Reproductive Health Effects of Pesticide Exposure

Efectos de la Exposición a Pesticidas en la Salud Reproductiva

Issues for Farmworker Health Service Providers

Temas para los Proveedores de Servicios de Salud a los Trabajadores Agrícolas

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Reproductive Health Effects of Pesticide Exposure: Issues for Farmworker Health Service Providers

Introduction and background
Exposure to pesticides at any point in the life cycle has the potential for causing a range of short-term or long-term health problems. Documented health effects include a wide variety of illnesses and diseases, from eye irritation, skin rashes and respiratory problems to neurological damage, birth defects, cancer and death. The risk for and severity of adverse health effects from pesticide exposure varies significantly depending on many factors, including individual characteristics such as age and health status, the specific pesticide, and exposure circumstances. Exposure to pesticides at certain developmental stages of life can result in irreversible damage to organ structure and function. Of particular concern is the effect of exposure at during the reproductive cycle, from preconception to breast feeding, because of the possibility of poor birth outcomes, congenital anomalies, developmental deficits, and possibly childhood cancer [1].

Introducción y Antecedentes
La exposición a los pesticidas en cualquier etapa del ciclo de vida tiene el potencial de causar problemas de salud a corto o largo plazo. Los efectos demostrados/documentados en la salud, incluyen una amplia variedad de enfermedades y padecimientos que van desde la irritación de los ojos, salpullido y problemas respiratorios hasta daños neurológicos, defectos de nacimiento, cáncer y muerte. El riesgo y la severidad de los efectos adversos a la salud por la exposición a pesticidas varía significativamente, dependiendo de muchos factores que incluyen características individuales, tales como edad y el nivel de salud, el pesticida específico y las circunstancias de la exposición. La exposición a pesticidas en ciertas etapas del desarrollo de la vida pueden resultar en daños irreversibles a la estructura de los órganos y a su función. Es particularmente preocupante el efecto de la exposición durante el ciclo reproductivo, desde la preconcepción a la lactancia, debido a la posibilidad de problemas durante el nacimiento, anormalidades congénitas, déficit en el desarrollo, y la posibilidad de cáncer de la niñez. [1]

Farmworker families often live near or on the farms on which they work, and thus spend much of their time in close proximity to areas where pesticides are applied on a regular basis. Twenty-one percent of farmworkers are women [2], who may be directed to or inadvertently enter recently treated fields while pregnant. Women in farmworker households who do not work in the fields may still be exposed to pesticide residues brought home by farmworker household members on their shoes, clothes and skin; from nearby applications that drift or are directly sprayed on outdoor play areas; and from chemicals used to control pests in and around the home, especially in poor quality housing.
Las familias de los trabajadores agrícolas frecuentemente viven en la granja o cerca de ella, donde ellos trabajan, así, pasan gran parte del tiempo cerca de las áreas donde se aplican los pesticidas en forma regular. El veintiuno por ciento de los trabajadores agrícolas son mujeres [2], quienes, estando embarazadas, entran, inadvertidamente, o porque tienen que hacerlo, a los campos recientemente tratados. Las mujeres en el ámbito del hogar agrícola, que no trabajan en los campos, pueden también estar expuestas a residuos de los pesticidas que el trabajador agrícola, miembro de la familia, trae al hogar, en sus zapatos, ropa o en la piel; al residuos de las aplicaciones cercanas que el viento trae, o a aspersiones directas de fuera, donde juegan los niños; y de los químicos que se utilizan para el control de plagas en o alrededor del hogar, especialmente en las casas de mala calidad.

This paper reviews the state of the research on the reproductive health effects of pesticide exposure with an emphasis on the needs and concerns of women in farmworker households.

Este trabajo analiza el estado de la investigación de los efectos de la exposición a pesticidas en la salud reproductiva, con énfasis en las necesidades y preocupaciones de las mujeres en el ámbito del hogar agrícola.

Some of the studies included in this overview investigated exposure in the context of residential pesticides, urban populations, or handler tasks rather than focusing exclusively on hired farmworkers. They are included here because: 1) many pesticides have both agricultural and residential uses; 2) the biological mechanisms of action by which pesticides affect the human body do not depend on product use; 3) some handlers and workers perform similar tasks and therefore face similar exposures; and 4) residential pesticides are regularly applied in poor quality farmworker housing.

