Pesticides and the Crisis in Children's Health

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We owe it to ourselves and to the next generation to conserve the environment so that we can bequeath our children a sustainable world that benefits all.

-Dr. Wangari Maathai

Introduction

Overview:

I. The State of our children's health

II. Health links to pesticides - What do the studies say?

III. What are the specifics involved with the usage of pesticides In Africa and children's health?

The role of pesticides as a major factor and prime cause in the downward trajectory of our children's health has been known for decades.[1] There are innumerable studies that have documented how pesticides work and why they are so dangerous for our children. Yet, agribusinesses and government officials ignore both the well-vetted scientific and clinical information available and continue to promote the application of pesticide usage despite these alarming negative trends in our children's health globally.

The goal of this chapter is to provide an understanding of the present health crisis facing our children via an overview and update of the status of their

[1] Adams V, et al. What's Making our Children Sick? The Effect of Industrialized Food on Children's Health and What Parents (and Doctors) Can Do About It; *Chelsea Green Publisher;* chap 1*;* Nov. 2017

health. While there are many disorders and diseases now facing our children, several disorders have been selected due to either their prevalence (obesity), lack of awareness of their existence (intestinal/liver) and because of their rapidly escalating growth (neurocognitive dysfunctional disorders such as Autism Spectrum Disorder or ASD). This small representation of the vast number of challenges facing our children are pivotal examples of health consequences and the cost of convenience from decades of pesticide applications. New studies as well as clinical perspectives will be presented highlighting the links between these diseases and the most commonly applied pesticides.

The narrative of this chapter will hone in on the particular challenges of pesticide usage and their effects on African children. Research demonstrating the health benefits of food free from chemical inputs is discussed concluding with practical and applicable solutions away from chemical farming in Africa that would benefit and promote well-being in children's lives.

Definitions

Pesticides are a broad term and encompass various classes of killing agents including herbicides, insecticides, fungicides, rodenticides and bactericides (disinfectants). It is unusual to be exposed to only one of these chemicals individually and more commonly, multiple chemicals are applied concomitantly. The toxic effects of this "chemical soup" have been inadequately studied.[2] It should be clearly understood that studies are often reporting on one chemical only. Additionally, an entire pesticide product with the "inert" adjuvants are not studied along with the "active" ingredient. The true toxic picture on children's health from multiple chemical exposures simultaneously is unknown.

Toxic Soup

Presently, over 85,000 chemicals are used in the US causing exposures to both known and potential health hazards. These chemicals are detected in various body fluids of almost all Americans and in the global population as well.[3] They are categorized based on type of usage, route of exposure, toxicologic effects

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[2] Henn BC, et al. Chemical Mixtures and Children's Health; *Curr Opin Pediatr. 223–229.* Apr; 26(2):223-229.

[3] *Fourth National Report on Human Exposure to Environmental Chemicals Updated Tables*, January 2019, Volume One; https://cfpub.epa.gov/ncea/risk/hhra/recordisplay.cfm?deid=23995

and their longevity/half-lives in biologic tissue.[4] The scope of the problem of trying to monitor blended effects from chemical mixtures is unwieldy. However, one can narrow down the largest groups employed and that cause some of the greatest harm. Those chemicals are pesticides.

Public Health – A precarious balance

A particular problem faced by African children that confounds the issue with pesticide application is the usage of pesticides in public health. There are serious diseases spread by animal and insect vectors (malaria, Dengue Fever, Zika Virus, Lyme Disease, etc.), and these organisms can contaminate food crops/processing facilities, homes and schools. In order to protect children from these health risks, pesticides have played a vital role.

A cogent example of the employment of pesticides in the treatment of vector-born illness, such as malaria, is the usage of insecticide-treated mosquito nets as promoted by the World Health Organization (WHO). In 2015, 438,000 people were killed by malaria and 70% of those killed were children under the age of 5 years.[5] However, even as this measure saved so many lives, a study in 2002 demonstrated mosquito resistance to pyrethroids, the class of insecticide used in the netting and recommended the addition of a carbamate insecticide to enhance the efficacy of the nets.[6] However, children would have significant exposure via respiratory and dermal routes by a dual pesticide combination (childhood exposure will be discussed later in this chapter) and both of these insecticides have been linked to neurologic disorders.[7],[8]

The delicate balance between children's health and pesticides from a public health perspective elucidates the need for vector control. However, it begs the question as to whether we can we do better in terms of health protection

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[4] Braun JM, Gray K. Challenges to studying the health effects of early life environmental chemical exposures on children's health; *Plos Biology*; Dec. 2017; https://doi.org/10.1371/journal.pbio.2002800

[5] United Nations Children's Fund, 'Malaria', *UNICEF,* New York, 22 July 2016.

[6] Corbel V, et al. Insecticide Mixtures for Mosquito Net Impregnation Against Malaria Vectors; *Parasite*; 2002 Sep;9(3):255-9. doi: 10.1051/parasite/2002093255.

