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The unintended consequences of agricultural input intensification: Human health implications of pesticide use in Sub-Saharan Africa

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1 | Introduction

Modern agricultural inputs such as inorganic fertilizer and pesticides potentially help farmers boost productivity significantly, a goal critical to structural transformation and poverty reduction, particularly in regions like sub-Saharan Africa (SSA). There is a strong, causal relationship between the use of modern agricultural inputs and crop yields and, subsequently, economic growth (McArthur and McCord 2014). This new empirical evidence builds upon a well-theorized literature and brings into focus the drivers of agricultural productivity growth as a prerequisite for structural change in SSA and elsewhere. But the use of modern agricultural inputs may put human health and the surrounding environment at risk, thereby decreasing net growth in productivity and well-being in the short and longer run. These unintended consequences may be most true of pesticides – like insecticides, fungicides, and herbicides – many of which are known to be toxic to humans, particularly when over-applied or used without appropriate protective equipment. This brief describes the tradeoffs between productivity benefits and human health costs of pesticide input use as observed in SSA. Prior work on this question is limited to small sample studies that focus on cash crop systems. Here we present the first broad, cross-country, and nationally representative analysis of productivity and health impacts of pesticide use in developing country agriculture across multiple crop types.

The prospective gains from pesticide use are considerable. Pesticides reduce incidence of harmful pests—insects, fungal pathogens, weeds, etc.—which can both directly impact human health (e.g., aflatoxin), increase labor requirements and severely limit yield amount and quality. Herbicide use reduces the drudgery associated with hand-weeding, which may improve quality of life, and decrease energy expenditure, physical hardship and risk of injury. Improved yields likely translate into improvements in human health of farming households. This can take place via nutrition and/or income effects in that farming output can improve nutrition through direct consumption, or through income that can indirectly improve human health if households use it to purchase nutritious food, health care and/or preventative care. Additionally, consumers benefit from increased yields through increased food supply, which should reduce prices in areas not well integrated into national and global food markets. Additionally, release of labor from manual agricultural tasks may contribute to more vibrant and economically diverse rural areas. Further afield, controlling pests on export crops can mean the geographical containment of pests that could potentially negatively affect other countries' environments and farming systems.

Pesticides are often toxic to humans. Depending on type and class, pesticides can contribute to neurological, respiratory, immunologic, and reproductive health problems (Weisenburger 1993) as well as cancer, immune system damage, and increased risk of sickness in the short term (Culliney et al. 1992). Harmful encounters with pesticides can occur in a number of situations. Most directly, farmers or other agricultural laborers applying these chemicals to crops risk contact via

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exposed skin and eyes, both of which can absorb chemicals at potentially toxic levels, or through ingestion via the mouth and nose. Beyond the time of application, contact with chemical residues during other agricultural tasks (like weeding, thinning, and harvesting) can also be problematic. Limiting exposure is possible by wearing protective equipment and other strategies to keep the chemicals away from the body. Protective equipment use is low in SSA, suggesting considerable scope for contamination (Ajayi and Akinnifesi 2007; Banjo, Aina, Rije 2010; Mekonnen and Agonafir 2002).

Pesticide exposure is not limited to agricultural laborers. Other members of farming households—including children—are likely to walk through or play in fields with chemical treatment, especially those located near dwellings. The storage of pesticides, especially in open containers, in close proximity to where household members congregate, eat, or sleep is another way for household members to come into contact with harmful substances. Rural agricultural households often reuse sturdy, plastic pesticide containers for water, grain, oil, or other consumables, putting family members at risk for ingesting pesticide residues. Williamson (2003) notes that over three-quarters of all pesticide poisoning cases reported to partners of the Pesticide Action Network in Benin and Senegal were related to food and drink contamination, not to exposure on fields. Though beyond the scope of this study, potential for such contamination extends beyond agricultural households to the consumers of agricultural products.

After application, pesticides can also pollute the environment from which rural households critically depend and derive livelihoods, indirectly affecting human health. Pesticides used in high amounts or applied at inappropriate times, such as just before rainfall, contribute to chemical run-off and the contamination of drinking water for the surrounding rural population. Pesticides can also damage agricultural soils through the degradation of beneficial soil microorganisms and the sorption or binding of important organic or mineral components (van der Werf 1996); poor soils will inevitably lead to lower harvests.

Data now exists to study these relationships in SSA. Given the potential for countervailing effects of pesticide use, we use the Living Standards Measurement Study Integrated Survey on Agriculture data from four countries—Ethiopia (2011/12 and 2013/14), Nigeria (2010/11 and 2012/13), Tanzania (2008/09, 2010/11, and 2012/13), and Uganda (2009/10, 2010/11, and 2011/12)—to explore the relationships between human health and agricultural productivity with respect to pesticide use. The findings below should not be interpreted as causal, nor as comprehensive estimates of such effects, but rather as a jumping-off point for further analysis on this very important topic.

