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Communities coping with risks: Household water choice and environmental health in the Ethiopian Rift Valley

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ABSTRACT

Resource-constrained households are often forced to make complex tradeoffs across multiple environmental health risks. In the Ethiopian Rift Valley, households face tradeoffs between relatively plentiful but fluoride-contaminated groundwater sources and seasonally-variable surface water sources having greater bacteriological risks. We assess factors influencing household water choice in this setting of varied environmental health risks. We analyze behaviors using mixed methods with qualitative and quantitative data that shed light on the relative importance of water quality and other factors, and place this behavior within households' community context. The paper thereby contributes to a wider view of the factors that restrict or promote household balancing of environmental risks. We find that social factors, as measured by survey measures of trust, play a role in household water sourcing behavior and the mitigation of risk. The large seasonal variation in fluoride levels observed in some households' stored drinking water also points to prioritization of convenience (use of surface water sources) during the rainy season, despite these sources' significant microbial risks. Understanding the combined environmental and social factors can better inform policy interventions in household water quality.

1. Introduction

Resource-constrained households are often forced to make complex tradeoffs among multiple environmental health risks (Jeuland et al., 2015). One domain where such difficult balancing is often observed in low-income settings is in the essential activity of water supply, and a case in point is the Ethiopian Rift Valley. In this setting, households cope with high variability of water availability and quality, and face tradeoffs between groundwater sources with inorganic contaminants (e.g., fluoride) and surface water sources that are more likely to have bacteriological contamination (Amenu, 2013; Rango et al., 2009, 2010; Reimann et al., 2003). Households can access water sources that tend to have lower contamination, but these sources are typically costly, in time, money, or both (WHO, 2017). In some communities, households cooperate for water access and quality by improving existing resources, or by constructing new systems such as deep borehole wells, but uncertainty in the natural distribution of groundwater contaminants implies that the health risks associated with these investments are usually not known *ex ante*, or are not taken into consideration. Moreover, water treatment is limited, and generally, individuals engage in less preventive health behavior than would be expected; this lack of self-protection is not unique to the Ethiopian Rift Valley (Whittington et al., 2012).

In this paper, we assess the factors influencing household water choice in the Ethiopian Rift Valley of varied health risks. Given constraints on water sources and options for treatment, and the variety of risks involved, we seek to understand how households balance between them, and how they choose to invest in costly mitigation. In prior literature, a range of individual and household characteristics have been found to influence water sourcing, including knowledge, education, and wealth (Pattanayak and Pfaff, 2009), as well as factors relating to the availability and relative cost of substitute sources (Mu et al., 1990). Individuals' risk preferences also appear to matter, especially those of the decision-makers who control and allocate scarce resources to this task (Brewer et al., 2004; Onjala et al., 2014). When collective solutions are possible, community social capital and other characteristics also influence the strength of collective action (Krishna and Uphoff, 2002; Ostrom, 1992). We consider each of these factors, but are particularly interested in household decision makers' risk preferences (e.g., those of the male and female household heads) and in the role of trust for

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collective action, both of which are measured using experimental methods. In particular, it is not obvious how households in this setting might balance short-term disease risks that result from microbial contamination, against the longer-term health effects of consuming groundwater whose quality is difficult to observe.

This paper contributes to a wider view of the factors that restrict or promote household water source choice by placing this behavior within their community context. Further, the paper is useful methodologically, in that it combines qualitative and quantitative analysis to yield deeper insight into household water-related behaviors. Such a mixed methods approach is critical because it allows us to conduct a deeper and more thorough investigation of the nature and function of social institutions relating to water (using qualitative interviews), while still leveraging data collected from a relatively large sample living in a range of conditions. The latter is important because it provides sufficient variation in the myriad factors that affect water-sourcing decisions. Finally, we also report seasonal variation in fluoride levels in household drinking water, which are statistically significantly related to seasonal rainfall averages, and could affect fluorosis risk and estimates.

The rest of the paper is organized as follows: Section 2 describes the water scarcity and quality situation of the Ethiopian Rift Valley, and gives context to household environmental behaviors such as water sourcing. In Section 3, we introduce the multiple data sources and methods used. The presentation of results follows in Section 4, and we conclude in Section 5 with theoretical and policy implications.

2. Background: water and health in the Ethiopian Rift Valley

Access to clean drinking water is critically important to the achievement of good health. Poor water, sanitation and hygiene results in over 800,000 deaths annually (WHO, 2014), and is expected to remain a major contributor to the burden of disease in Sub-Saharan Africa over the next several decades (Jeuland et al., 2013). Safeguarding clean drinking water is an important global development priority: UN Sustainable Development Goal 6, for example, calls for “ensur[ing] access to clean water and sanitation for all” (UN, 2015). In Africa’s second most populous country, Ethiopia, at least half of the population is considered to be adversely affected by inadequate or unsafe water (Onda et al., 2012; Stevenson et al., 2012; WHO, 2012; World Bank, 2014).

