

# streamline

The Migrant Health News Source

## Partnering With Health Network: A Case Study

Ricardo Garay and Candace Kugel, CRNP, CNM

**I**magine that you are a clinician working at a federally-funded community health center. Carolina R. learned that she was pregnant for the first time while under your care. She and her partner received the news with joy—joy that was doubled when they learned that she was carrying twins. They struggled to attend the many appointments for prenatal care, lab tests, nutrition counseling and childbirth classes, balancing them with the demands of work, transportation and finances. Two months before her due date, Carolina informed you that their farm jobs had ended for the season, meaning that they would be moving to another state...

### Enhancing Continuity of Care and the Medical Home—the Concept

After four years as Outreach Coordinator at Wisconsin's Family Health/La Clinica, Yurany Ninco had encountered too many situations like Carolina's when she heard about a possible solution. She attended a migrant health conference session in 2009 about continuity of care and learned about the Migrant Clinicians Network (MCN) Health Network—a program that helps mobile patients remain in care as they move to new locations. [See Figure 1] Family Health/La Clinica is a federally-funded health center located in a state where migrant families live and work for only three or four months of the year. Typically about 50 percent of their migrating patients return from one year to the next, so the clinical staff recognized the importance of keeping their patients in care while they were away from Wisconsin. "It helps us if our patients are able to see a provider once or twice while they are gone. If we can get those records, we will have more information—like HbA1cs for our diabetics—that helps us in continuing to develop their care plan," Ninco explained. This concern for her mobile patients meant that Ninco was spending time each year contacting Family Health/La Clinica's sickest patients after they moved away to be sure that they



Photo courtesy of Family Health/La Clinica, Wautoma, WI

Yurany Ninco is ideally suited for her job. She received a B.S. in Nursing from the Universidad de Antioquia, Colombia in 1997, and worked as a nurse in a private hospital there for eight years. "In 2005," she explains, "I moved to the United States to pursue a B.S. in Health Care Administration and graduated from the University of Wisconsin, Stevens Point in 2009." While attending school she heard about Family Health/La Clinica and its mobile unit program. "I thought the program was a good place to use my nursing and Spanish skills and in 2008 I applied for the health aide position. After working as a health aide that first summer I was offered the Outreach Coordinator position. I've now been the coordinator for 4 years."

were able to find care. When she heard about Health Network (HN), she realized that she had a partner in this endeavor. "We [realized that we] just aren't able to do it alone."

### The Family Health/La Clinica and Health Network Partnership — How it Works

Ninco began enrolling patients in HN during the summer of 2010. She started

by selecting only four patients she felt were most in need of ongoing care as a way to figure out how HN functions and to incorporate enrollments into her routine workflow. In 2011, 25 clients were enrolled in the HN partnership and in 2012 this number increased to 28. (see "Family Health/ La Clinica Statistics"). Twenty-four of those enrolled continue to receive HN

continued on page 4

# “Estudiar en Vano”?

Daniela Delgado and Rachel Becker

For first generation farmworkers, the mean highest grade completed in their country of origin is eighth grade.<sup>1</sup> For children of migrant workers, acquiring an adequate education may be a great challenge due to their transitory lives and language barriers. Migrant families relocate with every growing season, which changes the school for children at least twice a year.<sup>2</sup> At some schools the shortage of bilingual teachers and the lack of understanding of the transitory lives of migrant children might place them at risk to be assigned to lower level grades or even special education classes.<sup>3</sup>

A study was conducted in Homestead, Florida with farmworker families between 2011 and 2013 revealing attitudes, barriers and beliefs around educational attainment. The students participating in this study were attending middle school. Parents focused their discourse on their children in middle school or high school, as well as on their own educational goals. Preliminary findings from this research suggest a variety of contextual factors that present barriers to educational attainment. Our qualitative focus group data suggests that financial constraints create stress and worry, leaving parents emotionally drained. Although parents in our study desired that their children continue with school, either middle school or high school, they questioned whether their children were “estudiando en vano” (studying in vain). Parents noted several contextual stressors as preventing them from fully participating in U.S. educational opportunities. More specifically, they described barriers such as the lack of transportation, distrust of the school system, the need for interpretation services at the schools, and their immigration status (that prevents the parents themselves from pursuing their own education) (Delgado & Becker, in press).

