Pesticide Exposure and Health Problems Among Female Horticulture Workers in Tanzania

Authors: Mrema, Ezra Jonathan, Ngowi, Aiwerasia Vera, Kishinhi, Stephen Simon, and Mamuya, Simon Henry

Source: Environmental Health Insights, 11(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/1178630217715237

Pesticide Exposure and Health Problems Among Female Horticulture Workers in Tanzania

Environmental Health Insights
Volume 11: 1–13

DOI: 10.1177/1178630217715237

Ezra Jonathan Mrema, Aiwerasia Vera Ngowi, Stephen Simon Kishinhi and Simon Henry Mamuya

Department of Environmental and Occupational Health, School of Public Health and Social Sciences, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania.

ABSTRACT: Commercialization of horticulture farming, expansion of farms, and the practice of monoculture favor the proliferation of pests, which in turn increases the need for pesticides. Increased exposure to pesticides is associated with inadequate knowledge on the hazardous nature of pesticides, poor hygiene practices, lack of availability of washing facilities, and insufficient adherence to precautionary instructions on pesticide labels. Mitigating the risks posed by pesticides is considered a less compelling interest than alleviating poverty. Women working in horticulture in Tanzania usually have low levels of education and income and lack decision-making power even on matters relating to their own health. This contributes to pesticide exposure and other health challenges. Because of multiple factors, some of which act as study confounders, few studies on exposure to pesticides and health effects have been conducted among women. This review identified factors that contribute to the increased health effects among women working in the horticultural industry and how these effects relate to pesticide exposure.

KEYWORDS: Pesticide exposure, horticulture, women, diseases, Tanzania

RECEIVED: November 25, 2016. **ACCEPTED:** May 22, 2017.

PEER REVIEW: Five peer reviewers contributed to the peer review report. Reviewers' reports totaled 2399 words, excluding any confidential comments to the academic editor.

TYPE: Review

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The Norwegian Agency for Development Cooperation provided financial support through The Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED).

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Aiwerasia Vera Ngowi, Department of Environmental and Occupational Health, School of Public Health and Social Sciences, Muhimbili University of Health and Allied Sciences, P. O. Box 65015, Dar es Salaam, Tanzania. Email: vera.ngowi@gmail.com

The number of women in agricultural employment is increasing worldwide; women now account for about 43% of the total workforce in agriculture.[1] Approximately, 80% of economically active women in sub-Saharan Africa are working in the agriculture sector.[2] Similar to women in other developing countries, women in Tanzania engage actively in horticulture. Horticulture is fruit, vegetable, and ornamental agriculture. Women account for 65% to 70% of the horticultural labor force[3] and thus make a significant contribution to the national economy. There are patterns in men's and women's agricultural tasks. Weeding and postharvest processing are considered women's work no matter what the crop is. Men are largely responsible for cash crop farming and income-generating activities.[4]

Horticulture is the fastest-growing subsector of the Tanzanian economy, with an estimated growth rate between 6% and 10% per annum.[3] It is mainly practiced by small-scale farmers for local markets and large-scale farmers for export markets. In 2015, the subsector is reported to have contributed about US $0.6 billion to the agricultural sector, which was almost half of what the entire agricultural sector contributed to the economy.[5] Thus, horticulture has the potential to become one of the main sources of foreign exchange earnings for Tanzania. The main production areas include the southern highlands, the northern corridor, and the coastal zone. More than 85% of commercial horticultural investment is concentrated in northern Tanzania.[6]

Although horticulture provides food security to families and employment opportunities, especially to women, occupational health issues for women working in horticulture are not adequately documented. Much effort is put into promoting the use of pesticides to boost productivity and less effort into protecting health and the environment. Thus, women farmers and other women farmworkers are frequently exposed directly when working as pesticide applicators or indirectly during harvesting, planting, and soil preparation. They are at a greater risk of accumulated exposure because of long working hours from an early age and multiple exposures at work and in domestic settings.[7] This exposure to pesticides during work is in addition to other forms of exposure, from residues in food and water to air pollution, experienced by the general population. Washing pesticide-contaminated clothes and reusing of empty containers, 2 tasks traditionally done by women, are further causes of exposure. Consequently, women horticultural workers may suffer adverse health effects.[8-10] Also, women have a unique susceptibility to pesticides because of their physiological characteristics, lifestyle, and behavior.[10]

To support development of horticulture, approximately 5.6 billion pounds of pesticides are applied worldwide annually.[11] It is estimated that 81% of pesticides used in Tanzania are applied to control pests and disease in the agriculture and livestock sectors.[12] Exposure to pesticides has been reported to cause adverse health effects, and great numbers of people have been affected globally.[13-15] Annual severe pesticide poisoning cases amount to 3 million worldwide[16]; 25 million symptomatic occupational pesticide poisonings are said to occur each year among agricultural workers in developing countries.[17] Increased symptoms of respiratory and skin sensitization,

Table 1. Horticulture crops grown in production regions, Tanzania.

ZONE	REGION	HORTICULTURE CROPS
Southern highlands	Morogoro	Tropical and temperate fruits and vegetables (including dessert bananas and onions) and spices (clove, ginger, and turmeric)
	Iringa	Temperate fruits, tropical vegetables (tomatoes, onions, etc)
	Njombe	Cut rose flowers
	Mbeya	Temperate and tropical fruits and vegetables (avocados, tomatoes, banana, citrus, etc)
	Ruvuma	Onions, tomatoes, flowers, vegetables, and fruits (peaches, avocados, passion fruit, mangoes)
Northern corridor	Arusha	Flowers, temperate fruits, and vegetables
	Kilimanjaro	Flowers, avocados, bananas, temperate fruits and vegetables, mushrooms
	Manyara	Temperate fruits and vegetables
	Tanga	Temperate fruits and vegetables, tropical fruits and spices
Coastal zone	Coast (Pwani)	Tropical fruits
	Dar es Salaam	Tropical fruits and vegetables, mushrooms
Central zone	Dodoma	Grapes, tomatoes, and onions
Lake zone	Kagera	Vanilla, bananas
	Mwanza	Tropical vegetables (eggplant, cabbage, etc)
	Mara	Bananas and tropical vegetables
Western zone	Kigoma	Tropical vegetables (onions, carrots) and spices (vanilla, turmeric, ginger, etc)

malaise, vomiting, nausea, diarrhea, excessive sweating, abdominal pain, and excessive salivation have been reported as a result of pesticide exposure.[18-22] However, many studies are conducted mainly among the male population.[23-27] In Tanzania, where men are more involved in pesticide application than women, more occupational cases would be expected in men than women.[28] However, as has been shown by a study conducted in South Africa,[29] women's occupational health risks in the developing world can be grossly underestimated.

There are various laws, rules, and regulations on occupational health and safety formulated and implemented under different ministries, departments, and agencies in Tanzania. These laws and guidelines do not adequately address what is stipulated in regional or international requirements.[9] Occupational safety and health law in the country covers only formal economic sectors. Few workers in the formal sectors use occupational health services and even fewer in informal sectors such as agriculture. Moreover, farmers are not covered by the workers' compensation law of 2008, as they do not have formal employment.[30] Women who work in horticulture receive care through primary health care services.

Understanding pesticide exposure among workers is essential for drawing firm conclusions about its health effects. This review identifies factors that contribute to the increased health effects among women working in the horticultural industry and how those factors relate to exposure to pesticides in Tanzania.

Pesticide Use in Horticulture

In response to huge demand for Tanzanian agricultural products, there has been a great increase in horticultural production for both export and domestic use that has led to intensified cultivation, a reduction in the use of traditional methods of pest management, and an increase in the use of synthetic pesticides.[31] The main horticultural crops are fruits, vegetables, flowers, and spices (see Table 1), which are grown in 16 of the 24 regions of mainland Tanzania (see map, Figure 1). Pests and diseases have been the limiting factors in the horticultural development in the country. Historically, crops were grown for subsistence by smallholder farmers who practiced crop rotation and intercropping that put a check on pest populations.[32] However, recent developments have resulted in monoculture and thus an increased pest population. To cope with this situation, large amounts of pesticides and other agrochemicals are used to manage pests and ensure the cultivation of high-quality products. A study conducted by Barraza et al[33] on banana plantations in Costa Rica found that large-scale monoculture was perceived as one of the most important problems leading to pesticide risks.