[7] Viel J-F, et al. Pyrethroid insecticide exposure and cognitive developmental disabilities in children: The PELAGIE mother–child cohort; *Environment International*, Vol 82, Sept 2015, pgs 69-75; https://doi.org/10.1016/j.envint.2015.05.009

[8] Rowe C., et al. Residential proximity to organophosphate and carbamate pesticide use during pregnancy, poverty during childhood, and cognitive functioning in 10-year-old children; *Environmental Research*; Volume 150, October 2016, Pages 128-137; https://doi.org/10.1016/j.envres.2016.05.048

simultaneously decreasing toxicant exposures for the sake of protection and preservation of our children's health. It is important to note that this public health issue should not be seen as an open invitation for the biotechnology industry to put pressure on African nations to accept novel forms of transgenic technology such as gene drives and genome editing, with the goal of manipulating biologic ecosystems (such as The Target Malaria Project).[9]

It is worth referencing a recent report to best appreciate the African perspective, *Profiteering From Health and Ecological Crises in Africa*, published by *The African Centre for Biodiversity;*

"…A historical review of malaria eradication success stories in Africa shows that traditional methods can be successful in eradicating this killer disease. If, in the light of new discoveries related to how transmission is evolving, novel approaches to control malaria are warranted, applications that are based on shifting ecosystems and that entail unprecedented environmental and human health risks should be unequivocally rejected by African governments and society. African ecosystems have already reached tipping points; what we need is to protect our biodiversity and support domestic strategies to combat malaria that are focused on bolstering health care systems and fixing public infrastructure."[10]

Children's Health Landscape

Just observationally looking at children playing in a park or school in the US, stark changes are revealed than one might not have noted just a few decades ago. Presently, one might expect to see 1 in 5 to 1 in 3 of the kids with obesity; excessive behavioral disorders such as overt aggression or social isolation with ASD affecting 1 in 23 boys; 1 in 6 to 1 in 8 children seen having their asthma inhalers in their back pockets and cell phones in many of their hands, spending more time on their phones than in other physical activities. (As an aside, the epidemic of cell phone usage at schools has created flocks of kids looking downward consistently, so much so that a newly diagnosed condition has emerged, "text neck".)[11] Additionally, mental health challenges are

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[9] https://www.acbio.org.za/sites/default/files/documents/202006/profiteering-health-and-ecological-crises-africathe-target-malaria-project-and-new-risky-ge_0.pdf

[10] Ibid

[11] Fares J, et al. Musculoskeletal neck pain in children and adolescents: Risk factors and complications; *Surg Neurol Int*. 2017; 8: 72; doi: 10.4103/sni.sni_445_16

dominating adolescence, for example, with 1 in 6 US youth aged 6-17 years old experiencing a mental health disorder each year.[12]

What Do the Statistics Say about African Children's Health?

A look at obesity: The African Region is experiencing similar obesity rates as in many parts of the world.[13] A common misconception is that obesity and other chronic diseases are affecting the wealthy and the poorer populations are immune. This has been shown to be a fallacy and the upward trend in obesity is associated with a change in diet to sugary/highly processed foods, decreased consumption of legumes and vegetables, the navigation away from traditional diets, as well as an increase in sedentary life styles. Obesity in children is not a benign disorder and is associated with the development of metabolic syndrome, hypertension, mental health issues such as low self-esteem, bullying and risks of future chronic diseases in adulthood.[14]

While Africa comprises 54 countries with a vast array of different languages and cultures, there is a continental trend of countries undergoing a nutritional transition, with nutrition-related diseases such as nutrient deficiencies (zinc, iron, vitamin A), and growth retardation coexisting with obesity in children causing a significant health burden.[15] As noted globally, the pattern of changing diets to more "western diets" and decreased physical activity are contributing to this dilemma.[16] Upon a review of the literature on African children and diet, the role of infectious diseases is noted and reported, as well as the aforementioned factors. However, there is little mention of the role of contamination by pesticides as another root cause of nutritional disease. While there are contradictory studies and an element of industry bias in research, most of the data supports that organically grown crops contain more iron, magnesium, phosphorus and Vitamin C as well as fewer nitrates than

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[12] https://www.nami.org/mhstats

[13] https://www.afro.who.int/health-topics/obesity

[14] Weiss R, et al. The metabolic consequences of childhood obesity; *Best Practice & Research Clinical Endocrinology & Metabolism*; Volume 19, Issue 3, September 2005, Pages 405-419; https://doi.org/10.1016/j.beem.2005.04.009

[15] Mbogori T, Mucherah W. "Nutrition Transition in Africa: Consequences and Opportunities"; *Global Journal of Transformative Education* (2019) 1:1, 5-10. DOI 10.14434/gjte.v1i1.26141

[16] Ibid

conventional crops.[17] In addition, there are also lower levels of some heavy metals in organic crops as compared to those that are grown conventionally.[18] In other studies, contamination of glyphosate-based herbicides with heavy metals have been reported.[19] Indeed, providing the most nutrient-dense food free of contaminants and toxicants such as lead, aluminum and mercury should be a major consideration in childhood nutrient analyses, especially in lieu of the fact that small children do not eat large quantities. Therefore, one of the goals is to maximize nutrient density in smaller amounts of food.