Higher education for farmworkers is even more difficult to attain. Given their transitory lives, they often lack in-state residency, increasing tuition costs and preventing acceptance to some schools.<sup>4</sup> Most colleges and universities do not accept undocumented students, marginalizing the 48 % of farmworkers who are undocumented.<sup>1</sup> Moreover, a high percentage of students from farmworker families drop out even before reaching college to contribute to family income.<sup>4</sup>

## Educational Opportunities: High School Equivalency Program and College Assistance Migrant Program

There are two main national educational initiatives focused on migrant workers, addressing both high school and college



Photo courtesy of Kate Bero

completion. The High School Equivalency Program (HEP) is funded by the U.S. Department of Education, Office of Migrant Education. This program assists migrant and seasonal farmworkers, and their immediate family members, to obtain the equivalent of a high school diploma.<sup>5</sup> The purpose of HEP is also to facilitate acquiring employment by farmworkers or to continue on to an Institution of Higher Education (IHE). Participants must be 16 years of age or older, not currently enrolled in school and must not have earned a high school diploma or its equivalent. In addition, within the prior 24 months participants must have worked a minimum of 75 days in farm work. An IHE or private nonprofit may apply for a grant to host a HEP. In 2010, 69% of farmworkers who participated in HEP stayed throughout the program and exited with a General Educational Development (GED) diploma. Furthermore, 80% of those who received a GED continued on to an IHE, training, the military or employment.<sup>5</sup>

The College Assistance Migrant Program (CAMP) is also funded by the U.S. Department of Education, Office of Migrant Education. This program is also designed for farmworkers, or their immediate family members, to provide them with support in their first year of college.<sup>5</sup> Assistance includes: partial tuition payment, scholarship guidance, application assistance, housing and transportation expenses, and tutoring and counseling services. CAMP continues to provide follow-up support throughout postsecondary education but the program focuses on the first year of college since research has shown that students who

continue after freshman year are more likely to finish. To host this program IHEs can apply to receive a CAMP grant.<sup>5,6</sup>

A recent four-year study of CAMPs in 17 states — a total of 64 campuses, demonstrated the effectiveness of this program by showing that 86% of students enrolled completed their first year in good academic standing and 81% continued to attend school the following year.<sup>6</sup> In 2010, the U.S. Department of Education reported slightly higher numbers, with 85% of CAMP students continuing to attend school the following year.

## Conclusion

Migrant and seasonal farmworkers and their families face various barriers to educational attainment. However, farmworker families still value educational opportunities. In our current research, a farmworker woman and mother once mentioned, “Porque el niño que tiene educación va a ver la vida como de otro color y de un color mas bonito.” The child who has education will see life in a different color, in a more beautiful one. Migrant children also see the future advantages of education and school. A 12-year-old farmworker child once told us about how school helps a person to be someone in life: “La escuela nos ayuda a ser alguien en la Vida.” In our research, migrant workers’ stories reveal that they face a myriad of challenges related to education; yet, we found a desire to persevere and succeed in life through educational attainment.

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# Health Literacy

Peter Morrison, Director of Health Literacy, Health Literacy Forward, Literacy Coalition of Central Texas

**A**s a healthcare professional, you likely have heard about health literacy by this point. It has received a lot of national attention in the past two years as researchers have linked low health literacy to a surfeit of health and healthcare challenges among patients, including: reduced ability to understand labels and health messages, lower likelihood of accessing preventive care, greater use of emergency departments, shorter life expectancy and increased healthcare costs.

Despite growing recognition of the implications associated with low health literacy, efforts to reduce barriers to providing health-literate care among healthcare professionals are minimal. Even the most widely accepted definition of health literacy (*the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions*) places the entire onus of low health literacy on the patient. In partnership with University of Texas and published in *Patient Education and Counseling*, our office executed a study which found that healthcare providers routinely overestimate their knowledge of health literacy as well as their patients' ability to understand the information being communicated.<sup>1</sup>

This study verifies what I see in the field every day as Director of Health Literacy at the Literacy Coalition of Central Texas. Rushed for time, healthcare providers overlook the importance of effective, patient-centered communication, healthcare systems do not invest in trainings and resources to reduce barriers to health-literate care, and far too often patients leave the clinic or hospital not having a clue what they've just been told and what they need to do next.

The good news is that in this fast growing field of health literacy, new research is constantly being released on effective interventions to improve health literacy or to mediate the negative effects of low health literacy. As an interested individual, you can start by watching this short video with examples of low health literacy, found at [www.willread.org/health-literacy](http://www.willread.org/health-literacy). When you're ready to take action, review the Agency for Healthcare Research and Quality's Health Literacy Universal Precautions Toolkit,<sup>2</sup> a comprehensive guide to health literacy research and interventions. The top tool to lead Quality Improvement interventions for health literacy and effective communication is the Communication Climate Assessment Toolkit (C-CAT),<sup>3</sup> developed by the American Medical Association and endorsed by the