To meet the market demand for quality horticultural crops, farmers use various pesticides (Table 2).[34-53] Lekei et al[54] identified a total of 1182 pesticide products registered in Tanzania, representing a broad variety of active ingredients. Arusha region is known to be leading in pesticide trading and utilization in Tanzania because of intensification of horticulture.[55-57]

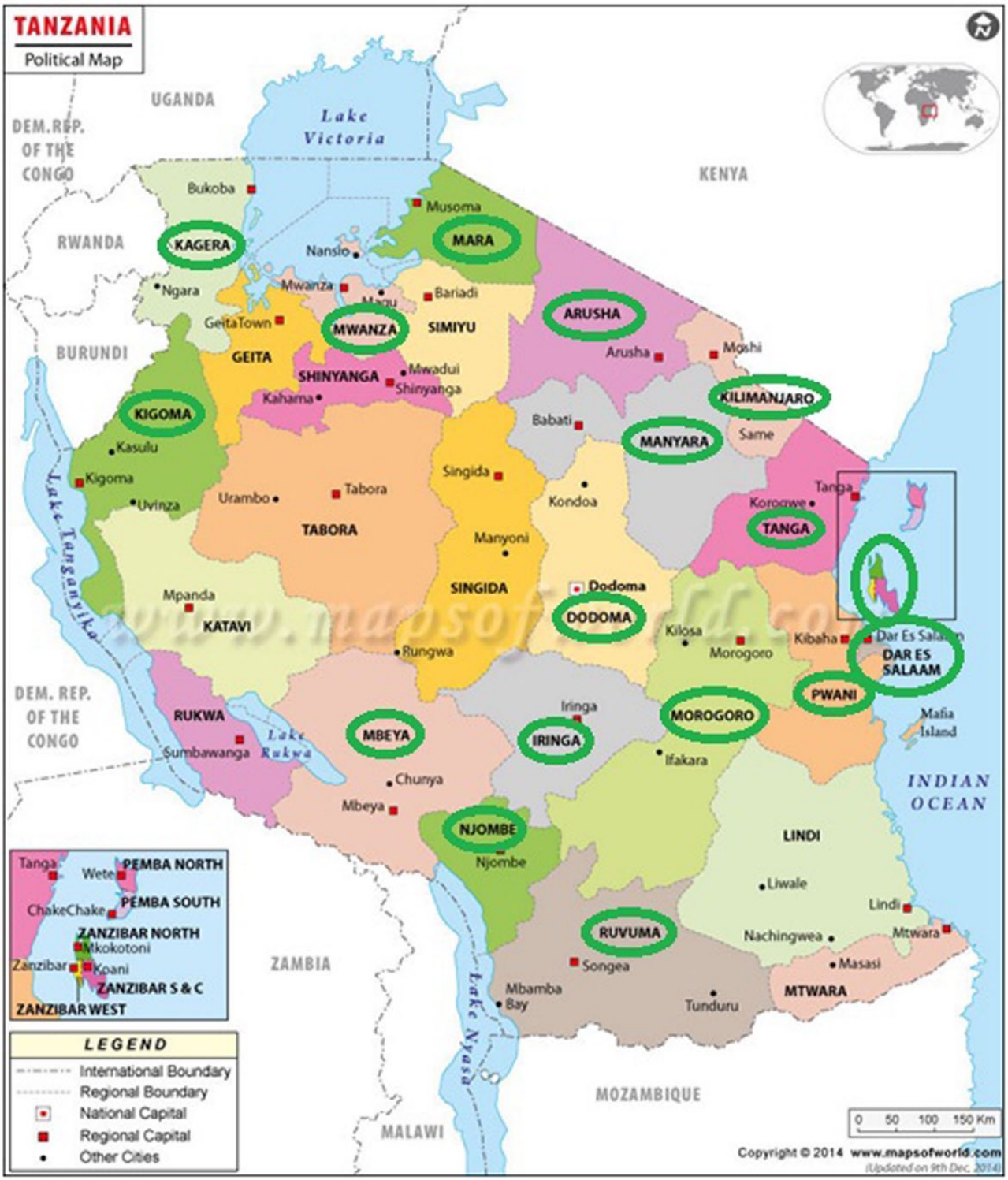

Figure 1. Horticulture production regions in Tanzania.

In 2003, Ngowi et al[58] reported the use of 41 different pesticides in northern Tanzania, including class IA (extremely hazardous) and IB (highly hazardous) pesticides. These pesticides are known to be hazardous to humans. The report also showed that even though they did not spray pesticides, women were exposed during pruning, grading, and general cleaning on flower farms. Also, in a study set in Kenya conducted by Tsimbiri et al,[18] women who were mainly engaged in weeding, planting, and harvesting reported the highest proportion of symptoms potentially related to pesticide exposure.

Pesticide regulations in Tanzania control imports, distribution, and sales, allowing pesticides to be used that are considered to be less harmful to end users. Most toxic and persistent pesticides are either banned or restricted in use, even though unregistered pesticides are found on the market. Inadequately staffed border-crossing points enable infiltration of substandard and

Table 2. Pesticides used in horticulture in northern Tanzania.

TRADE NAME	ACTIVE INGREDIENT	CHEMICAL GROUP	WHO CLASS[34]	TYPE	REGISTRATION STATUS	SOME HEALTH EFFECTS	REFERENCES ON HEALTH EFFECTS
Thionex/ thiodan	Endosulfan	OC	II	Insecticide	Registered	Suspected EDC	US EPA[35]
Selectron	Profenofos	OP	II	Insecticide	Registered	N, CI	US EPA[36]
Profecron	Profenofos	OP	II	Insecticide	Registered	CI	US EPA[36]
Helarat	λ-cyhalothrin	P	II	Insecticide	Registered	Suspected EDC, I	Kim et al,[37] NPIC[38]
Karate	λ-cyhalothrin	P	II	Insecticide	Registered	Suspected EDC, I	Kim et al,[37] NPIC[38]
Dimethoate	Dimethoate	OP	II	Insecticide	Registered	CI	US EPA[39]
Rogor	Dimethoate	OP	II	Insecticide	Registered	CI	US EPA[39]
Bamethrin	Deltamethrin	P	II	Insecticide	Registered		
Shumba Super	Fenitrothion + deltamethrin	OP/P	II	Insecticide	Registered	CI	US EPA[40]
Polytrin	Cypermethrin	P	II	Insecticide	Unregistered	C	US EPA[41]
Zetabestox	ζ-Cypermethrin	P	IB	Insecticide	Registered		
Dursban	Chlorpyrifos	OP	II	Insecticide	Registered	CI	NPIC[42]
Antokil	Chlorpyrifos	OP	II	Insecticide	Registered	CI	NPIC[42]
Furadan	Carbofuran	C	IB	Insecticide	Registered	EDC, CI	US EPA[43]
Termik	Aldicarb	C	1A	Insecticide	Unregistered	EDC, CI	US EPA[44]
Banko plus	Chlorothalonil + carbendazim	OC	U	Fungicide	Registered	C	US EPA[45]
Bravo	Chlorothalonil	OC	II	Fungicide	Registered	C	US EPA[45]
Rova	Chlorothalonil	OC	NK	Fungicide	Registered	C	US EPA[45]
Linkonil	Chlorothalonil	OC	NK	Fungicide	Registered	C	US EPA[45]
Kalachi	Glyphosate	OP	III	Herbicide	Registered		
Roundup	Glyphosate	OP	III	Herbicide	Registered		
Mamba	Glyphosate	OP	III	Herbicide	Registered		
Balton	2-4-D Amine	AA	U	Herbicide	Registered		
Bayleton	Triadimefon	T	II	Fungicide	Registered	PC	US EPA[46]
Permethrin	Permethrin	P	II	Insecticide	Unregistered		
Diazinon	Diazinon	OP	II	Insecticide	Unregistered	CI	US EPA[47]
Diazol	Diazinon	OP	II	Insecticide	Unregistered	CI	US EPA[47]
Malathion	Malathion	OP	III	Insecticide	Registered	CI	US EPA[48]
Actellic super	Pirimiphos-methyl	OP	II	Insecticide	Registered	N, CI	US EPA[49]
Carbaryl	Carbaryl	C	II	Insecticide	Unregistered	N, CI	US EPA[50]
Victory	Metalaxy	A	II	Fungicide	Registered		
Propamocarb hydrochloride	Pyrethrins	P	No class	Fungicide	Unregistered		