Algunos de los estudios incluidos en esta revisión general, investigaron las exposiciones en el contexto de pesticidas en residencias, poblaciones urbanas, o personas que los manejan, en vez de enfocarse exclusivamente en los trabajadores agrícolas contratados. Los trabajadores agrícolas se han incluido aquí porque: 1) muchos pesticidas se usan tanto en residencias como en la agricultura; 2) los mecanismos biológicos de acción que hacen que los que los pesticidas afecten al cuerpo humano no dependen del uso del producto; 3) las personas que los manejan y los trabajadores realizan tareas similares y por tanto enfrentan exposiciones parecidas, y 4) los pesticidas residenciales se aplican regularmente en las casas de mala calidad de los trabajadores agrícolas.

**Pesticides used in agriculture**

The chemicals used to control pests (any unwanted flora or fauna, e.g., weeds, insects, fungi, rodents) in agriculture vary widely in their target organism and mode of action. They include insecticides, rodenticides, herbicides, fungicides, and more. As their biological mechanisms are different, so too are the resulting effects on human health and the environment. Insecticides of the class known as organochlorines (OC; see Appendix for list of acronyms), which were widely used in the United States until the 1970s, are central nervous system stimulators. They cause a variety of neurological symptoms that may lead to convulsions, stupor and coma, as well as damage to organs and the endocrine and...
immune systems. Perhaps the best-known example of an OC is dichlorodiphenyl trichloroethane (DDT), an organochlorine that caused well-documented damage to the environment and human health before it was banned in the United States in 1972. A study of women who grew up while DDT was in wide use found a five-fold increase in breast cancer among women who were exposed before the age of 14 as compared with women who were not exposed prior to that age [3]. DDT is still used in many developing countries for malaria control [4;5], and a few other organochlorines, such as endosulfan and lindane, remain legal in the US. Lindane is used to treat scabies and lice even though effective alternatives exist and its use is discouraged, especially for infants, young children and pregnant women [6].

Pesticides used in the agriculture

Los químicos utilizados para el control de plagas (cualquier flora o fauna indeseable, e.g. maleza, insectos, hongos, roedores) en la agricultura varían ampliamente en cuanto al organismo-objetivo y modo de acción. Estos incluyen insecticidas, raticidas, herbicidas, fungicidas, y otros. Así como sus mecanismos biológicos son diferentes, también lo son, los efectos que resultan en la salud y el medio ambiente. Los insecticidas de la clase conocida como organoclorados (OC; ver Anexo de Acrónimos) que fueron ampliamente utilizados en los Estados Unidos hasta la década de 1970, son estimuladores del sistema nervioso central. Estos causan una gran variedad de síntomas neurológicos que pueden resultar en convulsiones, estupor y coma, así como daño a los órganos y los sistemas endocrinos e inmunes. Quizá el mejor ejemplo que se conoce de un OC es el diclorodifenil tricloroetano (DDT), un organoclorado que causó daños al medio ambiente y a la salud humana, lo que está bien documentado, antes de ser prohibido en los Estados Unidos, en 1972. Un estudio de mujeres que crecieron cuando el uso de DDT era generalizado, encontró un aumento de cinco veces mayor de cáncer de mama entre mujeres que se expusieron antes de la edad de 14 años, en comparación con mujeres que no se habían expuesto antes de esa edad [3]. El DDT aún se utiliza en muchos países en desarrollo para el control de la malaria [45], y otros organoclorados, tales como endosulfan y lindano, aún siguen siendo legales en los Estados Unidos. El lindano se usa para el tratamiento de sarna(escabiosis) y piojos, aunque existen otras alternativas efectiva ¹ no se recomienda su uso, especialmente para los niños y mujeres embarazadas [6]

Organochlorines are classified as persistent organic pollutants (POP), because instead of breaking down rapidly over time, they build up in the environment (e.g., soil) and in the fatty tissues of wild and domesticated animals. The half-life in soil for these chemicals can range from months to decades [7]. Over time, OCs accumulate in the food chain as smaller prey are eaten by larger animals and livestock eat feed grown in contaminated soil, ultimately settling in humans at the end of the food chain. Because of their tendency to bioaccumulate and the damage they do to the environment, most POPs were banned through an international treaty in 2001 [8].

