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Disease control, demographic change and institutional development in Africa

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ABSTRACT

This paper addresses the role of tropical disease in rural demography and land use rights, using data from Onchocerciasis (river blindness) control in Burkina Faso. We combine a new survey of village elders with historical census data for 1975–2006 and geocoded maps of treatment under the regional Onchocerciasis Control Program (OCP). The OCP ran from 1975 to 2002, first spraying rivers to stop transmission and then distributing medicine to help those already infected. Controlling for time and village fixed effects, we find that villages in treated areas acquired larger populations and also had more cropland transactions, fewer permits required for cropland transactions, and more regulation of common property pasture and forest. These effects are robust to numerous controls and tests for heterogeneity across the sample, including time-varying region fixed effects. Descriptive statistics suggest that treated villages also acquired closer access to electricity and telephone service, markets, wells and primary schools, with no difference in several other variables. These results are consistent with both changes in productivity and effects of population size on public institutions.

1. Introduction and motivation

In 1974, the World Health Organization and numerous partners launched the Onchocerciasis Control Program in West Africa. The OCP extended across Côte d'Ivoire, Niger, Mali, Togo, Benin, and Ghana and was centered on Burkina Faso (then Upper Volta), where the disease had infected about 10% of the population. New infections occurred primarily among rural children south of the 13° parallel, through painful bites from the aptly named *Simulium damnosum* blackfly carrying the microfilarial larva of a parasitic worm, *Onchocerca volvulus*. Those infected experienced itching, disfigurement, and eventual blindness. The blackfly vector can reproduce only in the oxygenated waters of a river or stream, hence the common name of this disease – river blindness – and the potential for intervention to have a large economic impact by facilitating settlement in otherwise productive river valleys.

To control the disease, starting in 1975 the OCP used helicopters to spray larvacide along rivers. The vector began to disappear by 1977, enabling people to move closer to rivers without fear of blackfly bites and new Onchocerciasis infections. The vector-control phase of OCP ended in 1989, after which the OCP focused on the distribution of ivermectin to control symptoms in those already infected. Ivermectin had been a veterinary deworming drug, which in the early 1980s was also shown to be effective in killing the microfilariae produced by *Onchocerca* in the human body. Adult worms are not affected, but ivermectin blocks their reproduction until they reach the end of their natural lifespan about 14 years after infection.

Distribution of ivermectin to help villagers with Onchocerciasis began in 1987. Annual doses successfully controlled symptoms of the disease and prevented further transmission of the *Onchocerca* parasite. The blackfly vector returned to the river valleys but the disease was no longer endemic and in 2002 the OCP ended, with ivermectin remaining in use against filarial parasites transmitted by other channels.

The OCP is widely recognized to have been one of the world's most successful public health projects (Levine, 2004). Fig. A1 (Online appendix) illustrates the remarkable extent to which Onchocerciasis was brought under control across West Africa between 1975 and 2002, with near-eradication in many places and continued endemicity only in Sierra Leone where the OCP was not active. How the OCP discovered and implemented their approach has been the subject of many studies in tropical medicine (e.g. Benton et al., 2002) and a widely read book in anthropology (McMillan, 1995).

In this paper, we use OCP exposure and associated changes in village population to address the role of public health in local institutions' provision of agricultural property rights, with additional data on changes in public services and infrastructure. Disease control could influence local institutions directly by changing the productivity of labor, land and capital, and could also matter via its effects on rural population size and

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density. The role of population density was emphasized by Boserup (1965), who argued that a larger rural population creates new incentives for institutional change and collective action, in addition to new incentives for induced innovation and technological change as had been suggested by Hicks (1932). Boserup's hypothesis could operate through scale effects from population size, relative-price effects from factor scarcity, or both.

Modern economic analyses of how rural demography affects property rights can be traced to Demsetz (1967), producing a vibrant debate on the evolution of land governance in Africa (e.g. Platteau, 1996) informed by insights from Australia and the Americas (Alston et al., 2012). Links to agricultural technology and economic development more generally were pioneered by Hayami and Ruttan (1971) comparing the U.S. and Japan, and tested in a large subsequent literature such as Johnston and Kilby (1975) and Olmstead and Rhode (1993). Some of the empirical work in this literature, such as Lin (1995) focuses on the emergence and adoption of institutions, while other papers ask how institutions affect technology adoption, such as Kazianga and Masters (2002, 2006). Focusing on rural demography also expands on our other previous work regarding the role of environmental factors in economic growth (Masters and McMillan, 2001) and African policy choices (McMillan, 2001; McMillan and Masters, 2003).