Table 2. (Continued)

TRADE NAME	ACTIVE INGREDIENT	CHEMICAL GROUP	WHO CLASS[34]	TYPE	REGISTRATION STATUS	SOME HEALTH EFFECTS	REFERENCES ON HEALTH EFFECTS
Thiovit	Sulfur	S	III	Fungicide	Registered	I	US EPA[51]
Meltatox	Triforine		U	Fungicide	Unregistered	I	US EPA[52]
Ridomil	Metalaxyl/ mancozeb	D	III	Fungicide	Registered	I/CI	Strivastava and Kesavachandran[53]
Farmerzeb	Mancozeb	D	II	Fungicide	Registered	CI	Strivastava and Kesavachandran[53]
Dithane	Mancozeb	D	III	Fungicide	Registered	CI	Strivastava and Kesavachandran[53]
Milthane	Mancozeb	D	U	Fungicide	Unregistered	CI	Strivastava and Kesavachandran[53]
Indofil	Mancozeb	D	III	Fungicide	Registered	CI	Strivastava and Kesavachandran[53]
Ivory	Mancozeb	D	IB	Fungicide	Registered	CI	Strivastava and Kesavachandran[53]
Red copper	Copper oxide	Cu	III	Fungicide	Registered		
Cuprocaffaro	Copper oxychloride	Cu	II	Fungicide	Registered		
Blue copper	Copper sulfate	Cu	II	Fungicide	Registered		

Chemical groups: C, carbamate; OC, organochlorine; D, dithiocarbamate; P, pyrethroid; OP, organophosphate; A, acylalanine; AA, aryloxyalkanoic acid; Cu, inorganic copper; T, triadimefon; S, sulfur.
WHO class: 1A, extremely hazardous; 1B, highly hazardous; II, moderately hazardous; III, slightly hazardous; U, unlikely to present acute hazard in normal use; NK, not known.
Health effects: C, carcinogen; CI, cholinesterase inhibitor; EDC, endocrine disruptor; I, irritant; N, neurotoxin; PC, possible carcinogen.
Symbols: λ, lambda; ζ, zeta.
Referenced organizations: US EPA, United States Environmental Protection Agency; NPIC, National Pesticide Information Center.
Adapted from Lema et al.[6]

unregistered pesticides into the country. Pesticide formulations are distributed by licensed pesticide retailers; however, unlicensed vendors also exist due to illegal trades and porous borders. To control this, pesticide retailers in the country are inspected by the Tropical Pesticide Research Institute to discourage them from selling unregistered products. However, due to geographical distance and inadequate funds to support travel for inspection, pesticide retailers in some regions are not regularly inspected. As a result, unregistered products become widespread in these areas.[54] As described by London et al,[59] liberalization of trade policy in Tanzania resulted in large increases in pesticide imports and altered the patterns of pesticide supply and distribution, with increases in the involvement of private retailers 80-fold from 1988 to 1997. The increase in retailers greatly outpaced the expansion of control facilities.

Among preventive measures for exposure are hazard warnings and general information posted on pesticide labels. Consumer groups and international bodies such as the World Health Organization, the International Labour Organization, and the Food and Agriculture Organization put emphasis on the promotion of activities, plans, laws, and treaties to prevent the negative effects of pesticides on human health and the environment. Because women are not considered to be pesticide users, such preventive measures do not reach them. Although there are no studies in Tanzania that have characterized women's exposures to pesticides, our personal observations indicate that women are exposed to pesticide due to ignorance of its hazard and effects. This observation is supported by Rother et al,[60] who showed that a major factor exacerbating risk was a lack of knowledge about hazards and how to protect oneself and one's family. For instance, farm residents often are not aware of or familiar with pesticides' labels; nor are they able, in many instances, to interpret information on labels meaningfully.

Although food consumers are exposed to pesticide residues in food, women in horticulture are also exposed to pesticides that are known to cause long-term health effects. Exposure studies in Tanzania have reported the use of pesticides that are suspected or possible endocrine disruptors or possible or probable carcinogens, neurotoxicants, cholinesterase inhibitors, or irritants.[6] Endosulfan, which is mainly used in cotton production in Tanzania, is listed as a moderately hazardous pesticide and is a suspected endocrine disruptor. A cohort study conducted among male schoolchildren showed that endosulfan exposure was associated with delayed sexual maturity, in particular, interference with synthesis of the male sex hormone and the development of pubic hair, testes, the penis, and serum

testosterone at age-appropriate levels.[61] Other persistent organochlorinated pesticides have been associated with health effects including cancer,[62-64] reproductive defects,[65] and behavioral changes.[66]

Risk Behavior in Pesticide Use

Risk behavior, that is, lifestyle activities that places a person at increased risk of suffering a particular condition, in this case pesticide exposure, is influenced by social, economic, and cultural aspects. The need to increase the quantity and quality of horticultural produce and pressure to use pesticides exerted by pesticide dealers increases the risk of high exposure to pesticide.

Tanzanian women have fewer educational opportunities. In total, 1 in 5 women in rural areas has never attended school, and a significant number of girls drop out at all level due to pregnancy or childbirth, early marriage, illness, the illness or death of a parent or guardian, or a lack of school fees. Although women in developing countries play a central role in smallholder agriculture, they often receive less training in pesticide management than men.[59,67] Women's roles are changing under the global system of trade liberalization and market economies. From a gendered division of labor at the household level, women are shifting to self-employment, engaging in more nontraditional activities such as salons, curio shops, child-care centers, and small trading in food and clothes. Although women continue with domestic duties, with responsibilities for children and for sick or elderly family members, their agricultural activities and responsibilities have increased.[59,68] Many have become wage earners, and some single parents, in particular, have felt obliged to take jobs that put their health at risk. In 2009, about 1 out of 5 households in Tanzania was headed by a woman, and such households were among the poorest in the country.[69] Women in developing countries have taken on additional agricultural roles that were initially perceived to be men's work. These include mixing and applying pesticides in agriculture,[67,70,71] which affects their health and that of their offspring. The potential for adverse pesticide-related health effects among women increases with the assumption of pesticide spraying duties.[67] Women with low levels of education, low levels of pesticide use safety awareness,[72] poor access to personal protective equipment, and limited training on proper use of pesticides may be at high risk of pesticide exposure and the resultant adverse health effects. Jørs et al[73] showed that lower levels of education are also associated with less knowledge of pesticides and with risky behavior when pesticides are being handled.

In Tanzania, women are typically located in lower-paid, low-status work, often casually employed, with little opportunity for promotion or access to safety measures. In general, the most of the women work in the informal sector doing physically demanding unskilled manual labor. On average, they work 11 hours a day during the nonfarming season and almost 16 hours during the farming season.[70,74] Moreover, they go to the field with their infants and children because they lack access to or cannot afford day care services.

Although women account for more than half the population of Tanzania, only a small proportion are involved in making decisions about agriculture, the economy, and family issues. About 40% have no decision-making power even in matters regarding their own health. The control of household income by their husbands means that women cannot act on their own. They are thus subjected to different stresses from trading, domestic, and agricultural work. In some parts of Tanzanian society, witchcraft accusations are also culturally accepted, with the health effects of pesticide exposure being attributed to bewitching or a similar traditional practice rather than a dangerous chemical. Consequently, individuals may not take the necessary measures to protect themselves from being exposed to pesticides.[59]

Women often work in fields while pesticides are being sprayed or enter the fields soon after spraying has taken place.[70,74] Older children help with work on the farm and get exposed to pesticides as well. Long working hours in contaminated fields increase the risk of exposure and associated adverse health effects. Farmers' knowledge and perceptions about pesticide risks play an important role in determining the extent of their exposure to pesticides.[75] However, given that higher risk perceptions and greater knowledge about the associated risk do not always translate into closer adherence to precautionary advice, the relationship between risk perception and behavior may not be direct. Factors such as economic and employment pressures, as well as pressures related to peer group influences, may also influence risk-related behaviors. As a consequence, many workers and operators do not adopt protective practices nor use protective equipment.[76] Women do not perceive the pesticide risk because they rarely handle pesticides directly; hence, they have no protection. Women also store pesticides nearer the home, particularly in the kitchen and bedroom because they have more control over these spaces than the field. They therefore risk exposing not only themselves but also their whole family.[15,77]

Pesticide-related education has an important role in increasing knowledge about pesticides' risks and how to avoid exposure.[78,79] As part of the intensification and commercialization of agriculture, concerns about the potential adverse impacts of pesticide use are often downplayed by pesticide dealers and agricultural extension service providers,[15] whereas the benefits of pesticide use in terms of improved crop returns are overemphasized. The end users do not perceive pesticides as a risk due to competing interests linked to the need to generate income.