Los organoclorados son clasificados como contaminantes orgánicos persistentes (POP= Persistent Organic Pollutant), porque en vez de descomponerse rápidamente a través del tiempo, éstos se

¹ Alternatives to lindane for controlling head lice include Lice B Gone (Safe Effective Alternatives, www.licebgone.com) and Lice Away Enzyme Shampoo (Nature’s Best, www.naturesbestenzyme.com).
With the banning of most OC pesticides, other types of compounds came into widespread use. The largest group of insecticides currently used worldwide includes the organophosphates (OPs), which have both agricultural and residential uses [6]. Unlike OCs, OPs are nonpersistent pesticides (NPP), that is, they break down relatively quickly in the sun, rain and dew found in the environment, and do not accumulate in the body over a long period of time. OPs are nonetheless highly toxic to humans and are responsible for tens of thousands of poisonings in developing countries [9] and thousands of poisonings in the US each year [10]. Many OPs are limited in the extent to which their effects discriminate between target and non-target organisms, including humans [11]. The NPP class also includes the carbamates and pyrethroids, both of which are neurotoxins and have similar effects on human health as the OPs. Pyrethroids, which are chemicals synthesized to mimic a naturally occurring plant pesticide, are also neurotoxins, but are generally considered less harmful than OPs, OCs, or carbamates.

Herbicides, which are designed to control unwanted plant growth, are also widely used in agriculture. Herbicides have a different mechanism of action from insecticides just described. The most common health effect of herbicides is irritation to the skin and respiratory tract, however, acute exposure to certain highly corrosive herbicides can cause multi-system injury and pulmonary failure [6]. Exposure to more than one class of pesticide at a time may amplify the negative health effects [12], while exposure to multiple pesticides that share a common mechanism can increase their specific toxicity [13].
Exposure pathways

Pesticides are used in 85% of homes in the US [14], but they or their residues can be found even on surfaces that have never been directly or peripherally treated. POPs introduced into the environment years ago are still around today, transported by human activity and through the food chain. Despite being banned in the US (and many other countries) some 30 years ago, traces of these insecticides are still found in the homes and bodies of individuals in the US who were not even alive when these products were used [6;15]. Chlorpyrifos (a nonpersistent OP) has also been found to accumulate on newly-introduced surfaces, such as pillows, carpet and soft toys, when brought into a treated area up to two weeks after application, even if applied according to manufacturer’s instructions [16].

Vías de Exposición

Los pesticidas se utilizan en el 85% de los hogares de los Estados Unidos [14], pero estos, o sus residuos, se pueden encontrar aún en las superficies que jamás fueron directamente o periféricamente tratadas. Los POPs introducidos en el medio ambiente hacen años, aún persisten hoy en día, transportados por la actividad humana y a través de la cadena alimenticia. A pesar de su prohibición en los Estados Unidos (y muchos otros países) hace mas o menos 30 años, los residuos de estos insecticidas aún se pueden encontrar en los hogares y en los cuerpos de los individuos en los Estados Unidos, quienes ni siquiera estaban vivos cuando estos productos se utilizaban [6.15]. También se halló que los Clorpirifos (un OP no persistente) se acumulan en las superficies intactas, tales como almohadas, alfombras y juguetes suaves, cuando se les lleva a áreas que fueron tratadas hasta dos semanas después de la aplicación, pese a seguir las instrucciones del fabricante. [16]

In agricultural settings, work-to-home exposure, or a “take-home pathway,” has been identified as a key source of pesticide residues (primarily to OPs) in children’s environment [17-21]. Workers who are exposed on the job on a daily basis, whether as applicators or re-entry workers, are likely to carry home pesticides on their shoes, clothes, skin, and vehicles. Most workers are not provided with adequate washing or changing facilities to remove residues and put on clean clothes before leaving the worksite. If these workers do not take basic precautions (e.g., removing work shoes outside the dwelling, showering before picking up a child), they may transfer residues to the indoor environment or directly to other household members.
En el ambiente agrícola, la exposición trabajo-hogar, o el “trayecto de transporte a casa”, fue identificado como una fuente clave de residuos de pesticidas (principalmente OPs) en el ambiente de niños [17,21]. Los trabajadores diariamente que se exponen en el trabajo, ya sea como aplicadores o como trabajadores que re-ingresan en áreas tratadas, es más probable que transporten a sus hogares los pesticidas, en sus zapatos, ropa, piel y vehículos. La mayoría de los trabajadores no están provistos de las instalaciones adecuadas para lavarse o cambiarse de ropa, para eliminar los residuos y ponerse ropa limpia antes de abandonar su sitio de trabajo. Si estos trabajadores no toman las precauciones básicas (e.g. sacarse los zapatos al entrar a su casa, ducharse antes de entrar en contacto con sus hijos) éstos pueden transferir los residuos al ambiente interior o directamente a los otros miembros de la familia.