Our focus on the specific challenge of *rural* population growth contrasts with most study of demography in development economics, which has focused either on demographic transition in the population as a whole (including the demographic "drag" or "dividend" from age structure emphasized by Bloom and Williamson, 1998), or on the structural transformation from farm to nonfarm employment in terms of output and employment shares (including the "growth bonus" associated with shifting from a low productivity to a high productivity sector as in Temple, 2005). Focusing on demographic conditions within rural areas addresses Africa's distinctive history of post-independence agricultural decline, providing grounds for optimism about the future as countries adapt to higher levels of rural population density and achieve sustained recovery in farm productivity (Block, 2013) and living standards (Young, 2012). Focusing on how rural Burkina Faso responded to the OCP also offers an opportunity to extend the literature on the role of location-specific diseases in economic development (Acemoglu and Johnson, 2007; Alsan, 2013; Ashraf et al., 2009; Bleakley, 2007; Cutler et al., 2010), as part of the broader literature on demography and growth (Galor, 2012; Galor and Weil, 1999).

The closest antecedent to our study is probably Grimm and Klasen (2008), who test for endogenous adoption of land titles at the village level on Sulawesi in Indonesia, but we address a wider range of property rights and also include data on a variety of other public services and infrastructure. Our study is made possible by the timing of Burkina Faso's decennial censuses in 1975 (before vector control), 1985 (before deworming), and then 1996 and 2006 (after the disease was fully controlled) to estimate OCP-related variation in village population, combined with new GIS data on village location and focus group interviews of village elders to reconstruct changes in land-use rights and various public amenities.

Methodologically, our use of focus groups to obtain village-level recall data on institutional arrangements and public amenities follows Chattopadhyay and Duflo (2004), building on a long tradition of participatory surveys in rural areas (e.g. Chambers, 1994). This approach allows us to ask about many different types of property rights, public services and infrastructure, as seen from the villagers' point of view. One purpose of this paper is to test the value of villagers' recall data in establishing stylized facts about how the actions of public institutions vary across space and time. In future work, recall data of this type could also be used to analyze causal effects of public services, infrastructure and property rights on economic outcomes. For example, Besley (1995) found evidence that institutions significantly affect investment outcomes in rural Africa. Pande and Udry (2006) provide a summary of these studies. In Burkina Faso specifically, Kazianga and Masters (2002) found that stronger cropland tenure was associated with more intensive soil and water conservation.

In the next section, we describe how OCP treatment affected rural Burkina Faso, before turning to our own empirical strategy, data and results.

2. Onchocerciasis control and population movements in Burkina Faso

River blindness is spread through bites from a blackfly that reproduces in rivers and subsists on human blood, transmitting the filarial larvae of a parasitic worm. These larvae develop into adult worms inside the body, forming nodules typically around the waist area, where they live for about 14 years and produce millions of microfilariae that move to and damage the victim's skin and eyes. The microfilariae themselves have a lifespan of up to two years in the human body, during which time they may be ingested by another blackfly, hosted for 6–8 days and transmitted to another person.

The blackfly can reproduce only in rivers and streams, from which they fly for many miles to take human blood meals. When the human population in that vicinity is sufficiently dense, these blackfly bites are painful but no transmission occurs because the fraction of blood meals containing microfilariae is too low to sustain the Onchocerca population. When human population is of lower density, the disease becomes hyper-endemic. Children will become infected soon after they begin to move outside the home, skin disfiguration occurs in the late teens, and eyesight deteriorates in adulthood. When transmission through the blackfly is interrupted, those infected become cured when the adult worms eventually die, and their symptoms can be relieved in the meantime by treatment with ivermectin.

In the southern parts of Burkina Faso where blackflies could carry Onchocerciasis, only a small fraction of locations had a sufficiently high human population density to prevent transmission before the OCP began. An analysis of the country's 1975 census suggested that high densities would have protected people around the capital city, Ouagadougou, and along a corridor 150 km from there northwest to Ouahigouya and southeast down to the Nazinon Valley on the border of Ghana. Soon after spraying started in 1975, people responded by spreading out into the newly attractive river valleys, expanding existing villages and also starting new ones. Some of this movement was spontaneously undertaken by individuals, and some of it occurred through planning in villages targeted for settlement by a government agency, the *Autorité des Aménagements des Vallées des Volta* (AVV).

The demographic changes that followed immediately after OCP intervention are illustrated in Fig. 1, showing population growth rates for 1975–1985 in our nationally representative sample of villages. The map shows the location of Burkina Faso's major rivers, with shading in the areas where pre-intervention surveys found the parasite to be endemic so OCP spraying occurred. Symbols for each village indicate its population growth rate between the 1975 and 1985 censuses, using triangles for villages in AVV areas, and dots for villages that were not part of AVV planning. Visual inspection suggests clear differences in growth rates between villages in the shaded and non-shaded regions, with most villages in the treated areas experiencing ten-year population growth exceeding 75%, and most villages elsewhere experienced growth of less than 50%.

The pattern of migration in response to OCP spraying is described in detail by McMillan et al. (1992, 1993). Some of this occurred from the drier and higher-altitude northeast and central plateau into the Onchocerciasis zone, while some involved movement within the zone closer to rivers where blackfly bites had been more frequent, transmission rates higher and parasite loads heavier. Some settlement was linked to AVV planning and investments, but McMillan et al. (1993) estimate that more than 80% of the increase in cultivated land in Burkina's river basins could be attributed to spontaneous settlers outside of AVV influence.

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