GROWING AGRICHEMICAL UBIQUITY: NEW QUESTIONS FOR ENVIRONMENTS AND HEALTH

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I. GENERIC AGRICHEMICALS AND PERVASIVE USE: NEW QUESTIONS FOR GLOBAL ENVIRONMENTAL HEALTH EQUITY

In the last 20 years, agrichemical use has increased significantly around the world. Dramatic changes in the global pesticide industry are restructuring trade patterns, driving down costs, and making agrichemicals more affordable across the global South. The result is a global pesticide complex that touches more people than ever, while its impacts become decreasingly legible on public health and the environment. The herbicide glyphosate, made famous under the brand name Roundup and increasingly sold as a generic, is a major force in this change. Marketed as a benign substance despite substantial evidence of human health harms (IARC 2017), glyphosate has become a pervasive agrichemical used on record-setting amounts of land. Overall, changes in the pesticide industry, underpinned by skyrocketing demand for glyphosate and other pesticides, is ushering in a new era of agrichemical ubiquity. Understanding these

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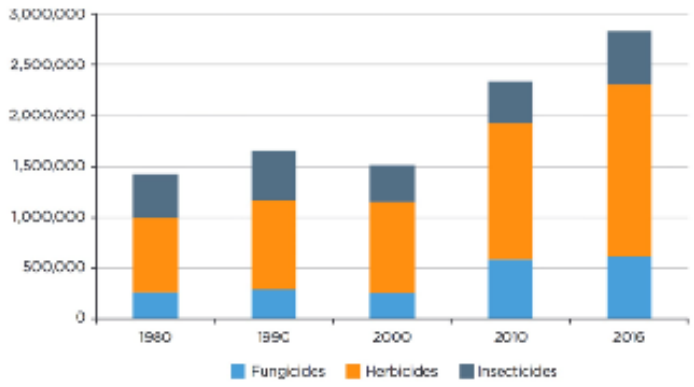
recent changes is crucial to forming an updated global environmental health research and policy agenda.

Increasing use in the global South

Over the last fifteen years, global pesticide use has risen at a faster rate than in decades past. Pesticide use is increasing almost twice as fast as food production (see Figure 1). While countries like the United States are still reporting higher pesticide use, most of this growth is taking place in the global South. For example, pesticide use in California grew 10% from 2005 to 2015, while use by Bolivian farmers, though starting from a low base, increased 300% in the same period. Pesticide use is growing steeply in countries as diverse as China, Mali, South Africa, Nepal, Laos, Ghana, Argentina, Brazil and Bangladesh. Most countries with high levels of growth have weak regulatory enforcement, environmental monitoring and health surveillance infrastructure.

Much of this growth is driven by increased demand for herbicides. Herbicides made up 43% of the global pesticide market in 2019 by value, far exceeding insecticides (27%) and fungicides (27%) (PMD, various years). Since 2000, Eastern European countries have seen a 50% increase in herbicide use (Bonanno et al. 2017). India saw a 250% increase since 2005 (Das Gupta et al. 2017) while herbicide use jumped by 2500% in China (Huang, Wang, and Xiao 2017) and 2000% in Ethiopia (Tamru et al. 2017). The introduction of glyphosate-tolerant soybean, maize, and cotton seeds in the US, Brazil, and Argentina is clearly driving much of the demand, but herbicide use is also expanding dramatically in countries that have not approved nor adopted such crops, and where smallholder farming is still dominant. Several other factors drive this "herbicide revolution" and rising pesticide use writ large: Rising rural outmigration has both driven up rural labor costs and squeezed labor availability for hand weeding, while farmers' increased market integration, export commodity booms, expanding supermarket supply chains and demand for new crops from urban consumers create a need for more pesticides. Farmers' ability to access herbicides has been amplified by falling prices due to corporate restructuring in the global pesticide industry.

Figure 1: Estimates of historical change in global herbicide, insecticide and fungicide use.