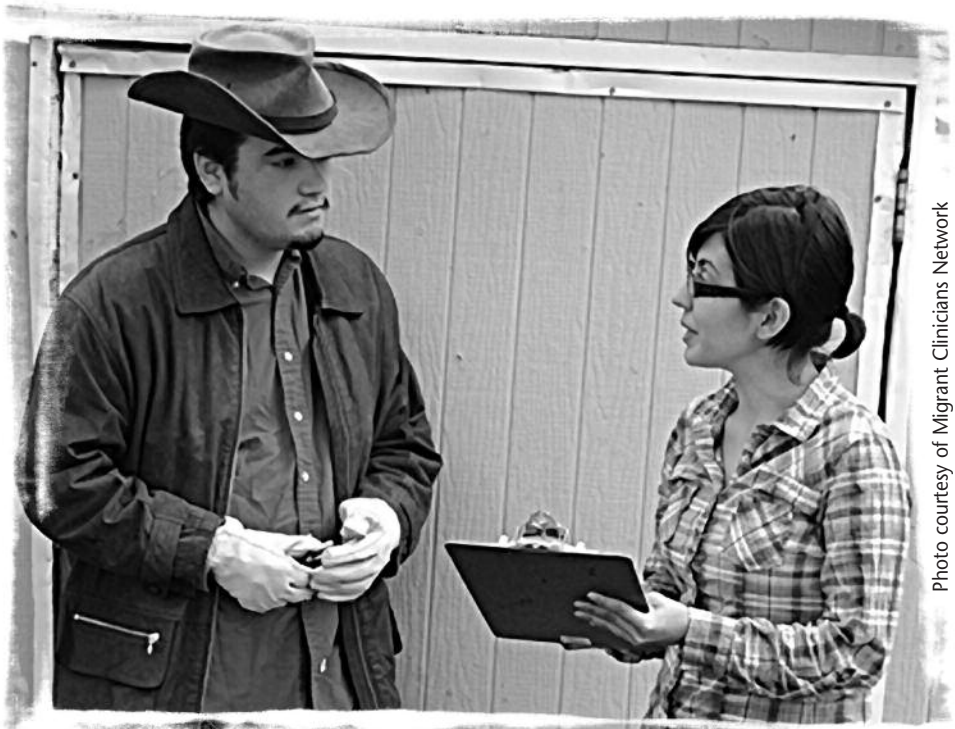


Photo courtesy of Migrant Clinicians Network

National Quality Forum. And as an individual trying to get your organization on board, use The Joint Commission's Advancing Effective Communication, Cultural Competence, and Patient- and Family-Centered Care: A Roadmap for Hospitals and Institute of Medicine's Attributes of a Health Literate Organization.<sup>4,5</sup>

## Health Literacy Forward — Texas' Health Literacy Resource

Health Literacy Forward, a program of the Literacy Coalition of Central Texas, provides quality improvement consulting and trainings for hospitals and clinics on effective health communication. While 75 percent of preventable readmissions result from miscommunication, Health Literacy Forward, a vendor-consultant of the American Medical Association, helps healthcare agencies reduce preventable readmissions, ensure compliance with accreditation and regulatory requirements, and improve patient-safety and reported quality of care.

Health Literacy Forward has pioneered Texas' health literacy and effective communication movement, and we want to continue to be a resource for Texas hospitals and clinics. On our website [www.willread.org/health-literacy](http://www.willread.org/health-literacy), you can find success stories, further resources, and the email address of the Director of Health Literacy to discuss interventions and opportunities for collaboration.

For more information contact: Health Literacy Forward, Literacy Coalition of Central Texas [pmorrison@willread.org](mailto:pmorrison@willread.org), 512-735-2531

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case management services in 2013.

Family Health/La Clinica’s migrant health services are delivered primarily by outreach staff, students and clinicians who travel in a converted RV mobile clinic. The mobile unit visits 10-12 labor camps, visiting each site two to three times throughout the growing season. Services include health screenings, health education, and examinations and treatment for acute and chronic illnesses. Patients requiring more in-depth care are referred to Family Health/La Clinica’s medical and dental sites or to other providers in the area.

Mobile unit patients who require ongoing care are identified by Ninco for enrollment in HN. “We would like to enroll all patients who are in need of chronic disease management,” she says. In addition to patients with diabetes, hypertension and elevated cholesterol, she selects those who need follow-up evaluation of abnormal test results or who are acutely ill. She explains the program to them, offering to enroll them. “Not many decline and we fill out the forms right there, getting their contact information and signature.” After returning from the field to the clinic, Ninco completes the enrollment process by faxing the demographics and consent forms and the patient’s medical records to HN’s home base at MCN’s Austin, TX, office. Once their phone number and contact information are verified, the patient is assigned to a Health Network associate, who then provides “virtual” case management services by phone, fax and email.