As discussed above, there are many chronic health disorders affecting children. Of concern, there are escalating rates of endocrinologic issues, asthma/allergies/eczema, behavioral and mental health issues in children, and a grave issue is in regard to neurocognitive dysfunction. Using US data for comparison, the prevalence of Autism Spectrum Disorder (ASD) can be seen as a canary in the coal mine or the flagship of the deterioration of our children's health and will be presented in comparison to African children. As we begin to dissect the causes of these issues in children, a brief review on the physiologic differences between children and adults will be presented as well as an explanation as to why this is so important in understanding the role of pesticide toxicity on children's health.

Understanding pesticide exposure in children

In relation to their body weight, children have a larger skin surface area than adults, breathe in more air and drink and eat more, hence they experience a much higher exposure rate than adults. Common routes of exposure for many children occur via the dermal and inhalational routes. Children are closer to the ground, often play barefoot in pesticide-sprayed areas and explore much of their world via hand-to-mouth behaviors. Pesticides can cross the epithelium of the skin and mucous membranes that exchange gases (alveoli) or via the gastrointestinal mucosa. The rate of absorption depends on the chemical properties, amount of the chemical, length of exposure and the physical state of the actual pesticide molecules. There are also other factors that may contribute to increased absorption, such as skin absorption is higher when there is vasodilatation (e.g. in summer or with heating), which would be more of

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[17] Worthington, V. Nutritional Quality of Organic Versus Conventional Fruits, Vegetables, and Grains; *The Journal of Alternative and Complementary Medicine;* Volume 7, Number 2, 2001, pp. 161–173

[18] Ibid

[19] Defarge N. Toxicity of formulants and heavy metals in glyphosate-based herbicides and other pesticides; *Toxic Rep:* 2018; 5: 156–163

a problem on the African continent. Respiratory absorption is many times higher when respiration is more rapid, e.g. when playing or running. Children have a much higher respiratory rate than adults and thus have a greater exposure via inhalation.[20]

Another important consideration is how children detoxify xenobiologics, particularly in comparison to adults. The first line of defense in processing foreign chemicals resides in the intestinal microbiota; the collection of organisms that are found in the large intestine, vital to the health of the child and one of the most important areas of study and treatment in modern medicine. This vast community of organisms (consisting of bacteria, archaea, fungi and viruses) have been shown to be impacted by pesticides that act as antibiotics.[21] For example, glyphosate, the main ingredient in Roundup® was patented by Monsanto (now Bayer) as an antibiotic in 2010[22]. Mechanisms on how glyphosate affects the microbiota have been demonstrated as well as potentially elucidated the link between glyphosate and cancer.[23] (In 2015, the WHO via its specialized cancer agency, the *International Agency for Research on Cancer* (IARC), classified glyphosate as a class IIa carcinogen.[24],[25]) Glyphosate has been found in both breast milk[26] and infant formula[27], so either method of nutrition will expose infants to glyphosate from the very first stages of life.

From a clinical perspective, again, there is tremendous importance in the role of the microbiota in terms of children's health. Children acquire their microbial communities from their mothers during vaginal births as well as breastfeeding. (Of note, progress is being made in Africa to support mothers to breast feed their infants for the first 6 months which is a source of nutrients and immune

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20 Health Council of the Netherlands. Pesticides in food: assessing the risk to children; The Hague: Health Council of the Netherlands; 2004

[21] Mesnage R, et al. Shotgun metagenomics and metabolomics reveal glyphosate alters the gut microbiome of Sprague-Dawley rats by inhibiting the shikimate pathway; *BioRxiv;* doi: https://doi.org/10.1101/870105

[22] https://patents.google.com/patent/US7771736B2/en

[23] Ibid 14

[24] https://www.iarc.fr/wp-content/uploads/2018/07/MonographVolume112-1.pdf

[25] Guyton KZ, et al. Carcinogenicity of Tetrachlorvinphos, Parathion, Malathion, Diazinon, and Glyphosate; *Lancet Oncol*; 2015 May;16(5):490-1. doi: 10.1016/S1470-2045(15)70134-8. Epub 2015 Mar 20

[26] https://www.telesurenglish.net/news/Brazil-Poisonous-Agrotoxin-Found-Over-80-of-Breast-Milk-Samples-in-Urucui-20180809-0008.html

[27] https://www.reuters.com/article/us-food-agriculture-glyphosate/fears-over-roundup-herbicide-residues-prompt-private-testing-idUSKBN0N029H20150410

development as well as infant immune support via the breast milk microbiota.)[28] If the mother has been exposed to antibiotics either via food or pharmacologics, her microbiome will be altered which will impact the baby's microbiota inheritance. One of the roles of the infant's microbiota is the establishment of the innate immune system.[29] The emergence of childhood health issues from obesity, immune dysregulation (allergies/asthma) and ASD are linked to early microbiome disturbances.[30] Based on the importance of the acquisition of the most robust microbiota possible from the mother, antibiotic usage in all forms for mother and infant should be used judiciously. Based on our current understanding of the antimicrobial effects of this ubiquitous herbicide, glyphosate should be banned outright.

