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Malaria suitability, urbanization and persistence: Evidence from China over more than 2000 years☆

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ABSTRACT

We show that the climatic potential for Plasmodium falciparum malaria transmission constituted a locational fundamental that influenced the spatial distribution of urbanization since the early start of the southward expansion of the Han Chinese around 200 BCE. This effect is still detectable in today's distribution of urbanization and economic activity even though the risk of malaria falciparum has been successfully eliminated. We do not find any indication of convergence between high- and low malaria potential regions after eradication. Our identification strategy relies on a climate-based measure of Plasmodium falciparum malaria transmission intensity which is fitted to experimental data on mosquito and parasite development from laboratory studies. This measure is exogenous with respect to human population densities.

1. Introduction

In this paper, we analyze the role of Plasmodium malaria falciparum—one of history's leading causes of death and disease (Webb, 2008) – in shaping the spatial distribution of economic activity in South China. The case of China offers a unique opportunity to analyze the role of the climatic malaria environment over a very long time period. The availability of both historical and current-day data on the location of urban centers – a proxy for economic development (Chang, 1961, 1963, de Vries, 1976, p.164, Paul Bairoch, 1988, Chapter 1, Lucas, 1988) – allows us to track the effect of the local malaria transmission potential on urbanization patterns of the Han Chinese,[1] today's dominant population group, over a period of more than 2000 years from their initial colonization of the malarious regions of South China around 200 BCE up until 2010 CE. An important feature of China's recent history is the implementation of large-scale eradication campaigns in the 1950s which successfully eliminated the malaria falciparum risk. This implies that we can analyze to what extent malaria-related regional differences in urbanization and economic activity persist after eradication. An additional advantage of focusing on the case of China is that by concentrating on a single country we ensure that the analysis is not affected by potentially confounding differences in country-level characteristics, such as institutions. Increasing the relevance of our study is further the fact that China has by far the largest urban population worldwide.[2]

Our empirical analysis focuses on South China, i.e., the part of today's China that lies south of the Huai River–Qin Mountains line

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[1] Throughout the paper, we will use the terms 'Han Chinese' and 'Chinese' interchangeably. In both cases, we refer to the people of Han ethnicity.
[2] As of 2010, more than 600 million people live in urban areas. This is almost twice as much as in India, the country with the second largest number of urban dwellers (World Development Indicators).

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and in which the majority of China's population lives. Prior to eradication, malaria falciparum was, in contrast to North China, endemic in this region. We make use of various data sources that provide information regarding the location of urban and political centers at various points in time. This allows us to track the spatial distribution of urbanization from the start of the southward expansion of the Han Chinese around 200 BCE up to 2010. The sources used include CHGIS (2010); Skinner et al. (2011, 2013) and Brinkhoff (2015). To obtain a time-consistent unit of observation, we aggregate the information contained in these data sources at the 0.5°×0.5° grid-cell level. South China spans over a total of 868 grid cells.