Failure to read labels, misuse of pesticides, poor knowledge of hazards, and misconceptions about pesticide exposure all influence the perception of pesticides' level of risk. Studies conducted in Ethiopia and Tanzania found that most farmers do not read instructions on pesticides packages because they are illiterate or are simply reluctant to take the trouble.[15,75] Another

study, conducted in Tanzania by Kapeleka et al,[12] revealed that only 1 out of 3 commercial farm workers sometimes read instructions on pesticides containers and that just a few follow the instructions. However, many depend on their supervisors to read the instructions for them. Many farmers who work on their own farms do not read labels but rely on advice from pesticide dealers, extension workers, and neighbors. The reasons for not reading or following instructions are that the labels are in foreign languages, the user is illiterate, the label uses unknown signs and symbols, or that labels are simply illegible. Kapeleka et al[12] also found that even though workers understand the poisonous nature of pesticides and their potential to harm and even kill users, most do not properly employ personal protective equipment. In places where the poverty level is high, householders give priority to basic needs, such as food, utilities, clothing, and transport, and not to the acquisition of personal protective equipment.[67] Empty pesticide containers have been found to be reused, mostly by women for domestic purposes such as storing cooking oil, water, milk, flour, salt, and kerosene. Empty containers always have residues and are a source of exposure that can cause harmful effects to users.

Lack of awareness and knowledge regarding personal hygiene and the unavailability of sanitary facilities increases the risks of exposure to pesticides among both women and men. People in rural areas do not get into the habit of washing their bodies regularly, even after handling pesticides, because of the scarcity of water. Laundry, including husbands' contaminated clothes, is usually done by women, which can be a source of pesticide exposure for them and other family members. In addition, shaking hands as a greeting behavior, the practice (among women) of carrying babies with the hands, and eating with the hands are common practices that increase the risk of pesticide cross-contamination.

Farmers tend to try to avert reduced output of high-value horticultural crops by overusing and misusing pesticides. They also tend to use pesticides (sometimes in excessive or insufficient doses) that are unregistered, obsolete, restricted, or recommended for other crops. This could be due to farmers' lack of awareness or low-risk perception.[32] Women sometimes improvise pesticide application methods using perforated containers or bunch of leaves instead of spray guns or knapsack sprayers, which seem to be too heavy and sometimes are costly. These makeshift methods of application expose women to pesticides and consequently affect their health.

As a study in the Philippines showed, the assumption that only men are involved in pesticide use and management means that women are not considered for training on pesticide hazards and do not even receive pesticide-related information. A result of this assumption is that women's exposure to pesticides is grossly underestimated.[80]

Pesticide Exposure and Possible Health Effects

Studies among women on associations between occupational exposure to pesticides and health problems are scarce; one reason is that the multiple factors that contribute to female fertility disorders, a significant outcome of pesticide exposure, are difficult to assess.[81]

Acute studies have been able to link pesticide exposure and adverse health effects such as dizziness, muscular pain, sneezing, itching, skin burns, blisters, difficulty breathing, nausea, and sore eyes. However, the major concerns in Tanzania are chronic exposures that are linked to noncommunicable diseases, such as reproductive impairment, diabetes, hypertension, and cancer, which take a great toll on women as they continue to face barriers to health care access when they are sick. Women are especially at risk, for both biological and social reasons. Pesticides are one of the causes of ill health, but there are no studies in Tanzania that link pesticide exposure to women's illnesses. However, studies in other countries have linked pesticide exposure to acute and chronic health effects.

In an attempt to map diseases afflicting women in horticultural regions of Tanzania, we collected data on diseases reported by women through the Tanzania Health Information Management System (HIMS) in 2015 and computed prevalence of the diseases by horticultural region (see Table 3). Among the diseases that were reported to occur most frequently were upper respiratory infections, hypertension, gynecological diseases, rheumatoid and joint diseases, pregnancy complications, skin infection, nonfungal bronchial asthma, and diabetes mellitus. All these diseases were prevalent in all horticultural production regions in the country. Other diagnoses and ill-defined symptoms were also very frequently reported. However, there was no explanation as to what constituted these categories. These findings underscore the need for a well-designed and detailed study that will address instances of pesticide use in these regions that have indicated the occurrence of health effects in humans.

We also found that other diagnoses and ill-defined symptoms are prevalent in all production regions. We think that some of these could be attributable to pesticide exposure because health care providers have been shown to lack the capacity to diagnose and treat pesticide poisoning cases[10,82] and would likely categorize pesticide poisoning as "other diagnoses and ill-defined symptoms." Unfortunately, in Tanzania, the occupational health services are not yet integrated into primary health care because of limited resources. By the nature of their work, women receive treatment from primary health care providers whose clinical staff are unlikely to consider their occupations in diagnosis and treatment.[9] It must also be noted that the women's diseases data collected from HIMS have some limitations. The HIMS groups are aggregated by age on the basis of whether they are younger or older than 5 years, which makes it difficult to determine the prevalence of diseases of women who are supposed to be aged 18 years or older. Upper respiratory infection was found to be highly prevalent, but it is difficult to ascertain whether this elevated prevalence is in young girls or in adult women. It is known that the disease is very common in children. The data need to be aggregated in

Table 3. Prevalence of certain diseases reported among women in horticultural regions of Tanzania that could be related to pesticide exposure—(presented by HIMS for OPD patients in 2015).

REGION		UPPER RESPIRATORY INFECTIONS	OTHER DIAGNOSIS	ILL-DEFINED SYMPTOMS	HYPERTENSION	GYNECOLOGICAL DISEASES	RHEUMATOID AND JOINT DISEASES	PREGNANCY COMPLICATIONS	SKIN INFECTION, NONFUNGAL	BRONCHIAL ASTHMA	DIABETES MELLITUS
Arusha (N = 665 097)	%	16.15	6.64	4.05	3.06	2.87	2.65	2.19	2.13	1.90	1.86
KLM (N = 589 420)	%	21.97	4.93	3.43	5.65	0.67	4.25	0.90	1.52	2.64	3.02
Manyara (N = 250 918)	%	15.53	5.12	2.96	1.00	0.78	1.53	0.93	1.76	1.96	0.98
Morogoro (N = 536 206)	%	10.52	4.57	2.18	1.98	0.64	0.74	0.85	1.30	0.89	0.59
Iringa (N = 275 851)	%	17.61	6.14	5.86	2.19	1.15	2.32	1.14	2.56	1.05	0.61
Njombe (N = 167 942)	%	18.09	6.52	6.02	2.40	0.91	3.02	1.14	2.00	1.17	0.62
Mbeya (N = 414 072)	%	14.86	4.91	3.27	2.48	0.90	1.70	1.84	2.09	1.89	1.02
Ruvuma (N = 332 073)	%	12.15	3.79	2.85	2.77	0.96	0.60	0.94	1.19	1.26	0.66
Dodoma (N = 149 806)	%	20.44	5.16	3.40	0.83	0.47	1.02	1.19	1.75	1.66	0.33
Kagera (N = 525 940)	%	11.94	4.09	3.11	1.84	0.35	0.56	1.02	0.80	0.78	0.92
Mwanza (N = 509 382)	%	8.97	5.10	2.44	1.08	0.65	0.45	1.20	1.13	0.72	0.84
Mara (N = 474 714)	%	12.76	3.34	1.69	1.31	0.55	0.31	1.24	1.03	1.13	0.83
Kigoma (N = 470 515)	%	12.49	3.58	3.10	0.79	0.00	0.82	0.61	0.74	0.81	0.44
Tanga (N = 646 688)	%	13.03	3.30	2.72	3.27	0.78	1.00	0.46	1.56	1.48	1.13
Coast (N = 266 929)	%	11.68	7.31	2.17	3.16	0.26	0.86	1.09	1.31	1.32	0.66
DSM (N = 151 1799)	%	10.69	4.03	2.76	4.17	2.32	0.84	1.38	2.21	0.96	2.28

KLM, Kilimanjaro; DSM; Dar es Salaam; HIMS; Health Information Management System; OPD, outpatient department.
N: number of patients, age 5 years or older who received outpatient care in 2015.

such a way that one could get a clear picture of the prevalence of diseases among the adult women who are the subject of this review.