In many low-income settings similar to that in our study, households rely on multiple sources of water to meet their needs (Shaheed et al., 2014). Individuals and households have a number of options to consider when balancing water quality and access concerns. They can (1) substitute between alternative sources such as surface water or wells that vary in cost, convenience, and quality; (2) treat water they deem to be of insufficient quality at home; (3) decrease their reliance on contaminated water in other ways, e.g., by consuming other types of beverages, or using higher quality but more expensive sources for particular purposes; (4) invest in infrastructure or technology that reduces convenience costs (e.g., purchasing storage containers); and (5) tap new water sources or improve existing ones by engaging in collective action or seeking assistance from external actors, such as community-based organizations or the government. Households often engage in less preventive behavior than would be expected, however, given the expected value of activities such as water treatment (Whittington et al., 2012). A poor understanding of preferences and relative priorities, including a lack of sufficient consideration of aesthetic or convenience features, may partly explain the low adoption rates of many development interventions including for water (Whittington et al., 2012).

When risk prevention is resource intensive in time or money, poverty, liquidity constraints, and other priorities may reduce preventive behavior; prior research suggests that the demand for prevention is highly price elastic (Cohen and Dupas, 2010; Miguel and Kremer, 2004) and sensitive to non-pecuniary costs (Persson, 2002; Whittington et al., 1990). Household decisions can thus be explained at least partly using a theory of constrained utility maximization, whereby households make rational decisions about engaging in risk-mitigating behavior. These decisions depend on a range of factors including their own risk and other preferences, cost, knowledge, and the behaviors’ of peers or external actors (Dupas, 2011; Pattanayak and Pfaff, 2009). Perceived risks have been shown to have major effects on household water treatment sourcing behaviors (Onjala et al., 2014; Orgill et al., 2013), but there is less work to characterize the influence of risk aversion on water sourcing and treatment, despite a broader health literature that points to its importance (Brewer et al., 2004). Risk preferences influence a household’s willingness to tolerate uncertainty, accept losses, and engage in risk-mitigating activities (Liu, 2013; Schechter, 2007; Tanaka et al., 2010). Given that water-related risks are heterogeneous and uncertain in time and space, households likely respond to these risks in varied ways, depending on their preferences, constraints, and opportunities, as well as community factors such as institutional capacity.

In effect, community participation has been found to positively affect water supply management (Kleemeier, 2000; Manikutty, 1997; Marks and Davis, 2012; Ostrom, 1992). Community institutions provide a key way for groups to reduce uncertainty and manage risks (North, 1991) through coordination and cooperation in environmental and water resource management (Ostrom, 1990, 1992). Formal water committees often provide a forum for action, but these also sometimes struggle to supply proper maintenance and management (Isham and Kähkönen, 2002). Social capital in terms of the connections between people may also improve participation and monitoring of water resources in communities (Krishna and Uphoff, 2002). Alternatively, water provision by governments or outside entities changes the role of the community in assuring supply or quality (Hunter et al., 2010). The relationship of institutional structure and individual choices should therefore influence development outcomes for households, through their collective influence on environmental health decision making, e.g., water source choice.

Our study is based in the Ethiopian Rift Valley, a semi-arid region, where water scarcity and variability is a persistent threat and where households cope with dual threats of poor water quality and uncertain supply (Ayenew, 2004; Pascual-Ferrer et al., 2011, 2014). Households can obtain water from surface sources, such as lakes; from hand-dug wells, which are sometimes capped to prevent contamination; from deep boreholes that require mechanical pumps; or from piped water systems managed by government agencies and drawn from a variety of improved sources (e.g. protected wells or springs). The quality, cost and convenience of these options, and the institutions needed to govern them, vary widely. Surface water in natural water bodies, particularly for domestic use that is largely non-rival, requires minimal institutions for management, and cost is mostly limited to transportation and time. Dug wells are usually privately built and managed by individual families, and rarely have user fees. Boreholes require a mechanical pump that is usually installed by NGOs or the government, either with a windmill or motorized pump (powered by diesel, solar, or electrical grid connection), and then typically involve user fees and a community water management committee that helps ensure sufficient maintenance. Finally, tap water systems are managed by municipalities or government water authorities, and charge consumers using a tariff system. Among our study households, use of piped water systems increased between 2013 and 2014.

Groundwater from boreholes is one of the principal sources for drinking water in the Ethiopian Rift Valley, yet many boreholes are contaminated with high levels of naturally-occurring fluoride and other inorganic contaminants including arsenic (Rango et al., 2009, 2010; Reimann et al., 2003). Consumption of fluoride-contaminated groundwater causes dental fluorosis in the Ethiopian Rift Valley (Rango et al., 2012, 2014, 2017), and may lead to skeletal fluorosis. Both of these fluorosis conditions have lifelong health consequences that range from loss of teeth to debilitating pain. Approximately 13 million people are