The primary routes by which pesticides enter the body are ingestion in food, soil, or water; inhalation, through the skin, and through the eyes [22]. OCs are absorbed through the lungs, stomach and skin, and excreted only slowly, sometimes over a period of years (e.g., DDT) [7]. Dietary ingestion is a significant source of exposure, especially for infants and children [23;24]. The residue monitoring program conducted by the FDA in 2003 found measurable levels of pesticides in baby foods, including DDT (6% of samples), captan + THPI (a possible carcinogen) (9%), carbaryl (carbamate) (6%), endosulfan (9%), dimethoate (4%), malathion (3%), and chlorpyrifos (all OPs) (2%) [25].

Las rutas principales de ingreso de los pesticidas al cuerpo son, ingestión de alimentos, tierra o agua, inhalación, a través de la piel, y a través de los ojos [22]. Los OCs se absorben a través de los pulmones, el estómago y la piel, y son excretados lentamente, algunas veces a lo largo de un período de años (e.g. DDT) [7]. La ingesta de la dieta es una fuente significativa de exposición, especialmente para los niños y niñas [23;24]. El programa de monitoreo de residuos realizado por FDA en el 2003 halló niveles que se pueden medir, de pesticidas en alimentos de bebé, incluyendo DDT (6% de muestras), captan THPI (un posible carcinógeno) (9%), carbaryl (carbamate) (6%), endosulfan (9%), dimetoate (4%), malation (3%) y clorpirifos (todos OPs) (2%) [25]

Post-natally, infants can be exposed to pesticides via breast feeding. The POPs, despite having mostly been banned, are still found in breast milk because they are stored in body fat [6;13]. Postpartum weight loss increases the likelihood of the release of OCs into the breast milk [13]. There is some evidence that the maternal body burden is actually transferred to her children via breast feeding, as the pesticide concentrations decrease with the more times a mother has breastfed [26]. Fortunately, the benefits of breast feeding still far outweigh the possibility of harm from pesticide transfer in breast milk, and should be encouraged for all mothers regardless of exposure history [26;27]

Los infantes pueden ser expuestos a los pesticidas via leche materna. Los POPs, a pesar de haber sido mayormente prohibidos, aún se encuentran en la leche materna. porque están almacenados en la grasa del cuerpo [6;13]. La pérdida de peso post-parto aumenta la probabilidad de liberar OCs en la leche materna [13]. Existe cierta evidencia de que la madre realmente, lo transfiere a su hijo via lactancia, las concentraciones de pesticida disminuyen a medida que la madre amamanta a su bebé con mayor frecuencia [26]. Afortunadamente, los beneficios de la lactancia materna aún contrarrestan la posibilidad de daño por la transferencia de pesticidas a través de la
Effects of exposure during the reproductive cycle
Assessing the effects of pesticide exposure on human health in general, and reproductive health in particular, is an enormous challenge. Research in this area draws heavily on animal tests since direct human testing would be unethical, but it is tricky to translate between animal and human health effects. While a variety of techniques are used to assess exposure, most can only estimate the amount actually absorbed by the body, e.g., surveys of occupational exposure, ambient air and environmental monitoring, skin surface measurements. Some can measure only fairly recent exposure, as is the case with urinary analysis for NPPs, while assessing exposure to fat-soluble pesticides such as OCs requires invasive tissue samples. Also, identifying populations that have not already been multiply-exposed to pesticides over the years is exceedingly difficult, rendering the possibility of finding a “clean” (non-exposed) control group for comparison close to nil [13;23]. Furthermore, the timing of exposure plays an important role in the characterization of the risks to reproduction from pesticides [28].