When women are exposed to pesticides, their fetus or children are also exposed through transplacental transfer or breastfeeding, respectively. As a result of this exposure, a growing fetus or child may suffer adverse health effects such as neurodevelopmental disorders.[83] A number of studies have reported adverse health effects on women exposed to pesticides and their offspring (see Table 4).[84-93] Pesticide exposure has been associated with menstrual cycle disturbances, reduced fertility, prolonged pregnancy, spontaneous abortion, stillbirths, and developmental defects, which may or may not be due to disruption of the female hormonal function.[94] In the case of Tanzania, pregnancy complications reported among the diseases in horticultural areas could be related to pesticide exposure. Associations between working on flower farms and experiencing reproductive problems such as spontaneous abortion and prolonged pregnancy have been explored. In a study done in Ecuador, Handal and Harlow[90] showed that the likelihood of a report of spontaneous abortion was 2.6 times greater among female flower farmworkers than among other women. Spontaneous abortions and irregular menstrual flow have been reported by women as common disorders due to exposure to pesticides. Bretveld et al[86] studied women in the Netherlands working in flower greenhouses where large amounts of pesticides such as abamectin, imidacloprid, methiocarb, deltamethrin, and pirimicarb were routinely used. The researchers reported that the risk of spontaneous abortion among these women was increased 4-fold. Meta-analyses conducted to assess potential adverse effects on reproduction showed a pooled estimate of a 2.24-fold increase in spontaneous abortion; figures of 1.31 for birth defects and 1.49 for premature infant birth were found among women with a history of working on flower farms. A study conducted in Denmark by Jørgensen et al[92] found a slightly increased risk of cryptorchidism in sons of maternal horticultural workers and farmers. It is therefore important to better understand pesticide exposure and health effects in women so that both women and their offspring can be protected.

An epidemiological study conducted by McLean et al[93] in New Zealand revealed an association between leukemia and pesticide exposure, particularly among women working in horticulture. In the above-cited study in Denmark conducted by Jørgensen et al, women's occupational exposure to pesticides was associated with an increased risk that their children would develop leukemia.[95] Zahm and Ward[96] reported that families of farmers have increased risks of neuroblastoma, nervous system tumors, Hodgkin disease, and bone and brain cancers due to long-term exposure to pesticide and pesticide residues.

Acute and chronic neurotoxicity, lung damage, respiratory failure, asthma, and male infertility have been associated with pesticide exposure.[22,97,98] Cancer,[99-102] aplastic anemia, and blood dyscrasia have been associated with occupational exposure to pesticides. Skin effects such as contact dermatitis and allergic sensitization have been frequently observed in pesticide workers after exposure to several pesticides.[18] These effects are believed to be related to the pesticides' ability to disrupt the functions of certain hormones, enzymes, growth factors, and neurotransmitters and to induce key genes involved in metabolism of steroids and xenobiotics.[103] Diseases such as skin infections, bronchial asthma, and diabetes reported in horticultural regions in Tanzania could also be pesticide related.

In the US Agricultural Health Study, wives of pesticide applicators living and/or working in an agricultural region had increased levels of thyroid disease compared with the general population.[104] The increased incidence of thyroid disease in these women was thought to be linked to their exposure to various fungicides and organochlorine insecticides.[105] In an area of Brazil that has been shown to be heavily contaminated with organochlorine pesticides, Freire et al[106] found that there was an increased prevalence of hyperthyroidism. There were also sex-specific differences; for example, women showed higher levels of thyroid hormones.

Workers in developing countries face many work-related health problems resulting from exposure to pesticides used to control pests and diseases. Both direct and indirect health effects of pesticide exposure in humans have been documented.[15,107] However, the magnitude of the environmental and health effects from pesticide use in Tanzania is not fully recognized,[30] and several studies have found that women's and children's exposure to pesticides is often underestimated.[29,80,108]

Final Remarks

Horticulture in Tanzania is mainly practiced by small-scale farmers, with the most of the workers and employees being women. Horticulture has transformed from subsistence to commercial with increased use of pesticides. Women working in horticulture are highly exposed to pesticide hazards due to lack of knowledge, low-risk perception, and poverty. Thus, a sex-sensitive educational programs targeting safety awareness, proper use of pesticides, and implementation of personal protective measures would be necessary to decrease the pesticide exposure risk of women farmers.[72,109] Training of practicing physicians and other health care professionals would also be necessary in implementing occupational health care at primary health care facilities in Tanzania and would improve diagnosis of diseases related to pesticide exposure.

Sex-specific data on effects of pesticide use in horticulture are limited, and women have not been the primary subjects of occupational studies historically. The link between pesticides and noncommunicable diseases in studies done in other countries has raised concern for Tanzanian women working in horticulture. Data from the HIMS do not adequately provide information that would make it possible to establish links between pesticide exposure and diseases affecting women in Tanzania. However, a number of pesticides used in horticulture in the country are suspected of causing chronic health effects,

Table 4. Studies of the impact of pesticides on women and their offspring.

PUBLICATION	YEAR OF PUBLICATION	POPULATION	NATURE OF EXPOSURE	CONCLUSION
Abell et al[84]	2000	Denmark: 1767 female members of Danish Gardeners Trade Union; 492 pregnant women assessed	Workers in greenhouses handling flower cultures, spraying pesticides	Female workers in flower greenhouses may have reduced fecundability and pesticide exposure may be part of the causal chain
Bazylewicz-Walczak et al[85]	1999	Poland: 51 women working in gardening enterprises. Of these, 26 performed planting jobs in greenhouses and were occupationally exposed to several organophosphates; 25 women were not exposed	Long-term exposure to several organophosphate	The exposed female workers were characterized by longer reaction times and reduced motor steadiness compared with the unexposed workers. Also, increased tension, greater depression and fatigue, and more frequent symptoms of central nervous system disturbances were observed in the exposed women compared with the controls
Bretveld et al[86]	2008	Review of epidemiological studies that found associations between pesticide exposure and reproductive effects that may have been due to disruption of the female hormonal function	Long-term exposure	Occupational exposure to pesticides appears to have adverse effects on female reproduction. Endocrine disruptors that accumulate in the body may eventually reach higher threshold levels necessary for exertion of their biological effects
Cohn et al[87]	2015	Child Health and Development Studies pregnancy cohort, Alameda County, California, 1959 to 1967, and their adult daughters	Widespread DDT use in the 1960s	This prospective human study linked measured DDT exposure in utero to the risk of breast cancer
Dalvie et al[88]	2010	Women residents on farms in Western Cape (South Africa)	Pesticide exposure experienced at work and from the environment	More women with low cholinesterase compared with normal levels (indicating that they were highly exposed to pesticides) had elevated levels of fractional exhaled nitric oxide, indicating the presence of lung inflammation associated with asthma
Farr et al[89]	2004	Women living on farms in Iowa and North Carolina	Exposures of interest were lifetime use of any pesticide	Women who used probable hormonally active pesticides had a 60%-100% increased possibility of experiencing long cycles, missed periods, and intermenstrual bleeding compared with women who had never used pesticides. Associations remained after occupational physical activity was controlled for
Handal and Harlow[90]	2009	Ecuadorian mothers with at least one child who had lived in the community at least 1 year	Occupational pesticide exposure	The findings suggest a potential adverse association between employment in the cut-flower industry and spontaneous abortion
Harari et al[91]	2010	In northern Ecuador, an intensive cross-sectional study assessed children's neurobehavioral functions at 6-8 years of age	Pesticide exposure during the index pregnancy	The findings support the notion that prenatal exposure to pesticides—at levels not producing adverse health outcomes in the mother—can cause lasting adverse effects on brain development in children
Jørgensen et al[92]	2014	The risk of cryptorchidism among sons of horticultural workers and farmers in Denmark was assessed	Pesticide exposure during pregnancy	A slightly increased risk of cryptorchidism in sons of maternal horticultural workers and farmers was found
McLean et al[93]	2009	Population-based case-control study of adult-onset leukemia and occupation in New Zealand	Occupational exposures, including agriculture	Confirmed previously observed associations between ever having been an agricultural worker and elevated risk of leukemia. The risk appeared to be higher in women than in men

Abbreviation: DDT, dichlorodiphenyltrichloroethane.

some of which have been reported by women in the regions. Therefore, we recommend that sex-specific studies be conducted to assess diseases and pesticide exposure in horticulture in Tanzania. The findings would, in turn, inform strategies at the level of public policy to reduce the burden of occupational health diseases that might be related to pesticide exposure in the horticulture sector.