Source: Phillips McDougall

Cheaper Pesticides: The rise of the generics industry and South-South trade

The agrichemicals industry transformed over the last 20 years. Regulatory changes, largely in the EU, have nearly doubled the cost of bringing a new pesticide active ingredient to market. In light of these costs, major firms concentrated innovation on seeds genetically modified to be tolerant of proprietary formulations of older herbicides, like glyphosate and dicamba,

instead of developing new pesticide active ingredients. Innovation decreased by half as consolidation in the industry reduced the number of companies large enough to shoulder high R&D costs. Patents on popular agrichemicals expired, with no new patented active ingredients to take their position in the market. For example, Monsanto's last commercially important patent on glyphosate, the top-selling agrichemical in the world, expired in 2000; imidacloprid, the top-selling insecticide, went off-patent in 2005.

The result has been a sea change. In 2000, 70% of global agrichemical sales were patented or proprietary formulations (UPL 2017). By 2018, this proportion was inverse: 76.6% of agrichemicals on the global market were generic products; another 7.7% were proprietary off-patent[i] while only 15.7% were patented (PMD, various years).

This change from patented chemicals to generics coincided with the rise of China's agrichemical manufacturing capacity. In the mid-1990s, the Chinese state invested in innovation in manufacturing for existing agrichemicals and built a favorable credit and regulatory environment for domestic companies. As the global market moved to off-patent products, Chinese companies were able to produce at very low cost, so much so that Chinese generic exports came to play a dominant position in the global market. By 2018, China accounted for 46% of all herbicide exports, while the US, the second largest exporter, accounted for just 9%. Herbicide prices in China dropped 69% between 2000 and 2015, while exports rose. The top three Chinese exports are the herbicides glyphosate and paraquat and the neonicotinoid insecticide imidacloprid, which is widely implicated in pollinator deaths and banned for outdoor use in the EU. Chinese production has become dominant: As of 2016, China produced 70% of the world's glyphosate and China now produces 56% more pesticide active ingredients than either the US or the EU.

While the four largest global agrichemical companies still account for the majority (59%) of the agrichemical market, they are now competing directly with generic firms. A spate of mergers and acquisitions took place over the last five years among generic firms and between generic firms and the big four R&D driven firms. Such mergers regularly involved a shift in production away from high income countries. For example, when the largest supplier of generics, the Israeli firm Adama, was fully acquired by ChemChina in 2016, Chinese facilities became their center of manufacturing.

Increasingly "emerging" market economies are principal producers and exporters. In 2018, beyond China, three other top ten global herbicide exporters included India (5), Malaysia (7), and Ireland (10), followed in the top 15 by Argentina (11), Hungary (13), Poland (14), and South Africa (15). Over the last 15 years, established companies sold older substances, intellectual property and registrations, including highly hazardous pesticides, to companies with a larger production presence in these countries. In many smaller markets, smaller companies selling largely Chinese generics play a dominant role. For example, Vietnam now imports approximately 50% of pesticides from China and nearly two-thirds of Ethiopia's herbicide imports are from China and India, up from

about 10% in the mid-2000s.

Local firms that previously did marketing for the multinational agrichemical companies have increasingly registered their own brands and formulations with local regulators, using low-cost, generic active ingredients imported from China and India. This practice has led to a proliferation of formulations from both domestic and international formulators. Each could contain different combinations of active ingredients and surfactants, which can be more toxic than active ingredients, increasing the complexity of exposures, as well as confusion among some farmers about what the differences are. The Ivory Coast, for example, has 147 registered brands of glyphosate-based herbicides.

The combination of a shift to off-patent agrichemicals, the rise of generic pesticide manufacture in and export from emerging markets, and the subsequent drop in price has set the stage for large-scale agrarian change, as herbicides increasingly replace labor. These developments, in turn, produce a near-total ubiquity of agrichemicals the world over. Demand for glyphosate is key to this change. As the main steppingstone of second- and third-tier firms to enter a rapidly expanding generics market, glyphosate has been a catalyst for increasing agrichemical use worldwide.