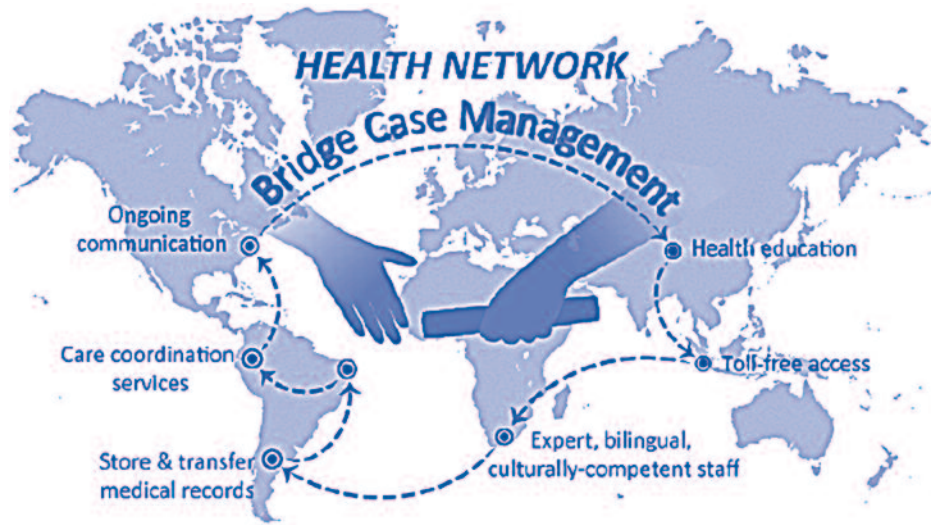
Family Health/La Clinica quickly saw results after beginning to use HN. Ninco describes one of their earliest enrollments:

*Julia P. had an abnormal mammogram at Family Health/La Clinica and required additional evaluation after leaving Wisconsin. HN ensured that she was seen for follow-up care and transferred her records to two locations that provided that care. She received additional testing and surgery, and when she returned to Family Health/La Clinica the next summer, HN forwarded those records to Wisconsin. She has returned yearly to Family Health/La Clinica and HN continues to remind her to have a yearly mammogram.*

**Health Network—Taking Collaboration to a New Level**

Health Network is designed to allow health-care organizations to “hand off” the responsibility for ensuring continuity of care for their mobile patients. HN remains in touch with the patient to encourage proper follow-up and provide patient navigation as

**FIGURE 1**



needed. Ninco, however, wanted to continue to be involved throughout the “off season,” since many of Family Health/La Clinica’s enrolled patients would be returning. A relationship that could be described as co-management thus evolved. Ninco has monthly conference calls with HN Program Manager Ricardo Garay to discuss the status of Family Health/La Clinica’s HN patients.

Garay says, “as a result of the working relationship we have developed with Family Health/La Clinica and Yurany Ninco, we are now using the same approach with other organizations that are heavy users of HN. We like it. Since all of our work with patients is done by telephone, it makes a real difference to have the involvement of someone like Yurany Ninco who has a personal connection with the patients.”

That personal connection is helping to make a difference for many migrant workers who urgently need care. For example, Ninco describes with concern the ongoing case of David L., a man who has received seasonal care from Family Health/La Clinica for heart disease for several years. Since he has become increasingly unstable, she recently

enrolled him in HN so that he could continue to get care when he moved south for the winter months. HN made 17 clinic contacts, 33 patient contacts and 4 records transfers over 6 months to establish affordable primary care services for this patient.

**Summary Points for Successful Partnerships**

Ninco recommends the co-management arrangement to other organizations. While healthcare organizations serving migrants struggle with the goal of being a health-care home for patients who move, partnering with HN makes that goal more attainable.

- “Closing the loop” — receiving follow-up records for returning patients — provides ongoing care and can lower operating expenses. “Knowing what a patient’s cholesterol level was while they were away, for example, helps us to know how they’re doing and prevents unnecessary testing,” Ninco notes.
- Monitoring clinical performance measures. “We recognize the importance of

continued on page 5

<b>Family Health/La Clinica Statistics</b>			
<b>Category</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>
Total migrant patients	737	555	437
Men	64%	62%	60%
50 years of age or older	60%	66%	61%
Returning patients	46%	53%	50%
Patients enrolled in Health Network	4	25	28



using follow up information to evaluate health outcomes for our patients,” Ninco states. Having patients enrolled in HN can help healthcare organizations monitor patient progress and outcomes.

- Expanding case management services. Using HN proactively by increasing the number of enrollments each year is a goal at Family Health/La Clinica, since there are hundreds of mobile patients who are not receiving case management services. These partnerships improve the efficiency of the enrollment process which can provide case management at a national or international level.
- Scope of HN services. HN attempts to find access to specialty care when needed by researching services available in the patient’s new location. In one such case, Ninco states, “Health Network played a valuable role in finding care at a manageable cost and helped us facilitate and coordinate that care by staying in contact with both the clinic and the patient to ensure proper follow up.”