Los efectos de exposición durante el ciclo reproductivo.
La evaluación de los efectos de la exposición a pesticidas en la salud humana en general, y la salud reproductiva en particular, es un reto enorme. Las investigaciones en esta área recurren, en gran medida, a pruebas con animales, ya que las pruebas directas en los seres humanos serían anti-ético; pero la transición entre salud animal y salud humana es complicado. Aunque se utiliza una variedad de técnicas para evaluar la exposición, la mayoría únicamente puede calcular el monto que el cuerpo realmente absorbe, e.g., las encuestas de exposición ocupacional, aire del ambiente y monitoreo del medio ambiente, mediciones en la superficie de la piel. Algunos pueden medir sólo las exposiciones relativamente recientes, como es el caso con los análisis de orina para NPPs, mientras que la evaluación de la exposición a pesticidas solubles en grasa, tales como los OCs, requieren muestras de tejido invasivo. Asimismo, la identificación de las poblaciones que aún no han sido multi-expuestas a pesticidas a través de los años es excesivamente difícil, haciendo que la posibilidad de encontrar un grupo de control “limpio” (no expuesto) para su estrecha comparación sea nula [13,23]. Más aún, la cuenta del tiempo de exposición juega un rol importante en la caracterización de los riesgos de pesticidas a la reproducción [28].

Exposure during periods of rapid development, especially in utero, is when pesticides cause the most damage in humans [13;24]. However, assessing exposure during this time is tricky. Amniotic fluid collected during amniocentesis, a process that carries its own risks, is the only medium available to characterize direct fetal exposures early in pregnancy (up to around 18 weeks of gestation) [29]. The placenta may be used to assess exposure during gestation, but it can obviously only be tested after birth.

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But even with these limitations, enough data have been collected to indicate that exposure to pesticides at any point in the reproductive cycle can have serious and potentially devastating effects on both mother and child.

**Preconception exposure**

Even before the fetal periods of increased sensitivity, studies have found that *preconception* exposure of either the mother or father may have an effect on reproductive outcomes. These increased risks include spontaneous abortion, neural tube and other birth defects, and even deviation from the expected ratio of male-to-female births (fewer males born than normal). Maternal occupational exposure during a critical risk period, from three months before to one month after the last menstrual period, has been associated with higher risk for anencephaly, an extreme form of neural tube defect. Furthermore, children of men who applied pesticides even prior to that critical period were at higher risk as well [31]. Preconception exposure to common phenoxy acetic acid herbicides such as 2,4-D is associated with increased risk of early spontaneous abortion. Preconception exposure to glyphosate (RoundUp®) is associated with late spontaneous abortion [28]. One study found that mothers with occupational exposure to pesticides as long as 2 years prior to conception were at an increased risk of having a child with childhood kidney cancer [32].

**Exposición pre-concepción**

Aún antes de que el periodo fetal sea más sensible, los estudios encontraron que la exposición preconcepción, ya sea de la madre o del padre, puede afectar los resultados reproductivos. Estos riesgos adicionales incluyen abortos espontáneos, defectos en el tubo neural, y otros defectos de nacimiento, y aún desviaciones de la proporción hombre-a-mujer (nacen menos hombres que lo normal). La exposición ocupacional de las madres durante el periodo crítico de riesgo, desde tres meses antes hasta un mes después del último período menstrual, ha sido asociada con mayor riesgo de anencefalia, una forma extrema de defecto del tubo neural. Más aún, los hijos de hombres que aplicaron pesticidas aún antes de ese periodo crítico también estuvieron con mayor riesgo [31]. La exposición preconcepción a herbicidas de ácido acético fenoxi, tales como 2,4-D está asociada con mayor riesgo al aborto espontáneo temprano. La exposición preconcepción a glifosato (RoundUp®) está asociada con el aborto espontáneo tardío [28]. Un estudio encontró
Evidence has been accumulating since the 1970s that exposure to certain pesticides reduces sperm counts and reduces sperm quality [23], first noticed with a nematocide, dichlorobromopropane [33], and more recently with OPs [34]. A large number of international studies suggest that occupational exposure to pesticides negatively affects male fertility [13]. A study being conducted in Minnesota with a group of male pesticide applicators since 1989 has identified increased risk for birth anomalies and miscarriages, and a lower-than-expected male-to-female birth ratio, especially among applicators exposed to a combination of herbicides, insecticides and fungicides. Lifetime use of fungicides by male applicators was associated with lowered testosterone levels, which may contribute to the change in sex ratio at birth [35-38]. Males who have been exposed may experience a decline in fertility due to interference with thyroid function [33;38].

Within this same population of male applicators, the researchers found that the rates for overall birth defects, as well as for specific categories of defects, such as circulatory, urogenital, musculoskeletal, and dermatological, were significantly increased. Interestingly, rates varied by crop region and by season of conception, with the highest rates occurring in children conceived in the spring. They also varied by the infant’s sex, with males being at considerably more risk.