2 | Key findings

Pesticides are more widely used than commonly acknowledged. Sheahan and Barrett (2014) show that 13% and 15% of agricultural households in Tanzania and Uganda use pesticides of one type or another. In Nigeria and Ethiopia, pesticide use is much higher at 31% and 34%, respectively. Herbicides are the most commonly used pesticide, followed by insecticides. Figures 1 and 2 display pesticide use in Ethiopia and Nigeria, respectively, disaggregated by pesticide type. The fact that pesticide use is higher than commonly acknowledged underscores the importance of exploring the tradeoffs associated with pesticide use in these countries.

Pesticides are associated with agricultural productivity. Pesticide use is strongly and consistently associated with greater agricultural output value in Ethiopia, Nigeria, Tanzania, and Uganda. Plots where pesticides were used see total harvest values increasing by $32-$85 on average, depending on the country. Alternative estimates suggest that there is a 33% increase in harvest value in pesticide-using plots across all countries.

Pesticide use is associated with higher health care costs. We find that pesticide use is correlated with higher levels of expenditure on health care as a result of sickness in Tanzania and Uganda. We rule out the possibility that this relationship is driven by wealthier farming households' ability to purchase more pesticide inputs and more health care, simply by virtue of their higher income levels. On the contrary, it may be the case that health expenditures underestimate the incidence of illness related to pesticide use, particularly in settings where access to health care is limited or households are liquidity constrained, and therefore will only seek costly health care in extreme cases. If this is true, then the relationship between pesticide use and health expenditure can be considered a lower bound of a possibly larger relationship.

Pesticide use is linked to other variables implying poor health. First, we find that households that use pesticides are 4-9% more likely to have missed work due to illness in the previous 1-2 months than households that do not use pesticides in their farms. This result is remarkably consistent across the three countries for which these data are available (Ethiopia, Nigeria, and Uganda). Second, we find that Ethiopian, Nigerian, and Ugandan households that use pesticides report are more likely to have experienced a recent illness among their members and to have made more visits to a health worker. Tanzanian pesticide-using households also report more visits to a health worker. For income and access reasons, we would not expect that all individuals suffering from an illness – related to pesticide exposure or otherwise – would visit a health worker for treatment or advice, and especially not if they consider the negative health effects normal or routine (Banjo et al. 2010). However, the consistency of the pattern is striking and is a cause for concern.

Herbicides underpin pesticide-health relationships. Of the three types of pesticides that appear in our data (herbicides, insecticides, and fungicides), preliminary evidence shows that herbicides account for all of the relationships above in Ethiopia and Nigeria. Recall that herbicides are the most commonly applied pesticide, particularly on staple crops such as teff and wheat (Ethiopia) and maize and rice (Nigeria), but that prior work on the health effects of pesticide use focuses on cash

crops such as cotton. When we limit our analysis to a bundle of staple crops, we continue to find the positive relationships between pesticide use and negative health implications, suggesting that any these relationships cut across crop types.

Gender matters for pesticide-health relationships. Finally, the association between pesticide use and negative health outcomes appears to be stronger for males than for females, though the mechanism is unclear given that prior work using the same data finds no discernable gender difference in agricultural activities that might be associated with different levels of pesticide exposure (Palacios-Lopez, Christiaensen, Kilic, 2015). This points to a need for further investigation along a gender dimension.

3 | Conclusions and policy implications

While we cannot say for certain that pesticides as they are currently used in SSA cause health problems, the consistency in our estimated correlations – across samples, specifications, and estimators combined with intuition and theory – suggests that much more attention should be directed towards understanding the causal link and, where it truly exists, the extent to which it might be mitigated with better policies or programs to promote farmer awareness of the human health consequences of pesticide application rates. Our results are consistent with a stylized model in which trade-offs exist and information gaps for farmers might naturally lead to dangerous exposure to toxic pesticides. Our findings lay a foundation for more detailed exploration of whether farmers accurately understand the prospective health effects of pesticides use and incorporate that knowledge into both chemicals handling and storage practices and application rates.

In light of our empirical results, one might expect that extension efforts, either public or private, aimed at informing farmers about the potential negative human health effects of pesticide use could promote optimal use of pesticides. Economists who have studied pesticide use in other contexts point to the importance of conveying good and accurate information about the risks of pesticide use, particularly overuse, and doing so using participatory methods (Dasgupta, Meisner, Huq 2007). At the same time, more judicious use of pesticides due to greater knowledge about ideal application conditions or amounts could also have positive crop output implications, implying even further benefits to household productivity or net income levels, especially if reducing chemical use cuts down on input costs or enables farmers to preserve the natural environment upon which their livelihood is based. The development community should remain cautious about how to couple access to modern inputs with the requisite knowledge and precautions to keep rural households healthy and productive, especially as rising wages will naturally coincide with rising agricultural productivity as structural transformation renders labor-saving pesticides more attractive.