MCN’s-HN partnerships with organizations like Family Health/La Clinica help MCN to identify the following areas that facilitate case management of mobile patients:

- Patient education: Garay would like to emphasize to enrolling organizations the crucial need to educate patients about adhering to treatment regimens. Having patients participate in and use HN as a proactive tool for their own health will yield the best results. HN can direct a patient, schedule an appointment and look for resources in their new location, but the patient must be willing to participate.
- Identifying patients: Having patients enrolled as soon as they are identified as being likely to move allows for better patient management. Knowing which patients will require follow-up helps direct attention to cases that really need it.
- Patient contact information: A critical component for patient follow-up is having the patients provide as many telephone numbers as possible and remaining in contact with HN. Having the patients understand their role in maintaining contact as they move is especially helpful to HN associates.
- Ongoing participation of enrolling organization: Enrolling organizations are encouraged to schedule staff trainings and to be as proactive as they can be with the patients that have been enrolled. HN is open to developing customized ways to share information and develop procedures that help organizations to promote continuity of care for their patients. ■



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Healthcare organizations face significant challenges when it comes to ensuring continuity of care for their mobile patients. Patient mobility also poses challenges to the Patient-Centered Medical Home model and to the monitoring of clinical outcomes and quality of care. Health Network, along with MCN’s other programs, ensures continuity of care, providing assistance with obtaining the data and outcomes necessary to report on clinical core measures and best practices in delivering test results and follow up for mobile patients. Health Network assures continuity of care and treatment completion for any condition requiring ongoing care by providing comprehensive case management, medical records transfer and follow-up services for mobile patients. Bilingual case managers based in MCN’s Austin office perform these functions on a daily basis, working with patients throughout the US and internationally.

For additional information and enrollment forms, go to <http://www.migrantclinician.org/services/network.html> or contact Health Network Program Manager Ricardo Garay at 512-579-4508 or [rgaray@migrantclinician.org](mailto:rgaray@migrantclinician.org)

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## Chronic Effects of Pesticide Exposure

*[Editor's Note: The following is excerpted from Chapter 21 of the new Sixth Edition of Recognition and Management of Pesticide Poisonings, Environmental Protection Agency, EPA 735K1300. Order information for the 6th addition is forthcoming. Copies of the 5th edition are available in English and Spanish at no cost from <http://www.epa.gov/oppfead1/safety/healthcare/handbook/handbook.htm>. The Sixth Edition of the Recognition and Management of Pesticide Poisonings is the first version to devote a chapter to current research on the chronic effects of pesticide exposure. This is an important addition to the conversation about pesticide exposure, particularly for people who work in occupations*

*at high risk for increased pesticide exposure. The information in this article provides an overview of the discussion, but we encourage everyone to obtain a copy of the full publication to become informed about the current research in both acute and chronic pesticide exposure.]*

The information in this chapter is designed to provide the practitioner with evidence for the better-established inferences for chronic effects of pesticides. This will offer some facility in the basic knowledge of chronic effects, allowing an approach to such effects, aiding the practitioner in answering questions from patients and the public, and providing a basis for further inquiry into

areas of interest. Knowledge of chronic effects of pesticide exposure is evolving rapidly and providers will need to be alert to new findings as they become available. The chapter is not intended to be a comprehensive review; such reviews are referenced when they are available.

In some cases, persistent effects may be those lingering after an acute poisoning, while in other situations, persistent symptoms or demonstrable physiological alteration may be associated with chronic, low-level or subacute pesticide exposure over time. Evidence linking pesticide exposure to

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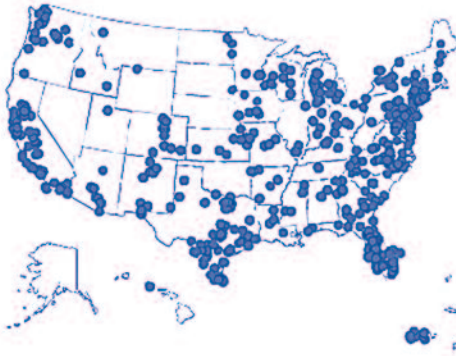




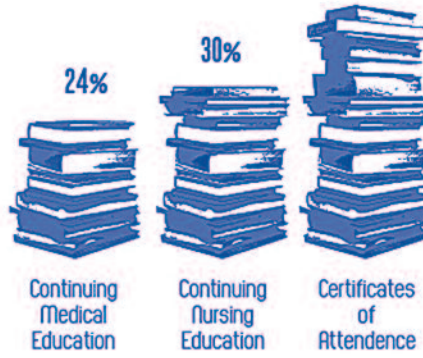
# TRAINING & TECHNICAL ASSISTANCE

**115** site visits (a 31% increase over 2017) **24,276** technical assistance encounters (a 25% increase over 2017)

## Domestic Training and Technical Assistance Locations



## Continuing Education/Training 46%



## ✓ Training Evaluations

**8.6** The webinar presented new areas of knowledge and/or new ideas/methods to implement  
**9.1** The scholarship and expertise of the presenter  
**8.9** Overall satisfaction with the training

AVERAGE SCORE (out of 10)

