various radii on child height-for-age (HAZ) z-scores. 4482 observations, child-specific, household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=61) below estimates.

Dependent Variable: Child HAZ in 2000 (IDR)				
	150km	100km	75km	50km
beta-IV	-0.00450	-0.00397	-0.00578	-0.01004
	0.00208	0.00190	0.00258	0.00386
beta-OLS	-0.00493	-0.00456	-0.00662	-0.01438
	0.00159	0.00139	0.00184	0.00546
Test of exogeneity: p-value	0.82054	0.67217	0.70262	0.39673

Table 7: Instrumental variables estimates of total number of Suspected Hazardous Areas for various radii on child height- for-age (HAZ) z-scores. 7684 observations, child- and household-specific household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=50) below estimates.

Dependent Variable: Child WAZ in 2001 (MICS)				
	150km	100km	75km	50km
beta-IV	-0.00405	-0.00904	-0.00544	-0.00560
	0.00188	0.00444	0.00248	0.00241
beta-OLS	-0.00238	-0.00127	-0.00010	0.00012
	0.00135	0.00319	0.00119	0.00133
Test of exogeneity: p-value	0.30376	0.05380	0.03778	0.01734

Table 8: Instrumental variables estimates of the effect of Suspected Hazardous Areas across various radii on child weight-for-age (WAZ) z-scores. 4482 observations, child-specific, household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=61) below estimates.

Dependent Variable: Child WAZ in 2000 (IDR)				
	150km	100km	75km	50km
beta-IV	-0.00195	-0.00172	-0.00250	-0.00435
	0.00156	0.00160	0.00226	0.00336
beta-OLS	-0.00355	-0.00240	-0.00319	-0.00936
	0.00164	0.00141	0.00201	0.00437
Test of exogeneity: p-value	0.37308	0.53240	0.68133	0.18362

Table 9: Instrumental variables estimates of total number of Suspected Hazardous Areas for various radii on child weight- for-age (WAZ) z-scores. 7684 observations, child- and household-specific household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=50) below estimates.

Dependent variable: Household Income in 2000 (IDR)				
	150km	100km	75km	50km
beta-IV	-0.00448	-0.00408	-0.00586	-0.01155
	0.00248	0.00192	0.00248	0.00586
beta-OLS	-0.00298	-0.00492	-0.00705	-0.01164
	0.00167	0.00142	0.00204	0.00398
Test of exogeneity: p-value	0.32874	0.35970	0.40927	0.98220

Table 10: Instrumental variables estimates of total number of landmines for various radii on log income per adult equivalent. 9171 observations, household-specific, commune-specific variables, and provincial dummies included. Standard errors clustered at the commune level (N=50) below estimates.