Of note, in addition to glyphosate, other pesticides have also been shown to affect the microbiota. There are many studies that have documented how organophosphate (OP) insecticides also affect the microbiota.[31] Of interest, many of the studies postulate modification techniques of the microbiota to reduce toxicity rather than elimination of OPs, and thus, do not acknowledge or address the true treatment which is removal of the root cause. OP insecticides will be addressed further below.

In trying to understand how much pesticide exposure such as glyphosate (the most commonly applied pesticides globally) African children receive, a quick review will be presented regarding glyphosate application.[32] The amount of glyphosate applied in continental Africa depends on the individual country. For example, South Africa accounts for 2% of the global pesticide usage secondary to its adoption of genetically modified organisms (GMOs) and there are 96 glyphosate-based herbicides registered.[33] Kenya reports that 2.6 million kilograms (kgs) of glyphosate-based herbicides are imported into their country annually and are present in 70 of their 1,540 pesticide products approved in

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[28] https://www.dw.com/en/many-african-countries-urged-to-support-breastfeeding-mothers/a-39966423

[29]Al-Shehri S, et al. Breastmilk-Saliva Interactions Boost Innate Immunity by Regulating the Oral Microbiome in Early Infancy; PLoS One. 2015; 10(9): e0135047

[30] Eshraghi RS, et al. Early Disruption of the Microbiome Leading to Decreased Antioxidant Capacity and Epigenetic Changes: Implications for the Rise in Autism; ***Cell. Neurosci.*, 15 August 2018 |** https://doi.org/10.3389/fncel.2018.00256

[31] Roman P, et al. "Microbiota and organophosphates"; *NeuroToxicology*; Volume 75, December 2019, Pages 200-208

[32]Vlavanidis A. Glyphosate, the Most Widely Used Herbicide. Health and safety issues. Why scientists differ in their evaluation of its adverse health effects; *Research Gate;* Mar 2018

[33] https://www.agribusinessglobal.com/markets/africa-middle-east/the-tenuous-future-of-glyphosate-in-africa/; accessed 27 May 2020.

crops.[34] Uganda reports 42 of 300 herbicides are glyphosate-based.[35] It is important to note that the usage of glyphosate-based herbicides in Africa has created significant controversy. Organizations, such as *The African Centre for Biosafety*,[36] is running a campaign to ban glyphosate. Additionally, there are other African countries looking at the health ramifications of glyphosate. In 2019, the Cancer Association of South Africa (CANSA) published a paper supporting the findings of IARC and its position on glyphosate to be carcinogenic, as well as an endocrine-disruptor, cytotoxic agent, genotoxic agent and teratogen.[37]

What should be alarming is that despite the vigorous research and number of organizations and countries that are engaged in either restricting or banning glyphosate-based herbicides, little attention has been paid to the ongoing exposure from a health perspective to our most vulnerable populations. As mentioned previously, South Africa grows GMO crops and according to the *African Center of Biodiversity*, half of South Africa's maize crop and 100% of the soya crop are GMO which means it is grown with glyphosate.[38] Maize and soya are main staples of the South African diet.

Further analyzing the question of how much African children are being exposed to glyphosate-based herbicides, let's look quantitatively at the actual amounts of glyphosate that children consume in their diets. In a South African study of 81 off-the-shelf maize and soybean food products tested for glyphosate, 67% contained glyphosate in the range of 27-2,357 parts per billion (ppb). 30 of 57 maize products contained glyphosate in the range of 27 to 95 ppb. All 11 soya products contained glyphosate in the range of 27 to 142 ppb. All 6 corn-soy blends tested positive for glyphosate in the range of 43-65 ppb. 7 texturized soy protein products tested positive for glyphosate in the range of 41 to 2,257 ppb. Clearly, the main diet of South African children, heavily comprised of maize and soya, is contaminated with very high levels of glyphosate and are much higher than acceptable levels determined to be safe in children.[39] The significance of these findings will be discussed below.

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[34] Ibid

[35] Ibid

[36] https://www.greenafricadirectory.org/listing/the-african-centre-for-biosafety-acb/

[37] https://www.cansa.org.za/files/2019/04/Fact-Sheet-and-Position-Statement-on-Glyphosate-web-April-2019.pdf. The original paper is from this source, but could not be accessed: https://scholar.ufs.ac.za:8080/xmlui/bitstream/handle/11660/6536/KoortzenBJ.pdf

[38] Ibid

[39] Ibid

Remove the blinders to glyphosate-based harm

Does dose make the poison?