# CLINICIAN ENGAGEMENT

**10,000+** constituents

Health Educator Dentist Student Social Worker  
 Nutritionist **Nurse** Educator Nurse Assistant  
 Outreach/Promotor(a)  
 Optometrist Mental Health Executive Director Public Health  
 Nurse Midwife Researcher Nurse Practitioner Affiliate  
 Physician Assistant **Physician** Medical Assistant

# PROGRAMS

## CANCER PREVENTION & SURVIVORSHIP

**118,000** resources delivered

**19,666** individuals trained about cancer prevention, screening and survivorship information



**38** promotoras trained



## HOMBRES UNIDOS

**326** Latino migrant men engaged to prevent sexual/intimate partner violence using HU curriculum



Community survey to **2,243** individuals in Texas-Mexico border region. Surveyed on knowledge, attitudes, behaviors and beliefs around cancer.

## ENVIRONMENTAL AND OCCUPATIONAL HEALTH

**7,897** clinical resources distributed

Established **11th** MCN Center of Excellence

**97%** of those who received comic books

agreed the educational content regarding pesticides and minimizing pesticide exposure was relevant and easy for farmworkers to understand.



agreed the comics served as a useful tool to educate farmworkers and their families and to illustrate ways to minimize pesticide exposure.

**181,606** comic books distributed



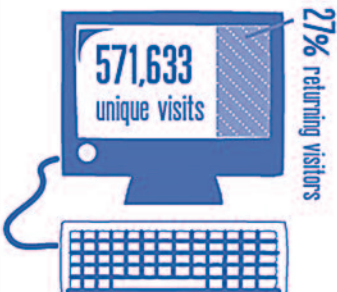
Peer Reviewed publication distributed 4 x per year to over **2,800** individuals

## Network News eNewsletter



**4,635** subscribers

[www.migrantclinician.org](http://www.migrantclinician.org)



## f facebook

**368** fans

**284** average weekly reach

**7,100** impressions (view of any content)



# HEALTH NETWORK

How do you ensure continuity of care to a patient who is never sure where or when the next move is going to happen?

Health Network ensures continuity of care and treatment completion by providing comprehensive case management, medical records transfer and follow up services for mobile patients.

**661** newly enrolled patients



**1,119** total active patients

= 20 patients new

Provided patient navigation to  
**63 countries**  
**45 U.S. states**



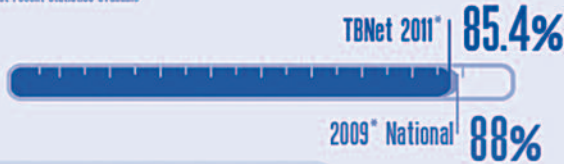
Health Network serves pregnant women who move during the course of their pregnancy.

**97%**

Of these women had a baby at the target birth weight

Tuberculosis treatment completion rate < 1 year

\*most recent statistics available



**62.5**  
encounters per day

Total contact minutes  
**122,760**

"There is no one else doing work like you! Integrity is the first word that comes to mind, and expertise...The way your organization weaves together providers, services, communication, with such integrity and respect for human dignity is extraordinary."

- Susan Auger, North Carolina

**22,786**  
encounters with clinics & patients

**43%**  
increase from 2011



**2,557**

records transferred

Patient Conditions in Health Network

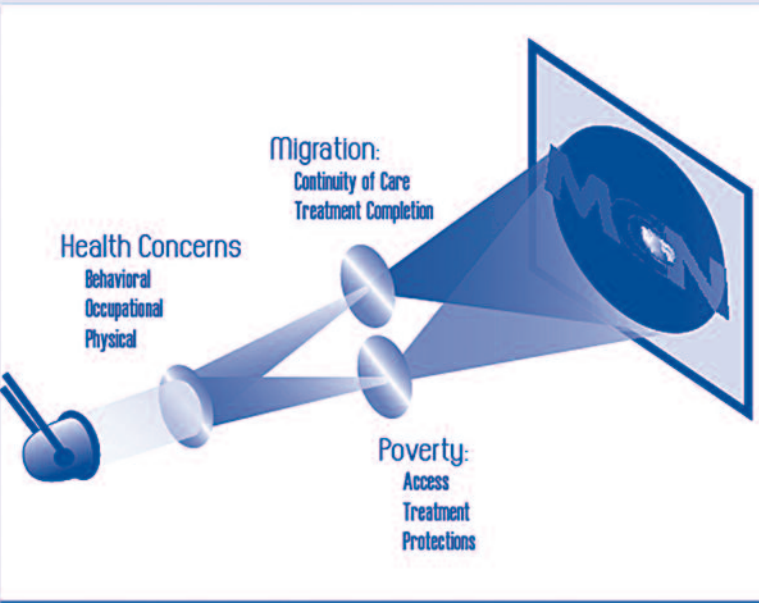
Cancer	10%
Diabetes	11%
General Health	14%
HIV	6%
Prenatal	8%
Tuberculosis	52%

"As an Outreach Worker and Case Manager, I love being able to refer clients into the program and know that after they leave us their care will continue and that when they return to us we will be able to know where they are in their care without having to go through red tape after red tape at numerous locations before we can know where to start"

- Kamis Ley, Haitian Creole Outreach Worker, Maine



## CONNECTING NEED TO ACTION



## RESOURCES DEVELOPED



"What is your role in recruiting consumer board members?" is an Implementation Plan for Increasing Consumer Board Members at FQHCs.