Acknowledgement

The authors would like to acknowledge the Tanzania Health Information Management System (HIMS) unit of Ministry of Health, Community Development, Gender, Elderly and Children for providing data on diseases which were used in this work. These diseases were reported by women who attended outpatient department (OPD) in 2015.

Author Contributions

Conceived the work: EJM, AVN. Conducted literature search from peer review journals and grey literatures, wrote the first draft of the manuscript and led revisions of the manuscript: EJM. Jointly developed the structure and arguments for the paper: EJM, SSK, AVN. Participated in writing, interpretation, discussion, comments on the manuscript and its revisions: EJM, AVN, SSK, SHD. Made critical revisions and approved final version of the manuscript: EJM, AVN, SSK, SHD. All authors read and agree with manuscript results and final remarks and finally approved the final manuscript.

REFERENCES

1. Food and Agriculture of United Nations (FAO). *The State of Food and Agriculture—Women in Agriculture Closing the Gender Gap for Development*. http://www.fao.org/docrep/013/i2050e/i2050e.pdf. Published 2011. Accessed May 15, 2017.
2. United Nations Department of International Economics and Social Affairs (UNDIESA). *The World's Women: Trends and Statistics 1970-1990*. New York, NY: UNDIESA, 120; 1991.
3. Horticultural Development Council of Tanzania (HODECT). *Tanzania Horticultural Development Strategy 2012-2021*. http://www.fao.org/fileadmin/templates/agphome/documents/horticulture/WHO/arusha/Tanzania_TAHA.pdf. Published 2010. Accessed April 25, 2016.
4. Leavens MK, Anderson CL. *Gender and Agriculture in Tanzania*. https://evans.uw.edu/sites/default/files/public/UW_EPAR_Request_134_Gender%20and%20Ag_04102011.pdf. Accessed May 15, 2017.
5. Tanzania Horticulture Association (TAHA). TAHA'S & FFD'S Packaging Initiative for Tanzania. https://drive.google.com/file/d/0B-YpKmnnEgb2cm9aQVZmMUFxWW8/view. Published 2017. Accessed June 9, 2017.
6. Lema E, Machunda R, Njau KN. Agrochemicals use in horticulture industry in Tanzania and their potential impact to water resources. *Int J Biol Chem Sci*. 2014;8:831–842.
7. Rother HA. Influences of pesticide risk perception on the health of rural South African women and children. *Afr Newslett Occup Health Saf*. 2000;10:42–46.
8. Lucchini RG, London L. Global occupational health: current challenges and the need for urgent action. *Ann Glob Health*. 2014;80:251–256.
9. Mrema EJ, Ngowi AV, Mamuya SH. Status of occupational health and safety and related challenges in expanding economy of Tanzania. *Ann Glob Health*. 2015;81:538-547.
10. Ngowi AV, Maeda DN, Partanen TJ. Assessment of the ability of health care providers to treat and prevent adverse health effects of pesticides in agricultural areas of Tanzania. *Int J Occup Med Environ Health*. 2001;14:349–356.
11. Alavanja MCR. Pesticides use and exposure extensive worldwide. *Rev Environ Health*. 2009;24:303–309.
12. Kapeleka JA, Lekei EE, Hagali T. Pesticides exposure and biological monitoring of ache activity among commercial farm workers in Tanzania: a case of tea estates. *Int J Sci Res*. 2016;5:2319–7064.
13. Konradsen F, van der Hoek W, Cole DC, et al. Reducing acute poisoning in developing countries-options for restricting the availability of pesticides. *Toxicology*. 2003;192:249–261.
14. Sekiyama M, Tanaka M, Gunawan B, Abdoellah O, Watanabe C. Pesticide usage and its association with health symptoms among farmers in rural villages in West Java, Indonesia. *Environ Sci*. 2007;14:23–33.
15. Ngowi AVF. *Health Impacts of Pesticides in Agriculture in Tanzania* [PhD thesis]. Tampere, Finland: Tampere University Press; 2002.
16. Dinham B. *Communities in Peril: Global Report on Health Impacts of Pesticide Use in Agriculture. Pesticide Action Network Asia and the Pacific (PAN AP)*. Manila, Philippines: Red Leaf Printing Press; 2010.
17. Magauzi R, Mabaera B, Rusakaniko S, et al. Health effects of agrochemicals among farm workers in commercial farms of Kwekwe District, Zimbabwe. *Pan Afr Med J*. 2011;9:26.
18. Tsimbiri PF, Moturi WN, Sawe J, Henley P, Bend JR. Health impact of pesticides on residents and horticultural workers in the lake Naivasha region, Kenya. *Occup Dis Environ Med*. 2015;3:24–34.
19. Nigatu AW, Bråtveit M, Deressa W, Moen BE. Respiratory symptoms, fractional exhaled nitric oxide & endotoxin exposure among female flower farm workers in Ethiopia. *J Occup Med Toxicol*. 2015;10:8.
20. Hanssen VM, Nigatu AW, Zeleke ZK, Moen BE, Bråtveit M. High prevalence of respiratory and dermal symptoms among Ethiopian flower farm workers. *Arch Environ Occup Health*. 2015;70:204–213.
21. Defar A, Ali A. Occupational induced health problems in floriculture workers in Seberta and surrounding areas, West Shewa, Oromia, Ethiopia. *Ethiop J Health Dev*. 2013;27:64–71.
22. Del Prado-Lu JL. Pesticide exposure, risk factors and health problems among cutflower farmers: a cross sectional study. *J Occup Med Toxicol*. 2007;2:9.
23. de Cock J, Westveer K, Heederik D, te Velde E, van Kooij R. Time to pregnancy and occupational exposure to pesticides in fruit growers in The Netherlands. *Occup Environ Med*. 1994;51:693–699.
24. Larsen SB, Giwercman A, Spano M, Bonde JP. A longitudinal study of semen quality in pesticide spraying Danish farmers. The ASCLEPIOS study group. *Reprod Toxicol*. 1998;12:581–589.
25. Whorton D, Krauss RM, Marshall S, Milby TH. Infertility in male pesticide workers. *Lancet*. 1977;2:1259–1261.
26. Wyrobek AJ, Watchmaker G, Gordon L, Wong K, Moore D, Whorton D. Sperm shape abnormalities in carbaryl-exposed employees. *Environ Health Perspect*. 1981;40:255–265.
27. Joffe M, Li Z. Male and female factors in fertility. *Am J Epidemiol*. 1994;140:921–929.
28. Lekei E, Ngowi AV, London L. Hospital-based surveillance for acute pesticide poisoning caused by neurotoxic and other pesticides in Tanzania. *Neurotoxicology*. 2014;45:318-326.
29. London L, Myers JE, Nell V, Taylor T, Thompson ML. An investigation into neurologic and neurobehavioral effects of long-term agrichemical use among deciduous fruit farm workers in the Western Cape, South Africa. *Environ Res*. 1997;73:132–145.
30. Ngowi A, Mrema E, Kishinhi S. Pesticide health and safety challenges facing informal sector workers: a case of small-scale agricultural workers in Tanzania. *New Solut*. 2016;26:220–240.
31. Akhabuhaya J, Lodenius M. *Pesticide in Tanzania*. Department of Environmental Conservation of University of Helsinki No 10; 1988.
32. Salami A, Kamara AB, Brixiova Z. Smallholder agriculture in East Africa: trends, Constraints and Opportunities. Working Papers Series No 105, African Development Bank, Tunis, Tunisia; 2010.
33. Barraza D, Jansen K, van Wendel de Joode B, Wesseling C. Pesticide use in banana and plantain production and risk perception among local actors in Talamanca, Costa Rica. *Environ Res*. 2011;111:708–717.
34. Food and Agriculture Organisation of the United Nations (FAO) United Nations Environment Programmed (UNEP) United Nations Industrial Development (UNIDO) United Nation Institute of Training and Research (UNITAR) World Health Organization (WHO) The Organization for Economic Co-operation and Development (OECD). *The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification*. Geneva: WHO. http://www.who.int/ipcs/publications/pesticides_hazard_2009.pdf. Published 2010. Accessed February 18, 2017.
35. United States Environmental Protection Agency (US EPA). Endosulfan RED facts. https://archive.epa.gov/pesticides/reregistration/web/html/endosulfan_fs.html. Published 2002. Accessed April 3, 2017.
36. United States Environmental Protection Agency (US EPA). Profenofos facts. https://archive.epa.gov/pesticides/reregistration/web/pdf/2540fact.pdf. Published 2000. Accessed April 3, 2017.
37. Kim CW, Go RE, Choi KC. Treatment of BG-1 Ovarian cancer cells expressing estrogen receptors with lambda-cyhalothrin and cypermethrin caused a partial estrogenicity via an estrogen receptor-dependent pathway. *Toxicol Res*. 2015;31:331–337.