In a study by Mesnage, et al, rats administered 0.1 ppb of Roundup® showed signs of enhanced liver injury via several biologic samples as well as oxidative stress, demonstrating that **ultra low doses** of glyphosate-based herbicides caused fatty liver (NAFLD - nonalcoholic fatty liver disease).[40] This issue has now surfaced as a major epidemic. In Americans, 1 in 3 adults are presently diagnosed with NAFLD.[41] This disorder can further progress to more serious forms of liver disease and cirrhosis. Children are not faring better than adults in respect to NAFLD. The prevalence of NAFLD in the pediatric population is estimated between 3-12%, and found in a shocking percentage of 70-80% of children with obesity.[42] Acknowledging the previously reported issues of obesity in African children, the obvious question is whether this type of problem is even being addressed or considered. With the high levels of glyphosate reported in the foods children consume, one can surmise that these children are overloaded with pesticides and their ability to detoxify may be significantly impaired. The reality exists that a significant number may have undiagnosed/unrecognized NAFLD with the potential for further advancement of liver disease. A further look at the detoxification capacity of children will follow in the next section.

Research continues to focus on genetics and "environmental factors" as causative agents in the epidemic of liver disease, some pointing the finger to high fructose corn syrup (HFCS) as an etiology for the rise in NAFLD as well. Equally disturbing is that upon review of the literature, reporting or further discussion of the issue of the link between ultra low doses of Roundup causing NAFLD in either children and adults could not be found despite the research previously published by Mesnage and the American National Liver Foundation ringing the bell regarding the epidemic of NAFLD. Clearly, we must also address the derivatives of the components of HFCS as being potential causal factors: GMOs and their associated pesticides.

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[40] Mesnage R., et al. Multiomics reveal non-alcoholic fatty liver disease in rats following chronic exposure to an ultra-low dose of Roundup herbicide; *Scientific Reports*, volume **7**, Article number: 39328 (2017)

[41] https://liverfoundation.org/?s=NAFLD

[42] Bush H., et al. Pediatric Non-Alcoholic Fatty Liver Disease; *Children (Basel)*. 2017 Jun; 4(6): 48.

How could we have ever believed that it was a good idea to grow our food with poisons?

-Jane Goodall

Can children clear the toxic load?

The second line of defense in clearing xenobiologics after the front-line defenders, the microbiome, is the liver, which has many housekeeping responsibilities in health maintenance. The impact of NAFLD and its sequelae of worsening liver disease could potentially impair detoxification. One of the ways detoxification occurs is via the cytochrome p450 pathway. The cytochrome p450 pathway as well as the paraoxonase1 (PON1) pathway play a major role in the metabolism and detoxication of OP insecticides and are involved in the metabolism of oxidized lipids as well. The role of OPs in children's health such as neurodevelopment disorders is well-known.[43]

Children's detoxification mechanisms are not well developed until several years after birth.[44] The role of the PON1 plasma enzyme in the detoxification scheme is an undervalued variable. In a study from 1953[45], PON1 was shown to hydrolyze the toxic metabolites of OP insecticides. Hence, the information regarding this enzyme has been available for decades. Studies have shown that the PON1 levels of newborns are one-third to one-fourth the levels of adults.[46] These levels have an impact on OP exposures in small children which can effect developmental neurotoxicity.[47]

OPs can reach children by various routes of exposure via fetal exposure crossing the placenta and in breast milk. The blood brain barrier is not

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[43]Rowe C, et al. Residential Proximity to Organophosphate and Carbamate Pesticide Use During Pregnancy, Poverty During Childhood, and Cognitive Functioning in 10-year-old Children; *Environ Res;* 2016 Oct;150:128-137. doi: 10.1016/j.envres.2016.05.048. Epub 2016 Jun 6

[44] Freeman K. Capability to Detoxify Pesticides; *Env Health Persp;* Vol. 117, No. 10; 1 October 2009https://doi.org/10.1289/ehp.117-a454b

[45] W.N. Aldridge. "Serum esterases. I. Two types of esterase (A and B) hydrolysing p-nitrophenyl acetate, propionate and butyrate, and a method for their determination"; Biochem J, 53 (1953), pp. 110-117

[46] Huen K. Developmental Changes in PON1 Enzyme Activity in Young Children and Effects of PON1 Polymorphisms; *Env Health Persp*; 117(10):1632-8 · October 2009

[47] Furlong C et al. PON1 Status of Farmworker Mothers and Children as a Predictor of Organophosphate Sensitivity; *Pharmacogenet Genomics;* 2006 Mar;16(3):183-90. doi: 10.1097/01.fpc.0000189796.21770.d3

developed until after age one and does not protect the infant from unwanted chemicals crossing into the brain.[48] There is significant genetic variability of the PON1 gene which will impact susceptibility to OPs. PON1 can be seen as a biomarker of susceptibility to neurodevelopment effects.[49]

Due to its toxicity, OPs are being phased out in many parts of the world. However, the usage forecast in Africa has been estimated to continue to grow at the rate of 4.8% between 2017-2022, with South Africa and Egypt requiring the highest demands.[50]

Pesticides and the link to neurodevelopment disorders

ASD is now a global epidemic facing children and data exists transcontinentally as presented in the graph below:

Prevalence of autism spectrum disorder among children in select countries worldwide as of 2020

(per 10,000 children)[51]