Health Center Recruitment and Retention Review Tool



Binational Pilot Project for the Monitoring and Control of Tuberculosis in the Border Region Chihuahua-New Mexico

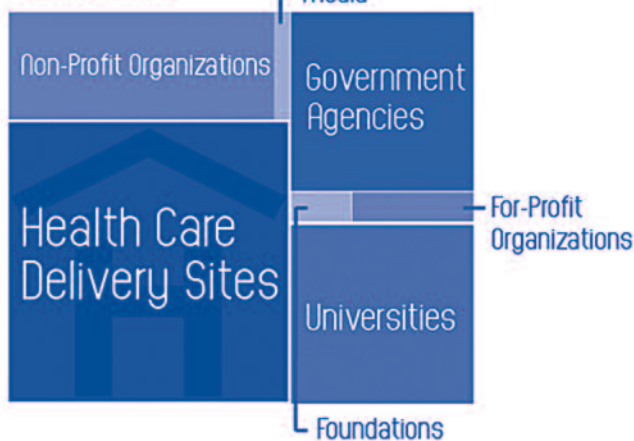


Cholinesterase Testing Protocols and Algorithm for Healthcare Providers

## COLLABORATION & PARTNERSHIPS

**6,000+** organizations in the United States and internationally that MCN works with

We work with:



**5**

articles in peer reviewed journals

"MCN is the guru at providing clinical training, research, and data resources to those that work with migrant & seasonal farmworkers."

– Rosa Navarro, North Carolina

"MCN is not just a simple not for profit with a mission. You demonstrate tireless leadership, thinking out of the box every day as well as insightful and judicious allocation of finances and resources towards your goals."

– Dennis Penzell, DO, Florida

"I tell patients that MCN is a group that looks after migrant populations and underserved and makes sure their health-care needs are met. I also tell them the mission is health-care justice and no one goes neglected."

– Venkat Prasad, MD, North Carolina

"Even though MCN has been around for a long time, they are continually evolving, successfully creating different programs to address new health needs. MCN is savvy to government, political and funding resource trends and developments."

– Larry Li, MD, California

"MCN is the foremost authority and one of the greatest educational resources on migrant health. Their Health Network provides valuable linkages for both farmworkers and providers to help ensure continuity of care as the mobile poor move about the nation."

– Selina Zygmunt, Outreach Coordinator, Pennsylvania



## ■ Chronic Effects of Pesticide Exposure continued from page 6

chronic health conditions relies on observational epidemiological studies and/or standard chronic toxicity testing using animal models. For obvious ethical reasons, experimental studies with purposeful dosing of pesticides are not conducted in humans. Therefore, while cause and effect is not proven with any one epidemiology study, several well designed studies in different populations, alone or combined with inferential evidence from animal exposures, can strongly support the likelihood that a given association is in fact causal in nature.

This chapter covers chronic health conditions that may have an association with pesticide exposure. Neurological effects, particularly neurodevelopmental abnormalities in children, have been implicated with exposure to insecticides that have toxicological activity on the central nervous system. Numerous studies have examined the effects of pesticides on the development of cancer in children and adults. Several classes of pesticides have properties that mimic endocrine hormones and may affect multiple organ systems and functions including reproductive health and cancer risk. Recently, data have emerged indicating a potential relationship between certain pesticides and asthma. Chronic, low-level arsenic exposure is associated with multiple chronic disease endpoints including skin disease, neuropathy and cancer.

### Differences between Children and Adults

When evaluating the effect of chronic, low-level exposures in humans, important differences in exposure sources and patterns between children and adults stemming from differences in physiology and behavior must be considered. From a developmental standpoint, children in the first few years of life spend a considerable amount of time on the floor, where residues following indoor application of pesticides (or outdoor application that may be tracked inside) accumulate.<sup>1,2,3</sup> Children have more frequent hand-to-mouth activity, which can be an added source of oral exposure.<sup>4,5,6</sup> Children ingest a larger amount of food and water per body weight than adults. For example, in the first year of life, infants may take in 100-150 cc/kg/day of liquids. For a 70-kg adult to ingest an equivalent amount of fluid, he/she would need to drink six 2-liter bottles of fluids a day. Dietary composition of children differs from adults. For example, U.S. children are much more likely to routinely ingest a variety of apple-based



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products on a daily basis, thus ingesting any pesticide residue from apples to a greater extent than adults.<sup>6</sup>

### NEUROLOGICAL AND NEURODEVELOPMENTAL EFFECTS

Many registered pesticides are specifically toxic to the central nervous systems of target pests including insects and mammals such as rodents. Neurotoxicity to animals has been a useful attribute for the development of pesticides for use as insecticides and

rodenticides. It is not surprising that these agents also have neurotoxic effects on large mammals including humans. However, many other pesticides, including herbicides, fumigants and fungicides, have human neurotoxicant properties. This section summarizes those effects that may persist following acute exposure, as well as describes subacute and chronic effects following long-term exposure.