Preconception exposure of male applicators to the fumigant phosphine and to the herbicide glyphosate, the active ingredient in RoundUp®, was also associated with elevated risk for later neurodevelopment problems. (Another study conducted with RoundUp® suggests that the commercial product, which contains additional chemicals, is in fact more toxic than glyphosate alone [39]). Overall, reproductive
toxicity was primarily through the males, which implies that the damaging exposure took place preconception [36]. Similar results have been found in other farming areas, notably in several wheat-producing states where chlorophenoxy herbicides are used extensively (Minnesota, Montana, South Dakota and North Dakota) [40].

La exposición preconcepción de los aplicadores varones a los fumigantes fosfinos y a los herbicidas glifosatos, ingrediente activo en RoundUp®, también se asoció, posteriormente, con elevado riesgo de problemas de desarrollo neurológico. (Otro estudio conducido con RoundUp®, sugirió que el producto comercial que contiene químicos adicionales es, en efecto, más tóxico que el glifosato sólo [39]) En general, la toxicidad reproductiva fue principalmente a través de los hombres, lo que implica que la exposición nociva fue preconcepción [36]. En otras áreas agrícolas se hallaron resultados similares, especialmente en varios estados productores de trigo donde los herbicidas clorfenoxi se utilizan extensivamente (Minnesota, Montana, Dakota del Sur y Dakota del Norte) [40].

It is worthwhile noting that certain types of birth anomalies observed in the Minnesota study were more strongly associated with the application of the fumigant phosphine and the herbicide glyphosate (active ingredient in RoundUp®) [35;36], rather than products targeting insects or animals. Studies of perceptions of pesticide held by both farmworkers and growers have found that herbicides are not considered as dangerous as the other chemicals and that pesticides in general are believed to only affect the target organism [41-43]. This points up the importance of emphasizing in pesticide safety education settings that all agricultural chemicals are potentially harmful and exposure to them should be avoided to the maximum extent possible.

Vale la pena notar que ciertos tipos de anomalías de nacimiento observadas en el estudio de Minnesota fueron asociadas fuertemente con las personas que aplicaban el fumigante fosfito y del herbicida glifosato (ingrediente activo de RoundUp® [35, 36], en vez de estarlo con los insectos o animales a los que estaban dirigidos. Los estudios de pesticidas que tienen tanto los trabajadores agrícolas como los cultivadores, tienen evidencia que los herbicidas no son considerados tan peligrosos como los otros químicos y que los pesticidas en general se cree que afectan sólo al organismo al que está dirigido [41-43]. Esto resalta la importancia de hacer énfasis en los espacios de educación de seguridad de pesticidas, que todos los químicos agrícolas son potencialmente dañinos y que debería evitarse la exposición a éstos en la máxima medida posible.

**Prenatal (in utero) exposure**

Extensive research worldwide has identified potential associations between *in utero* exposure and a number of adverse birth outcomes, such as miscarriage, low birth weight, and small head circumference. Exposure during gestation has also been associated with developmental and neurobehavioral problems in infants and young children, as well as with potentially increased risk for childhood cancers. Pesticide exposure experienced by the mother during pregnancy also results in exposure for her developing child, generally by means of the placenta [7;26;30;44-46]. Post-conception exposures have been associated with a number of negative birth outcomes, including late spontaneous
abortion(s) [28]. One study found that occupational exposure during the first and second trimesters was associated with increase in stillbirths due to all causes, while exposure in first two months of gestation contributed to an even higher risk of stillbirth due to congenital anomalies [47].

**Exposición Prenatal (en útero)**

Las extensas investigaciones realizadas en todo el mundo han identificado la asociación potencial entre exposición en útero y varios resultados adversos de nacimiento, tales como abortos, peso bajo al nacer, y circunferencia pequeña de la cabeza. La exposición durante la gestación también se ha asociado con problemas de desarrollo y comportamiento neural en infantes y niños pequeños, así como con potencialmente mayor riesgo de cáncer en la niñez. La exposición a pesticidas experimentada por las madres durante el embarazo también resulta en exposición del niño que está gestando, generalmente por medio de la placenta [7, 26, 30, 44-46]. La exposición postconcepción ha sido asociada con cierto número de resultados de nacimiento negativos, incluyendo abortos espontáneos tardíos [28]. Un estudio halló que la exposición ocupacional durante el primer y segundo trimestre fue asociado con aumento de nacimientos prematuros debido a todas esas causas, mientras que la exposición in los primeros dos meses de gestación contribuyó a un riesgo aún mayor de nacimientos prematuros debido a anomalías congénitas [47].