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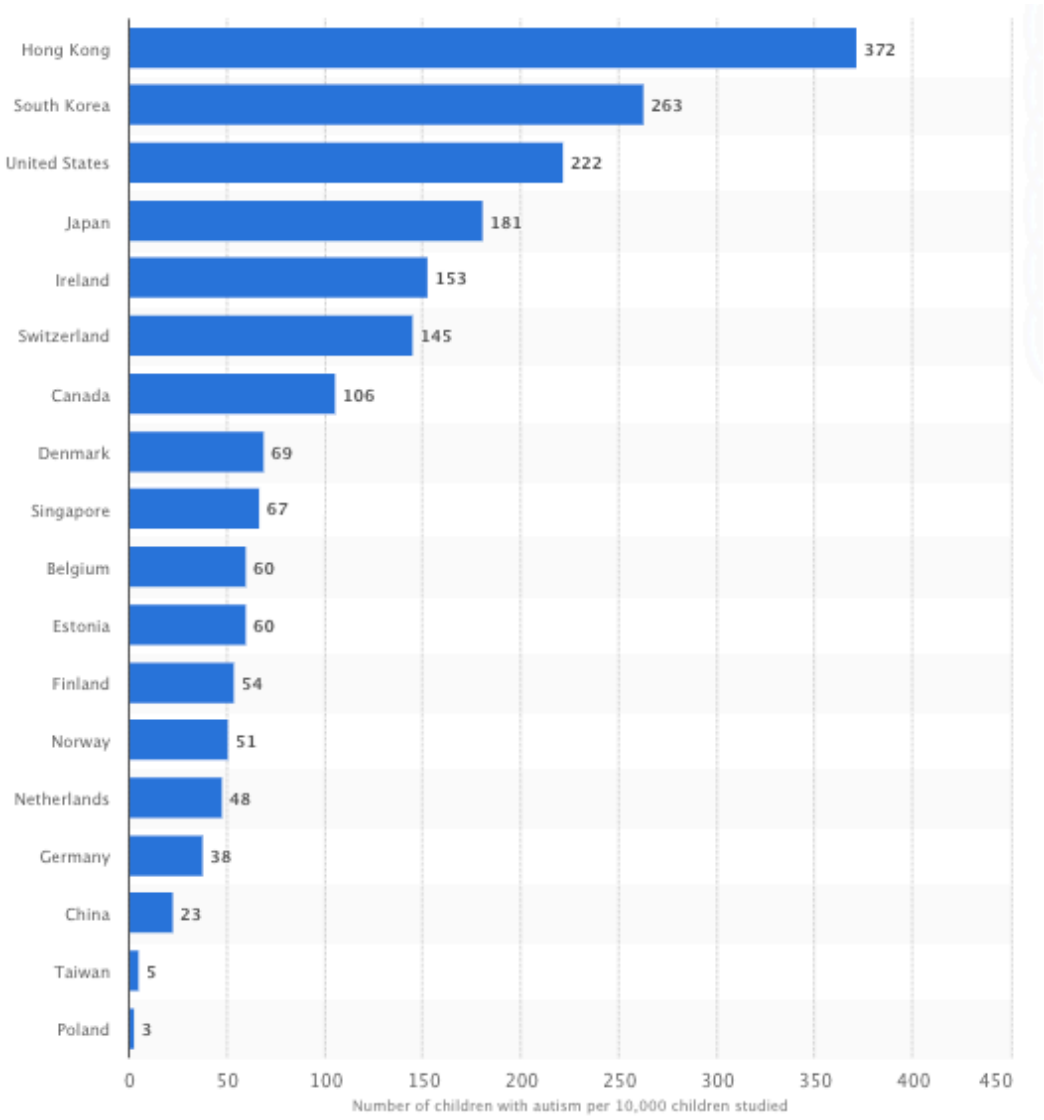
[48] Eaton DL, et al. "Review of the toxicology of chlorpyrifos with an emphasis on human exposure and neurodevelopment"; *Crit Rev Toxicol*, 38 (suppl 2) (2008), pp. 1-125

[49] Marsillach J, et al. "Paraoxonase-1 and Early-Life Environmental Exposures"; *Annals of Global Health;* Volume 82, Issue 1, January–February 2016, Pages 100-110

[50] https://www.mordorintelligence.com/industry-reports/africa-organophosphate-pesticides-market

[51] https://www.statista.com/statistics/676354/autism-rate-among-children-select-countries-worldwide/



However, rates of ASD in Africa are not clearly defined nor are any African countries included in global reporting. One research paper laid out all of the peer-reviewed studies on autism from the 46 countries in sub-Saharan Africa. 80% of the studies focused on South Africa and Nigeria, two of the wealthier countries in Africa.[52] This study showed that there were inadequate methodologies utilized as well as a lack of standardized diagnostic tools and studies were generally small-scale in terms of the assessment of ASD in Africa. However, unpublished data shows that 1% of children from Kenya are autistic,

[52] Franz L, et al. Autism Spectrum Disorder in Sub-Saharan Africa: A Comprehensive Scoping Review; Autism Res; 2017 May;10(5):723-749. Doi: 10.1002/aur.1766. Epub 2017 Mar 7

in-line with global reports.[53] Of concern, there are acknowledged lack of resources, educational limitations, diagnostic challenges such as late-onset of diagnoses and a paucity of specific programs to assist ASD children and their families. What is not being addressed both in Africa as well as in countries such as the US is what are the root causes of the autism epidemic. Specifically, what are the links between pesticides and the autism epidemic?