We offer these relationships as a call to other researchers to better understand the decision making and behavior that underpin our results using more tailored questionnaires to help answer the obvious follow on questions. Are farmers operating without full knowledge of the potential human health costs? Or are the costs theoretically known, but farmers unable to make the link for themselves that the sickness occurring within their households may be driven by the use of pesticides on farm and stored within the family dwelling? Or, perhaps even worse, are they fully aware that household sickness is related to pesticide use and continuing to apply them at the expense of household members' health?

Where pesticide use may undermine human health status, more focused and intensive investigation of that adverse relationship will inform discussions about potential extension and regulatory programming, both within the agricultural and public health arenas. Forsaking the health, and thereby productivity, of the very individuals who will carry out the structural transformation still yet to truly unfold in rural Africa while promoting the use of yield-enhancing inputs may prove unwise.

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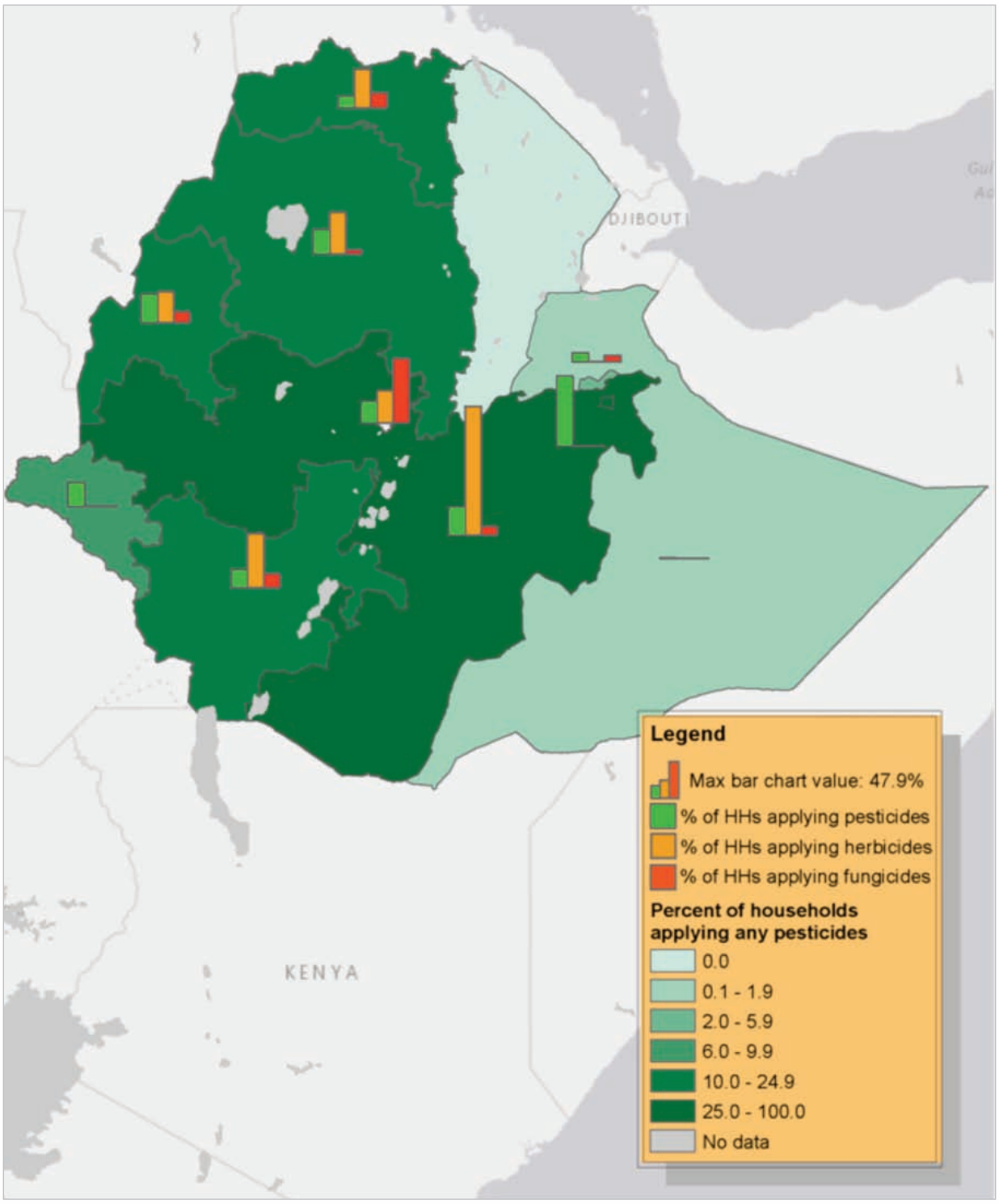
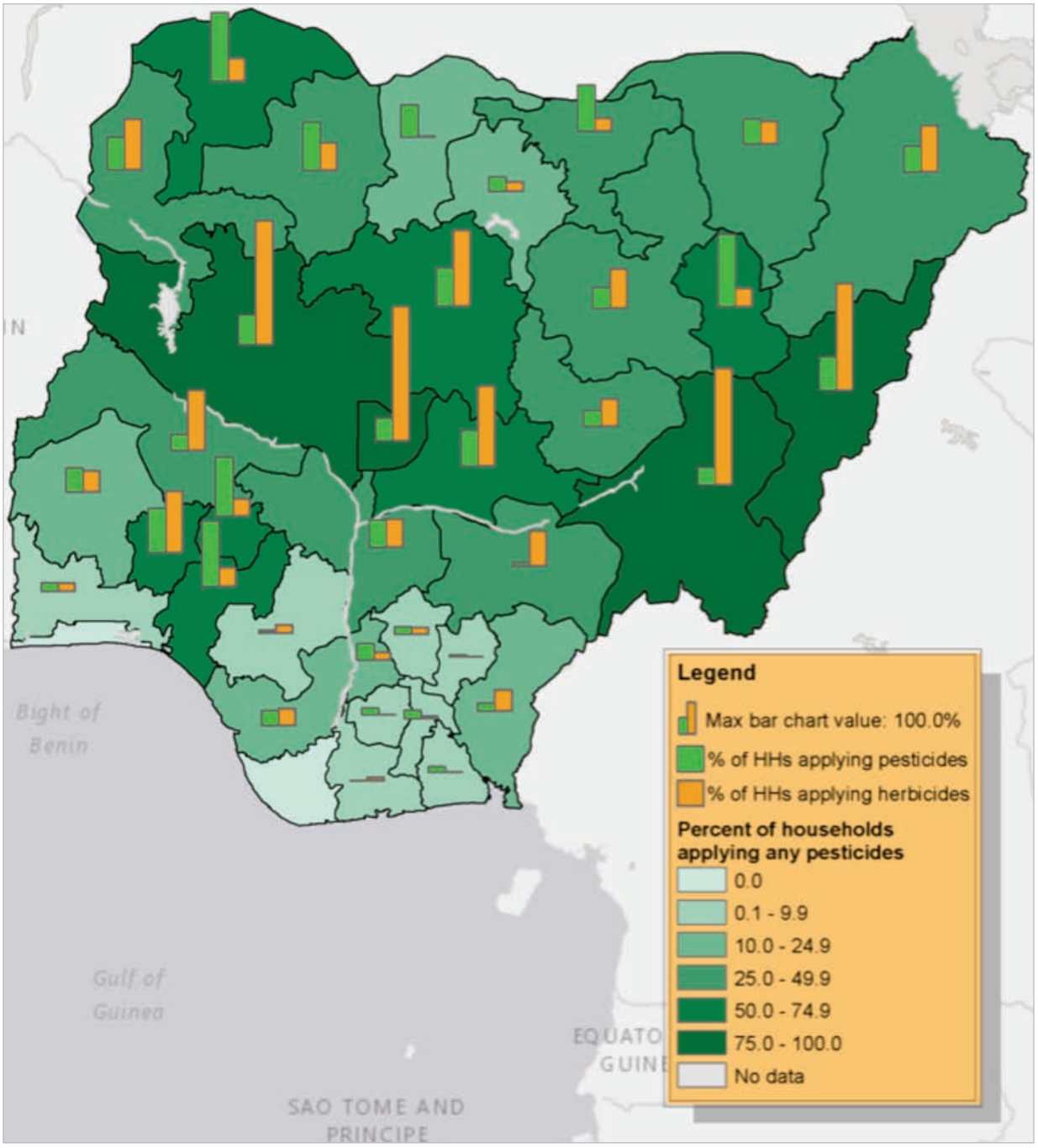
Figure 1 Map of agro-chemical use in Ethiopia Y1 (2011/12) cross section



Source: Authors' calculations using the Living Standards Measurement Study Integrated Survey on Agriculture cross section for Ethiopia 2011/12.

Figure 2 Map of agro-chemical use in Nigeria Y1 (2010/11) cross section



Source: Authors' calculations using the Living Standards Measurement Study Integrated Survey on Agriculture cross section for Nigeria 2010/11.

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