Exposure to DDE and chlorpyrifos in the third trimester was associated with lower birth weight, smaller head circumference and shorter birth length, especially when coupled with certain maternal genetic features (low PON1 activity, an enzyme needed to detoxify OPs) [15;48]. One study found that exposure to OCs, as measured in breast milk, was associated with increased risk for undescended testicles in male newborns [49]. Pesticides can interfere with endocrine function of both men and women. Dioxins, organochlorines, and other POPs at even low environmental levels during pregnancy can disrupt maternal thyroid function, which is an important determinant of infant brain development [6;50].

La exposición a DDE y clorpirifos en el tercer trimestre fue asociada con peso bajo al nacer, menor circunferencia de la cabeza y menor tamaño al nacer. Especialmente si está asociado con ciertas características genéticas de la madre (actividad PON1 baja, una enzima necesaria para la detoxificación OPs) [15, 48]. Un estudio halló que la exposición a los OCs, medido en la leche materna, fue asociada con mayor riesgo de criptorquideas (que los testículos desciendan) en los recién nacidos varones [49]. Las pesticidas pueden interferir con la función endocrina tanto de hombres como de mujeres. Las dioxinas, los organoclorados, y otros POPs, aún en niveles medioambientales bajos, durante el embarazo, pueden trastornar la función de la tiroides de la madre, lo que es un determinante importante del desarrollo cerebral del feto [6;50].

While the relationship of birth anomalies to pesticide exposure is difficult to assess with certainty because of limited access to the population, reporting issues, and the overall small number of cases [23], several recent, very serious birth defects in infants born to farmworker women underscores the importance of making the effort both to continue the investigation, and to protect farmworkers from exposure as much as possible. Three women who worked for the same employer, Ag-Mart Farms, at the same time in Florida and North Carolina worked during a critical stage in their pregnancies in fields that
had been treated with six pesticides that have been associated with birth defects in animal studies. All three gave birth within an 8-week span to children with major deformities. All the mothers had worked in treated fields, sometimes in violation of post-application re-entry intervals; each had few or no other risk factors for birth defects; and two had already given birth to normal children [51]. Because of the large number of variables that contribute to birth outcomes, it is difficult to definitively connect the three cases to pesticide exposure. However, an investigation by the North Carolina Department of Health & Human Services concluded that it is “plausible” that occupational pesticide exposure caused one of the children to be born with no arms or legs [52]. The fact that the exposures occurred at nearly the same time and in the same setting is cause for major concern. Farmworker women who may become pregnant should insist that all possible measures be taken to reduce the likelihood of their occupational exposure to teratogenic pesticides.

**Neonatal and long term effects**

Beyond the adverse effects of *in utero* exposure, neonates and infants are at a high risk for, and especially vulnerable to, pesticide exposure from numerous sources. Certain protective biological features do not develop in infants for several months (e.g., enzymes) increasing the risk of pesticide accumulation in the brain. Furthermore, the blood-brain barrier is not fully developed in infants, making it easier for pesticides to cross into the brain [13].
Much of the research on the accumulation and subsequent effects of pesticides in breast milk, especially for pesticides that have been banned in the US, e.g., DDT and other POPs, has been conducted in countries outside the US. Some of the effects reported include shorter length at birth, a variety of developmental problems, and increased risk for cancer. Combinations of pesticides, or pesticides with nicotine in smoking mothers, may magnify the toxic effects [7]. Studies in North Carolina and Mexico found that the presence of DDE (the metabolite of DDT) in breast milk was associated with a shorter period of breastfeeding, perhaps the result of interference with the mother’s milk production due to DDE’s estrogenic effects [53;54]. However, the importance of breast feeding in optimal infant development cannot be overemphasized, even for mothers with high exposure levels [27].

The potential long-term effects of fetal pesticide exposure, especially in utero, continues to be a subject of considerable research. Establishing definitive links between exposure and a health outcome that may develop years or decades later is a huge challenge. Current research is being conducted on connections possible between prenatal pesticide exposure and allergies and hay fever [55]; neurodegenerative diseases such as Parkinson’s Disease and Alzheimer’s Disease [56]; neurodevelopment delays [27;57]; neurobehavioral problems [58], hyperglycemia [59]; and obesity, diabetes, and depression [60].
The potential carcinogenic effect of pesticide exposure is a major children’s health concern. While epidemiological investigations cannot directly establish causal links or determine mechanisms of action, a number of studies have nonetheless identified statistically significant associations between prenatal exposure and some childhood cancers [32;61-65]. It should also be noted that, because of small sample sizes common in studies of childhood cancers and the inherent limitations of ecological studies, this research may underestimatethe true risk of childhood cancer [62;64]. Nonetheless, the totality of the evidence is sufficiently compelling to warrant the imposition of strong measures to protect children from exposure to pesticides from the moment of conception, if not before.