Glyphosate: from 'benign' molecule to a pervasive generic

When glyphosate was launched in 1972, it was called a "once-in-a-century herbicide" in that it was widely thought to be both effective and safe. Because the biological process glyphosate targets is unique to plants, fungi and bacteria, Monsanto scientists claimed the substance would not harm people or other non-target organisms, that it did not persist in soil and water and did not bioaccumulate up the food chain. These claims made Roundup and other glyphosate-based herbicides unique compared to other popular products at the time like 2,4-D, atrazine and paraquat: 2,4-D and atrazine are known carcinogens, while paraquat is acutely toxic to humans at low doses.

Glyphosate became the largest selling and most profitable herbicide ever to appear on the global market. By 2018, glyphosate alone made up almost 8% of the total global agrichemical market. Glyphosate sales are roughly six times the next best-selling herbicide, and 3.3 times higher than the best-selling insecticide. Glyphosate served both as an effective agrichemical and as an ideological construct promoting agrichemical safety. In so doing, it made possible a new configuration within the global pesticide complex that set the stage for agrichemical ubiquity.

When the WHO's International Agency for Research on Cancer (IARC) declared glyphosate to be a "probable carcinogen" in 2015, the fragile consensus about its safety was upended. The ruling fueled fierce scientific debates on glyphosate's environmental and health risks, several thousand legal challenges, and regulatory struggles around the world. In 2020, the US Environmental Protection Agency affirmed that glyphosate-based herbicides (GBHs) pose no risk to human health, apparently disregarding new evidence about the link between glyphosate and non-Hodgkin's lymphoma as well as its non-cancer impacts on the liver, kidney and

gastrointestinal system. New research has also linked glyphosate to epigenetic changes, finding it acts as an endocrine disruptor that potentially produces long-term, including intergenerational, reproductive and developmental impacts. The recent US EPA's assessment contrasts with the State of California, which followed the IARC designation, and the US Centers for Disease Control, which confirmed both cancer and non-cancer risks to human health of glyphosate exposure. Other recent studies have documented pervasiveness in soil, the human microbiome, food, and water. Despite these findings, the EPA increased allowable residue levels in cereals and feed crops three times in recent decades (1999, 2012, and 2015) largely to reflect glyphosate's increased use as a "dry-down" chemical applied as a "harvest aid" and ripening agent. These increases ranged from 15% to 600%, thereby allowing considerable exposures of the general population through residues in food.

Glyphosate's very pervasiveness poses key challenges to the current paradigms of safety and risk that dominate pesticide management. Because it has been used in such large quantities over such large areas, glyphosate and its breakdown products are nearly ubiquitous in human bodies and the environment. In just under 20 years, much of the Earth has been coated with glyphosate, in many places layering on already chemical-laden human bodies, other organisms and environments. Glyphosate is not the only pesticide to achieve broad-scale pervasiveness. The insecticide imidacloprid, for example, coats the majority of US maize seed, making it the most widely used insecticide in US history. Between just 2003 and 2009, sales of imidacloprid products rose 245% (Simon-Delso et al. 2015). The scale of such use, and its overlapping effects on bodies and environments, have yet to be fully reckoned with, especially outside of countries with relatively strong regulatory and monitoring capacities.

II. PRACTICAL TAKEAWAYS: AGRICHEMICAL UBIQUITY, DECREASED LEGIBILITY AND PUBLIC HEALTH EQUITY

The rise of generic pesticides, and especially the explosive growth in glyphosate, is driving a rearrangement of the global pesticide industry, lowering prices and fueling increasing pesticide use worldwide. This has deep implications for global environmental health equity:

1. Unprecedented scale of agrichemical use – The volume of pesticide use and exposure is occurring on a scale that is without precedent and world-historical in nature. Agrichemicals, especially glyphosate, are now pervasive as they cycle through bodies and environments.[ii]

2. Low dose exposures are extensive – Given that low dose exposures of pesticides used pervasively, like glyphosate and neonicotinoids, are extensive, such exposures should be monitored and regulated in both bodies and environments with methods that match this new reality.