38. National Pesticide Information Center (NPIC). Lambda-cyhalothrin technical fact sheet. http://npic.orst.edu/factsheets/archive/l_cyhalotech.pdf. Published 2001. Accessed May 15, 2017.
39. United States Environmental Protection Agency (US EPA). Revised interim reregistration eligibility decisions for dimethoate. https://archive.epa.gov/pesticides/reregistration/web/pdf/dimethoate_ired_revised.pdf. Published 2008. Accessed April 28, 2017.
40. United States Environmental Protection Agency (US EPA). Fenitrothion facts. https://archive.epa.gov/pesticides/reregistration/web/pdf/0445tredfact.pdf. Published 2000. Accessed April 28, 2017.
41. United States Environmental Protection Agency (US EPA). https://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+6600. Published 2006. Accessed April 28, 2017.
42. National Pesticide Information center (NPIC). Chlorpyrifos technical fact sheet. http://npic.orst.edu/factsheets/archive/chlorptech.html. Published 2001. Accessed May 15, 2017.
43. United States Environmental Protection Agency (US EPA). Carbofuran I.R.E.D. facts. https://archive.epa.gov/pesticides/reregistration/web/html/carbofuran_ired_fs.html. Accessed April 28, 2017.
44. United States Environmental Protection Agency (US EPA). Reregistration eligibility decision for aldicarb. https://archive.epa.gov/pesticides/reregistration/web/pdf/aldicarb_red.pdf. Published 2007. Accessed April 28, 2017.
45. United States Environmental Protection Agency (US EPA). Chlorothalonil RED facts https://archive.epa.gov/pesticides/reregistration/web/pdf/0097fact.pdf. Published 1999. Accessed April 28, 2017.
46. United States Environmental Protection Agency (US EPA). Triadimefon Reregistration Eligibility Decision (RED) and Triadimenol Tolerance Reassessment and Risk Management Decision (TRED) Fact Sheet. https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/fs_UG-6_01-Aug-2006.pdf. Published 2006. Accessed April 28, 2017.
47. United States Environmental Protection Agency (US EPA). Diazinon IRED facts. https://archive.epa.gov/pesticides/reregistration/web/html/diazinon_ired_fs.html. Accessed April 28, 2017.
48. United States Environmental Protection Agency (US EPA). Reregistration Eligibility Decision (RED) for Malathion. https://archive.epa.gov/pesticides/reregistration/web/pdf/malathion-red-revised.pdf. Published 1999. Accessed April 28, 2017.
49. United States Environmental Protection Agency (US EPA). Pirimiphos-Methyl IRED Facts. https://archive.epa.gov/pesticides/reregistration/web/html/pirimiphosmethyl_ired_fs.html. Published 1999. Accessed April 28, 2017.
50. United States Environmental Protection Agency (US EPA). Carbaryl IRED facts. https://archive.epa.gov/pesticides/reregistration/web/pdf/carbaryl_factsheet.pdf. Accessed April 28, 2017.
51. United States Environmental Protection Agency (US EPA). R.E.D. FACTS sulfur. https://archive.epa.gov/pesticides/reregistration/web/pdf/0031fact.pdf. Accessed April 28, 2017.
52. United States Environmental Protection Agency (US EPA). Reregistration eligibility decision for triforine. https://archive.epa.gov/pesticides/reregistration/web/pdf/triforine_red.pdf. Accessed April 28, 2017.
53. Strivastava AK, Kesavachandran AC. *Health Effect of Pesticides*. New Delhi, India: TERI; 2016.
54. Lekei EE, Ngowi AV, London L. Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. *BMC Public Health*. 2014;14:389.
55. Mdegela RH, Mosha RD, Ngowi HA, Nonga H. Environmental and health impacts associated with usage of agrochemicals in Mindu dam catchment area, Morogoro, Tanzania. *Huria*. 2013;15:18–33.
56. Kariathi V, Kassim N, Kimanya M. Pesticide exposure from fresh tomatoes and its relationship with pesticide application practices in Meru district. *Cogent Food Agric*. 2016;2:1196808.
57. Pesticide and Poverty. A case study on trade and utilization of pesticides in Tanzania: implication to Stockpiling. Final Report, published by Agenda for Environment and Responsible Development, 2006:72.
58. Ngowi AVF. Occupational exposure to pesticides at flower farms in Northern Tanzania. *Afr Newslett on Occup Health and Safety*. 2003;13:16–18.
59. London L, de GS, Wesseling C, Kisting S, Rother HA, Mergler D. Pesticide usage and health consequences for women in developing countries: out of sight, out of mind? *Int J Occup Environ Health*. 2002;8:46–59.
60. Rother HA, Hall R, London L. Pesticide use among emerging farmers in South Africa: contributing factors and stakeholder perceptions. *Develop South Afr*. 2008;25:399–424.
61. Saiyed H, Dewan A, Bhatnagar V, et al. Effect of endosulfan on male reproductive development. *Environ Health Perspect*. 2003;111:1958–1962.
62. Aronson KJ, Miller AB, Woolcott CG, et al. Breast adipose tissue concentrations of polychlorinated biphenyls and other organochlorines and breast cancer risk. *Cancer Epidemiol Biomarkers Prev*. 2000;9:55–63.
63. Cohn BA, Wolff MS, Cirillo PM, Sholtz RI. DDT and breast cancer in young women: new data on the significance of age at exposure. *Environ Health Perspect*. 2007;115:1406–1414.
64. Mathur V, Bhatnagar P, Sharma RG, Acharya V, Sexana R. Breast cancer incidence and exposure to pesticides among women originating from Jaipur. *Environ Int*. 2002;28:331–336.
65. Nicolopoulou P, Stamanti P. The impact of endocrine disrupters on the female reproductive system. *Hum Reprod Update*. 2001;7:323–330.
66. Zala S, Penn DJ. Abnormal behaviors induced by chemical pollution: a review of the evidence and new challenges. *Anim Behav*. 2004;68:649–664.
67. Naidoo S, London L, Burdorf A, Naidoo RN, Kromhout H. Agricultural activities, pesticide use and occupational hazards among women working in small scale farming in Northern KwaZulu-Natal, South Africa. *Int J Occup Environ Health*. 2008;14:218–224.
68. Doss CR. Men's crops? women's crops? the gender patterns of cropping in Ghana. *World Develop*. 2002;30:1987–2000.
69. Food and Agriculture Organization of United Nations (FAO). *Tanzania Mainland Country Profile: Gender Inequalities in Rural Employment in Tanzania Mainland, an Overview*. Rome, Italy: FAO; 2014.
70. Mancini F, Van Bruggen AH, Jiggins JL, Ambatipudi AC, Murphy H. Acute pesticide poisoning among female and male cotton growers in India. *Int J Occup Environ Health*. 2005;11:221–232.
71. Erbaugh MA, Kyamanywa S, Adipala E. The role of women in pest management decision making in Eastern Uganda. *J Intl Agric and Ext Educ*. 2003;10:71–80.
72. Atreya K. Pesticide use knowledge and practices: a gender differences in Nepal. *Environ Res*. 2007;104:305–311.
73. Jørs E, Hay-Younes J, Condarco MA, et al. Is gender a risk factor for pesticide intoxications among farmers in Bolivia? A cross-sectional study. *J Agromedicine*. 2013;18:132–139.
74. Ngowi AV, Maeda DN, Partanen TJ, et al. Acute health effects of organophosphorus pesticides on Tanzanian small-scale coffee growers. *J Expo Anal Environ Epidemiol*. 2001;11:335–339.
75. Mekonnen Y, Agonafir T. Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. *Occup Med*. 2002;52:311–315.
76. Remoundou K, Brennan M, Hart A, Frewer LJ. Pesticide risk perceptions, knowledge, and attitudes of operators, workers, and residents: a review of the literature. *Hum Ecol Risk Assess*. 2014;20:1113–1138.
77. Christie ME, Van Houweling E, Zseleczky L. Mapping gendered pest management knowledge, practices, and pesticide exposure pathways in Ghana and Mali. *Agric Hum Values*. 2015;32:761–775.
78. Jensen HK, Konradsen F, Jørs E, Petersen JH, Dalsgaard A. Pesticide use and self-reported symptoms of acute pesticide poisoning among aquatic farmers in Phnom Penh, Cambodia. *J Toxicol*. 2011;2011:639814.
79. Shetty PK, Murugan M, Hiremath MB, Sreeja KG. Farmers' education and perception on pesticide use and crop economies in Indian agriculture. *J Exp Sci*. 2010;1:3–8.
80. Tanzo IR. *Women and Pesticide Management in the Philippines: an Assessment of Roles and Knowledge* [thesis]. State College, PA: The Pennsylvania State University.
81. Bretveld RW, Thomas CM, Scheepers PT, Zielhuis GA, Roeleveld N. Pesticide exposure: the hormonal function of the female reproductive system disrupted? *Reprod Biol Endoc Frinol*. 2006;4:30.
82. Lekei E, Ngowi AV, Mkalanga H, London L. Knowledge and practices relating to acute pesticide poisoning among health care providers in selected regions of Tanzania. *Environ Health Insights*. 2017;11:1178630217691268.
83. Marks AR, Harley K, Bradman A, et al. Organophosphate pesticide exposure and attention in young Mexican-American children, the CHAMACOS study. *Environ Health Perspect*. 2010;118:1768–1774.
84. Abell A, Juul S, Bonde JP. Time to pregnancy among female greenhouse workers. *Scand J Work Environ Health*. 2000;26:131–136.
85. Bazylewicz-Walczak B, Majczakowa W, Szymczak M. Behavioral effects of occupational exposure to organophosphorous pesticides in female greenhouse planting workers. *Neurotoxicology*. 1999;20:819–826.
86. Bretveld RW, Hooiveld M, Zielhuis GA, Pellegrino A, van Rooij A, Roeleveld N. Reproductive disorders among male and female greenhouse workers. *Reprod Toxicol*. 2008;25:107–114.
87. Cohn BA, La Merrill M, Krigbaum NY, et al. DDT exposure in utero and breast cancer. *J Clin Endocrinol Metab*. 2015;100:2865–2872.
88. Dalvie A, Jeebhay MF, London L, Rother HA. Health effects due to pesticide exposure among women in Western Cape. Final Report on women on the farm. http://www.wfp.org.za/publications/general-reports/doc_view/77-pesticides-final-report.html; 2010. Accessed November 22, 2016.
89. Farr SL, Cooper GS, Cai J, Savitz DA, Sandler DP. Pesticide use and menstrual cycle characteristics among premenopausal women in the Agricultural Health Study. *Am J Epidemiol*. 2004;160:1194–1204.