One might argue that in order to show a clear causation between pesticides and neurocognitive disorders, there are specific research requirements that demonstrate causation and not correlation including the following metrics; an extended meaningful time period of the participants being studied, a large number of participants, exclusion of other confounding factors, human subjects and multiple markers of monitoring (such as surveys, biological markers and blinded reproducible interpreters of the data). A look at CHAMACOS…

The CHAMACOS Study; "little children"[54]

The University of California (Berkeley, CA; US) began enrolling women in an agricultural region of Northern California (Salinas) to evaluate the effect of pesticides in a farmworker community. This 21 year longitudinal birth study has been evaluating children's health every 1-2 years with a focus on neurodevelopment, following them into adulthood with more than 800 children enrolled, 536 followed since birth and 305 followed since age 9. More than 300,000 biological samples have been collected. The CHAMACOS Study has been a pivotal force in exposing the critical role of pesticides as well as other toxicants on child and maternal health and is undeniably a leader in providing impervious data with nearly 150 publications to date. Their findings meet the requirements of the type of obligatory research that provides clear evidence between pesticides and neurodevelopment disorders.

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[53] https://www.spectrumnews.org/features/deep-dive/autism-remains-hidden-africa/

[54] https://cerch.berkeley.edu/research-programs/chamacos-study

In another groundbreaking study, 2,961 patients with a diagnosis of ASD were evaluated from California's Central Valley, a heavy agricultural region.[55] After adjusting for confounding factors, the researchers found increased risks of ASD in those children exposed to 7 of the most commonly used pesticides (including glyphosate, chlorpyrifos, diazinon, malathion, permethrin, bifenthrin and methyl bromide) before birth and during the first year of life compared with controls.[56]

Unraveling the mechanisms of neurologic toxicity

In a newly published study, increasing levels of Roundup in mice were associated with ASD-like behavior in the juvenile offspring.[57] The mechanism appears to be related to epoxide hydrolase which is involved in the metabolism of polyunsaturated fatty acids. When the mice were given an inhibitor of sEH (TPPU), it prevented these behavioral changes. The importance of this study is that the mechanisms of how brain changes occur in children with ASD from pesticide exposures are now being identified. Additionally, changes in the microbiota were reported and there is significant data now demonstrating abnormal microbiota in children with autism.[58] These changes in the microbiota may be secondary from the already known antibiotic effects of glyphosate as an antibiotic as previously discussed. The communication between the gut and the brain via the enteric nervous system is now accepted with the microbiota producing a vast arrange of metabolic modifying compounds affecting the brain.[59] The gut-brain axis appeared to be affected by the administration of increasing doses of Roundup as noted in this study with the subsequent development of neurocognitive changes seen in ASD as well as death in some of

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55 Ehrenstein OS et al. Prenatal and infant exposure to ambient pesticides and autism spectrum disorder in children: population based case-control study. *BMJ*. 2019;364:l962. doi: 10.1136/bmj.l962

56 https://www.gmoscience.org/early-exposure-to-pesticides-linked-to-increased-risk-of-autism/

57 Pu Y, et al. Maternal glyphosate exposure causes autism-like behaviors in offspring through increased expression of soluble epoxide hydrolase; *PNAS* May 26, 2020 117 (21) 11753-11759; first published May 12, 2020 https://doi.org/10.1073/pnas.1922287117

58 Eshragi R et al. Early Disruption of the Microbiome Leading to Decreased Antioxidant Capacity and Epigenetic Changes: Implications for the Rise in Autism; Front. Cell. *Neurosci.,* 15 August 2018 | https://doi.org/10.3389/fncel.2018.00256

59 Carabotti M. The gut-brain axis: interactions between enteric microbiota, central and enteric nervous systems; Ann Gastroenterol. 2015 Apr-Jun; 28(2): 203–209

the animals. A stronger study would have identified that the control group was fed an organic chow and given Roundup-free water (since one can assume that Roundup is present in animal feed as well as the water supply) and the study's findings may have shown even greater power. Additionally, further clarification of whether the effects reported are from the glyphosate or its toxic adjuvant, polyethoxylated tallow amine (POEA) are clinically relevant.

From a clinical perspective, the removal of pesticides and chemical inputs are the first steps in my treatment plan (as well as being practiced by colleagues from meetings, organizations and personal correspondence) to reverse neurobehavioral disorders. But let it be clear, that although individuals bear responsibility for their own actions, it is equally true that social determinants of health (such as access to quality food, water, air, education, racial equality) create the fabric in which we live. These other factors must be taken into account in order to nurture and create well-being for children.