To identify the effect of the malaria environment on economic development, we rely on a measure that describes the development of the mosquito as well as the Plasmodium falciparum parasite as non-monotonic functions of air temperature. The functional form of the model is derived exclusively from experimental data gained in laboratory studies and is therefore arguably exogenous to the spatial distribution of human population.[3] Our measure can be interpreted as a locational fundamental, i.e., a first nature characteristic. It reflects the local, time-invariant climatic suitability for malaria falciparum transmission which not only influences outcome variables via contemporaneous effects on health, but also through its effects on long-term determinants of economic development. For example, a continuously adverse health environment can influence the evolution of local institutions or social and cultural traits. Furthermore, it can deter the establishment of settlements which can, through the existence of increasing returns to scale, influence a region's path of urbanization and economic development. When interpreting our empirical results, it is important to keep in mind that our estimates capture reduced-form effects of the malaria environment. They represent the net effect of all channels through which the malaria environment influences outcome variables. Our cross-sectional OLS regression results document that the climatic potential for malaria transmission constituted a locational fundamental during the Imperial Era (221 BCE–1911 CE), i.e., the pre-eradication era. From the beginning of the Han Chinese colonization of the South—that is, the earliest point in time for which urbanization data for South China are available – we observe that the local variation in the climatic malaria potential strongly influenced the spatial pattern of urbanization. After the successful eradication of malaria falciparum that started in the 1950s, the climatic potential for its transmission ceased to pose a threat to human health. Nevertheless, we find that the negative relationship between the local potential for malaria transmission and urbanization as well as economic development persists to the present day. We do not observe any convergence between high- and low-malaria potential areas as a result of eradication-related individual health benefits. The strong degree of persistence in the spatial pattern of urbanization suggests that the negative effects of the malaria environment on long-term determinants of development dominate the positive health-related effects that result from eradication. However, given the short period of 50 years that has passed since the beginning of the malaria eradication campaigns, there is also the possibility that convergence between previously highly malarious areas and less affected regions has started but is not detectable yet due to a slow pace of the adaptation processes.

The remainder of this paper is organized as follows: In the next section, we discuss the related literature. Section 3 describes the malaria environment in South China and the problems it posed for the Han Chinese during their colonization of the South. Furthermore, we briefly discuss why the grid-cell level number of administrative capitals can be used as a proxy for the degree of urbanization during the imperial era. Next, we outline the properties of our malaria suitability measure and present our empirical strategy. In Section 5, we describe the data employed in the empirical analysis and conduct a descriptive analysis. In Section 6, we address our research question more formally in a regression setup. Finally, Section 7 concludes.

2. Related literature

Our paper is related to the large body of research that analyzes the effect of malaria on aggregate economic development (e.g., Gallup et al., 1999; Gallup and Sachs, 2001; William and Levine, 2012 or Depetris-Chauvin and Weil, 2013). These studies are usually conducted at the country level and do not employ an exogenous measure of malaria suitability.[4] The findings are inconclusive, even though mostly suggesting a negative effect of malaria. Compared to the country-level studies, we abstract from cross-country differences in the quality of institutions and document that the local disease environment induces regional inequalities within a given set of national institutions. In that respect, our study relates to our recent paper (Flückiger and Ludwig, 2016) in which we analyze the effect of the malaria environment on the geographical distribution of urbanization in Sub-Saharan Africa. We find that an increase in malaria suitability reduces urbanization as well as economic activity at the sub-national level. Compared to China, however, malaria is still endemic in large parts of Africa. Further differentiating the two studies is the economic system as well as the time span within which the empirical analysis takes place.

Our paper is also closely related to the macroeconomic literature on health and development (Young, 2005; Cervellati and Sunde, 2013; Aghion et al., 2011; Soares, 2005).[5] The theoretical models of Gollin and Zimmermann (2008) as well as Chakraborty et al. (2010) specifically analyze the effect of malaria within a general equilibrium framework. Their models suggest that malaria eradication generate large economic gains and lead to convergence between previously highly malarious areas and less affected regions. Contrasting these findings are the results of Acemoglu and Johnson (2007) and Ashraf et al. (2009). They show that a decline in (child) mortality and morbidity does not necessarily increase the level of economic development in the short run. Acemoglu and Johnson (2007) argue that disease eradication improves health but also leads to population growth. When land supply is inelastic, an increase in population reduces output per capita due to the existence of diminishing marginal returns. While our findings are more in line with the latter studies, our analysis suggests that, in the

[3] Note that prevalence-based malaria intensity measures are not exogenous with respect to the spatial distribution of human population. Reverse causality is inherent in the relationship between human population density and malaria prevalence. In a region where humans are absent, the prevalence is zero. Likewise, for malaria to be prevalent among humans, we need the presence of a sufficiently high human population density (see Section 4.1).

[4] The malaria measures used in the cited papers are usually based on malaria prevalence (see Section 4.1).

[5] See Weil (2014) for a complete review.