90. Handal AJ, Harlow SD. Employment in the Ecuadorian cut-flower industry and the risk of spontaneous abortion. *BMC Int Health Hum Rights*. 2009;9:25.
91. Harari R, Julvez J, Murata K, et al. Neurobehavioral deficits and increased blood pressure in school-age children prenatally exposed to pesticides. *Environ Health Perspect*. 2010;118:890–896.
92. Jørgensen KT, Jensen MS, Toft GV, Larsen AD, Bonde JP, Hougaard KS. Risk of cryptorchidism among sons of horticultural workers and farmers in Denmark. *Scand J Work Environ Health*. 2014;40:323-330.
93. McLean D, Mannetje A, Dryson E, et al. Leukaemia and occupation: a New Zealand cancer registry-based case-control study. *Int J Epidemiol*. 2009;38:594–606.
94. Sarwar M. Indoor risks of pesticide uses are significantly linked to hazards of the family members. *Cogent Medicine*. 2016;3:1155373.
95. Van Maele-Fabry G, Lantin AC, Hoet P, Lison D. Childhood leukaemia and parental occupational exposure to pesticides: a synthetic review and meta-analysis. *Cancer Causes Control*. 2010;21:787–809.
96. Zahm SH, Ward MH. Pesticides and childhood cancer. *Environ Health Perspect*. 1998;106:893–908.
97. Hanke W, Jurewicz J. The risk of adverse reproductive and developmental disorders due to occupational pesticide exposure: an overview of current epidemiological evidence. *Int J Occup Med Environ Health*. 2004;17:223–243.
98. World Health Organization (WHO)/United Nations Environment Programme (UNEP). *Libreville Declaration on Health and Environment in Africa*. Libreville: WHO/UNEP; 2008.
99. Choi SM, Yoo SD, Lee BM. Toxicological characteristics of endocrine-disrupting chemicals: developmental toxicity, carcinogenicity, and mutagenicity. *J Toxicol Environ Health B Crit Rev*. 2004;7:1–23.
100. Recio-Vega R, Velazco-Rodriguez V, Ocampo-Gómez G, Hernandez-Gonzalez S, Ruiz-Flores P, Lopez-Marquez F. Serum levels of polychlorinated biphenyls in Mexican women and breast cancer risk. *J Appl Toxicol*. 2011;31:270–278.
101. Safi JM. Association between chronic exposure to pesticides and recorded cases of human malignancy in Gaza Governorates (1990-1999). *Sci Total Environ*. 2002;284:75–84.
102. Waddell BL, Zahm SH, Baris D, et al. Agricultural use of organophosphate pesticides and the risk of non-Hodgkin's lymphoma among male farmers (United States). *Cancer Causes Control*. 2001;12:509–517.
103. Kleanthi G, Katerina L, Evaggelia P, Andreas L. Mechanisms of actions and health effects of organochlorine substances. A review. *Health Sci J*. 2008; 2:89–98.
104. Giannandrea F, Settimi L, Figà Talamanca I. The use of personal protective equipment in pregnant greenhouse workers. *Occup Med (Lond)*. 2008;58:52–57.
105. Goldner WS, Sandler DP, Yu F, Hoppin JA, Kamel F, Levan TD. Pesticide use and thyroid disease among women in the agricultural health study. *Am J Epidemiol*. 2010;171:455–464.
106. Freire C, Koifman RJ, Sarcinelli PN, Simões Rosa AC, Clapauch R, Koifman S. Long-term exposure to organochlorine pesticides and thyroid status in adults in a heavily contaminated area in Brazil. *Environ Res*. 2013;127:7–15.
107. Kihampa C, Mato RR, Mohamed H. Residues of organochlorinated pesticides in soil from tomato fields, Ngarenanyuki, Tanzania. *J Appl Sci Environ Manage*. 2010;14:37–40.
108. Slunge D, Norin H, Rosander P. Assessment of safeguarding systems for the use of pesticides within Swedish financed programmes in Tanzania. http://sidaenvironmenthelpdesk.se/wordpress3/wp-content/uploads/2016/04/Pesticide-safeguards-in-Swedish-financed-programmes-in-Tanzania-Final-Report-December-2015.pdf. Published 2015. Accessed April 30, 2016.
109. Wang W, Jin J, He R, Gong H. Gender differences in pesticide use knowledge, risk awareness and practices in Chinese farmers. *Sci Total Environ*. 2017;590-591:22–28.