Africa Poised at the Organic Cotton Crossroads

As much of world embraces genetically modified (GM) cotton, as of May 2020, only 7 of Africa's 54 countries adopted GM technology:

South Africa - 1997
Eswatini and Sudan - 2012
Ethiopia, Kenya, Malawi and Nigeria - 2018

However, Algeria, Burkina Faso, Egypt and Madagascar have prohibited the use of GMOs. The pressure on Africa to adopt GM technology is increasing and the continent is at a crossroads in terms of its own financial, health and environmental future as to whether to adopt GMOs and their associated increasing pesticide application due to weed/organism resistance or maintain their well-poised global position in terms of organic cotton production.[60]

As outlined in the recent paper produced by the Textile Exchange, there are many problems with the introduction of GM cotton throughly outlined in their report.[61] Briefly summarized, these concerns include seed ownership and the need for repurchasing seeds and chemical inputs annually, cross-contamination

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60 https://store.textileexchange.org/wp-content/uploads/woocommerce_uploads/2020/06/Cotton-in-Africa-Sustainability-at-a-Crossroads-White-Paper_final-2020608-tj8cl8.pdf

61 https://textileexchange.org/organic-cotton-round-table/africa/

of GM cotton with organic cotton, consumer concerns, environmental hazards and climate change as well as profits.[62] Despite this thorough overview, very little was discussed in terms of the fact that cotton is the world's most heavily sprayed crop and with the increased introduction of GM cotton into Africa, there will be greater applications of pesticides.[63] Again, of concern was that there was no mention of the massive potential health risks to children from this pending significant increase of pesticide application with the adoption of GM cotton.

In addition to the environmental and health advantages of organic cotton production, sustainable agriculture has brought significant economic advantage to countries such as Benin, where conversion to organic cotton resulted in a net income increase of 50% due to more profit from consumer demand and reduction of input costs.[64] Sustainable agriculture offers a solution to poverty to small farms and provides an incentive for stabilization and development of rural communities due to the fact that organic cotton farming is performed mostly by small farm owners.[65]

On a final note, in addition to a dominant global role Africa could play in organic cotton production, there are secondary social benefits including the role of women in the workforce. Women seem to prefer organic production and made up approximately 35% of the organic cotton farmers in 2014.[66] The success of women in owning their own cotton farms increases economic independence while strengthening the resilience of their own families as well the environment.

From *The Textile Exchange Pan-Africa Sourcing Working Group*:

"…support(s) and encourage(s) the growth of preferred cotton programs that prohibit the use of genetic engineering. These currently include organic (specifically those in the IFOAM Family of Standards), Fairtrade, and Cotton made in Africa. These programs embrace organic practices that build organic

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[62] Ibid

[63] https:store.textileexchange.org/product/2019- organic-cotton-market-report/。

[64] *Pesticide Action Network UK*; Cotton Farming in Benin - A Case Study (Unpublished manuscript); 2020

[65] Ibid 66

[66] http://farmhub.textileexchange.org/upload/Sustainability%20Assessment%20Tool/OC_SUSTAINABILITY_ASS ESSMENT_R1-2.pdf。

matter in soils (increasing carbon sequestration), support smallholder farmers, and protect human health and the environment."[67]

An End to Pesticide Profiteers

In is indisputable that children are victims to ubiquitous herbicide usage, such as glyphosate, whether it is from the food they consume, indirectly from drift, contamination from air and water, living in proximity to farms and farm workers or access via inappropriate storage of dangerous chemicals. Africa has a large agricultural base and many of those farming are children. Occupational hazards from sprayers with leaky hoses or workers without appropriate personal protection results in a high dermal exposure. Are there adequate safeguards in place for worker protection including medical access? Additionally, in 2016, The European Union called for a ban on the toxic adjuvant component of Roundup, POEA. Will Africa be subject to "overstocked" chemicals and receive these unwanted rejects?[68]

African organizations, such as T*he Alliance for Food Sovereignty* (AFSA), are taking a strong position against not only glyphosate, but other toxic pesticides and have created a call to action away from pesticides and towards agroecology via the creation of networks of support with farmers, consumers, NGOs and international partners.[69] It is clear that Africans decide what is best for their communities without political and profit pressure. A movement is underfoot to promote agroecology, diverting away from unsustainable chemical farming which undermines self-determination and resilience. Evidence exists that agroecology is capable of feeding the world's population.[70]

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[67] Ibid 63

[68] EU agrees ban on glyphosate co-formulant; *Euractiv;* Published 12 July 2016. https://www.euractiv.com/ section/agriculture-food/news/eu-agrees-ban-on-glyphosate-co-formulant/

[69] https://www.acbio.org.za/sites/default/files/documents/Africa_must_ban_glyphosate_now_Aug2019.pdf

[70] https://www.agroecology-pool.org/showcases/

"If governments won't solve the climate, hunger, health and democracy crises, then the people will. Regenerative agriculture provides answers to the soil crisis, the food crisis, the health crisis , the climate crisis and the crisis of democracy."

-Dr. Vandana Shiva