Clinical recommendations
Health care providers are in an ideal position to identify and assess a patient’s risk for exposure. The first step is to obtain an environmental history that covers residential and employment histories, types of work activities performed currently and in the relevant past, and possible sources of exposure to biological or chemical agents. For each exposure source identified, additional information needs to be collected, such as frequency, duration, and intensity. Women who are pregnant or planning a pregnancy, especially those currently performing farmwork, should be informed of the implications of exposure before, during and after pregnancy, and assisted in making decisions that are appropriate for their individual work and home situations [66]. In addition, providers should encourage mothers to avoid exposure that might contaminate breast milk without unduly alarming them, perhaps by associating it with the importance of not smoking or drinking alcohol during pregnancy and nursing [26]. Of course, breast feeding should continue to be strongly encouraged since all evidence indicates that the known benefits far outweigh the potential risks [27].

Recomendaciones clínicas
Los proveedores de salud están en una situación ideal de identificar y evaluar el riesgo del paciente a exposiciones. El primer paso es obtener un historial del medio ambiente que cubra antecedentes residenciales y de empleo, tipos de actividades de trabajo, realizados en el momento y en el pasado relevante, y fuentes posibles de exposición a agentes biológicos o
Education about pesticide safety is an important measure for preventing exposure. The Migrant Clinicians Network has recently developed a 14-page full-color Spanish language comic book and Wake Forest University School of Medicine has produced patient education handouts and posters in English and Spanish (see box). Women living in farmworker households should be offered additional education on ways they and the farmworkers with which they live can reduce take-home exposure:

- remove work clothes and shoes before entering the home
- shower or bath upon returning home and before touching other people
- store and launder dirty work clothes separately from other clothing [20]

As the evidence continues to accumulate of the overall hazards that pesticides pose to human health, it is important that health care providers consider the possibility and consequences of occupational, dietary and residential exposure to pesticides for their female patients. Occupational exposure is almost certainly the primary source of exposure for farmworkers and their families [66]. Awareness of the ways in which pesticide exposure occurs and the danger it poses are a crucial component of comprehensive preconception and prenatal care for farmworker women.

Quitar la ropa y los zapatos antes de ingresar a la casa
- Ducharse o bañarse tan pronto se llega al hogar y antes de tocar a otra gente
- Guardar y lavar la ropa de trabajo sucia, separadamente, sin mezclarla con otra ropa[20]
trabajadores agrícolas y de sus familias [66]. El conocimiento de las formas en las que la exposición a los pesticidas tiene lugar y los peligros que significan son componentes cruciales del cuidado preconcepción y prenatal de las mujeres trabajadoras agrícolas.
Patient Education Materials:

- **Migrant Clinicians Network. Lo Que Bien Empieza ... Bien Acaba: Consejos para las mujeres para prevenir daños a la salud y a sus bebés causados por pesticidas.** Austin, TX: Migrant Clinicians Network, 2007. available for download at: [http://www.migrantclinician.org/resources_search?qry=lo+que+bien+empieza&filter_scope=all](http://www.migrantclinician.org/resources_search?qry=lo+que+bien+empieza&filter_scope=all).

For more information:

- Additional NEETF pesticide-related links and documents for health care providers available at [http://www.neefusa.org/health/Resources/healthcare.htm](http://www.neefusa.org/health/Resources/healthcare.htm)
- **Migrant Clinicians Network. Pesticides, Clinician Training and Education, Clinician Tools.** [http://www.migrantclinician.org/resources_search?filter_program=84](http://www.migrantclinician.org/resources_search?filter_program=84)
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APPENDIX: Acronyms

OP: organophosphate (category of pesticide)
OC: organochlorine (category of pesticide)
NPP: nonpersistent pesticide (includes OPs)
POP: persistent organic pollutant (includes OCs)
DDT: dichlorodiphenyl trichloroethane (an organochlorine)
Reference List