3. Decreased public health legibility – Increased sales of generic agrichemicals add complexity to efforts to assess health and environmental impacts since they often occur in places with minimal public health monitoring infrastructure. When poorly regulated, product content, including the wide-range of non-active ingredients, may not be well known or correctly reported.

4. Increasing exposure of agricultural workers and communities is likely – Pesticide use is expanding in countries with high levels of employment in agriculture, and with limited enforcement of regulations, especially labor rights, and weak environmental monitoring, including of water quality. Rural communities and farmworkers are as a rule already marginalized, and lack political power to force redress for environmental harms.

5. Economic incentives extend the life of older, more toxic generics – Some governments, including the US, have recently extended the life of several other older, generic, highly toxic agrichemicals; many of these are now widely available at lower prices than in the past.

6. New approaches needed – Existing approaches to monitoring, regulation and safe use are insufficient to address the era of pervasive agrichemical use.

Figure 2. Farmworker applies insecticide on rice fields in the Dominican Republic.

Source: Marion Werner

III. POLICY TAKEAWAYS

1. New regulatory approaches needed, potential for increased regulatory capture – As farmers increase their access to pesticides through low-cost generics, governments should strengthen regulatory frameworks and support for alternatives to agrichemicals, while maintaining regulatory independence from both the R&D and generics industry. Ministries of Environment and Health specifically will need political and scientific support to cope with these changes. Increased international cooperation is needed to support such a regulatory environment. Independent international standards on pesticide registration and use that reflect new challenges of ubiquity can bolster government efforts to update and strengthen national regulations. The FAO and the WHO could continue to play key roles here.

2. Community scale health and environmental monitoring – Water contamination and pesticide drift, especially from plantations and large-scale production facilities, is likely increasing, producing a need for new, more rigorous community scale health and environmental monitoring. New monitoring mechanisms suitable to the social and environmental realities of the places where generic pesticide use has become pervasive are needed. These may include a combination of formal and informal methods, stronger research and testing infrastructure, health surveillance (including national disease registries), citizen science, low-cost lay monitoring technologies, documenting exposure patterns, and other methods.

3. Occupational health protections for farm laborers – Labor laws on pesticide safety require better enforcement and potential re-evaluation in some places to meet the reality of pervasive use. Regulatory enforcement must include aid for compliance to smallholder farmers.

4. Opportunities and hazards for small scale farmers – Given pressures on smallholders, including increasing labor migration and the continued collapse of agrarian economies, less expensive agrichemicals may provide short-term relief to small-scale farmers already dependent on such inputs. New and intensified pesticide use increases the need to address pesticide dependence over the long term through support for and extension of more sustainable production methods. Valuing local ecological knowledge and "informal" social norms among farmers can aid in this goal. Public health monitoring, health care access, and state support to transition away from pesticide dependence will be necessary to accompany a transition to a more sustainable agriculture.

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FOOTNOTES

[i] Off patent products where company that held patent still accounts for more than 90% of global sales.

[ii] In contrast to chemicals like DDT, which bioaccumulates in mammals, agrichemicals like glyphosate have a short residence time in the body and break down relatively quickly, yet because of pervasive exposure are also ubiquitous in bodies.

AUTHORS

Annie Shattuck, Marion Werner, Christian Berndt, Becky Mansfield and Ryan Galt

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SERIES EDITORS

Dr. Emmanuel Frimpong Boamah, Dr. Katarzyna Kordas, and Dr. Samina Raja

DESIGN

Nicole Little

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Alex Judelsohn

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