**continued on page 12**

## ■ Chronic Effects of Pesticide Exposure *continued from page 11*

### **Chronic Effects Following Acute Exposure**

Acute pesticide intoxications may leave recovered individuals with residual neurologic impairment, particularly if they result in multi-organ failure or nervous system hypoxia. Several studies document that patients with a history of a single acute organophosphate or other pesticide poisoning are at risk of neuropsychiatric sequelae when examined as long as 10 years after the episode. These show significantly impaired performance on a battery of validated neuro-behavioral tests and, and in some cases, compound-specific peripheral neuropathy. The findings are subtle and, in some cases, identified only through formal neuropsychologic testing rather than as frank abnormalities on clinical neurologic exam.<sup>7,8,9</sup>

Certain organophosphates have caused damage to the afferent fibers of peripheral and central nerves. The mechanism of this type of toxicity is the inhibition of "neuropathy target esterase" (NTE). This delayed syndrome has been termed organophosphate-induced delayed neuropathy (OPIDN) and is manifested chiefly by weakness or paralysis and paresthesias of the extremities. In addition to acute poisoning episodes and OPIDN, an intermediate syndrome has been described. This syndrome occurs after resolution of the acute cholinergic crisis, generally 24-96 hours after the acute exposure, with signs and symptoms lasting from several days to several weeks.<sup>10</sup> It is characterized by acute respiratory paresis and muscular weakness, primarily in the facial, neck and proximal

limb muscles. In addition, it is often accompanied by cranial nerve palsies and depressed tendon reflexes. Both this syndrome and OPIDN lack muscarinic symptoms. The intermediate syndrome appears to result from a combined pre- and post-synaptic dysfunction of neuromuscular transmission.

### **Effects Following Low-Level, Chronic Exposure**

The effects of chronic, low-level exposures to pesticides on the nervous system are less well understood, but consistent evidence of neurodevelopmental toxicity arising from chronic, low-level exposure in gestational or early postnatal life is accumulating. One well established example of such effects is arsenic exposure. Neurologic symptoms are also common with chronic exposure. Peripheral neuropathy, manifested by paresthesia, pain, anesthesia, paresis and ataxia, may be a prominent feature. These effects may begin with the sensory symptoms in the lower extremities and progress to muscular weakness and eventual paralysis and muscle wasting.<sup>11,12,13</sup> Central nervous system effects may also occur, including mood changes such as depression, irritability, anxiety and difficulty concentrating. Additional symptoms include insomnia, headaches and neurobehavioral impairment.<sup>13</sup>

### **Low-Level Insecticide Exposure**

Research on insecticide toxicity to the developing brain and neurodevelopmental outcomes has been reviewed.<sup>14,15</sup> Most studies focus on exposure to organophosphates and organochlorines. Since these pesticides have historically been and/or currently are in wide usage for household or agricultural pest control, exposures to the child and pregnant mother have been common. Since these exposures have been common and widespread over many years, it is not surprising that they would be studied and that association of effects from these agents would be among the first documented in epidemiological research. Little or no research has been done on the neurodevelopmental effects of other common agents, such as pyrethroids commonly used in households and agriculture or exposures to herbicides and fungicides used extensively in agriculture. One published longitudinal cohort study assessed prenatal exposure to household permethrin and piperonylbutoxide by maternal air monitoring and examination of maternal and cord blood plasma. When





## ■ Chronic Effects of Pesticide Exposure continued from page 12

assessing neurodevelopment at 36 months, significant adverse impacts were observed for exposure to piperonylbutoxide (PBO), the most common synergist used in household pyrethroid products. No adverse associations were observed with exposure to the active ingredient permethrin. The authors note the more challenging task of measuring permethrin in biological and environmental samples compared to assessment of PBO and the need for confirmatory studies to clarify the roles of pyrethroids and PBO.<sup>16</sup>

The following sections review some of the data available for neurological and neurodevelopmental effects by age group of the studied population.

### CANCER

Epidemiological data support associations for both adult and childhood cancer,<sup>17,18,19,20</sup> with occupational exposure playing a role in cancer development for both adults and children. However, the most common types of cancer vary for children and adults, and as such, associations between pesticides and cancer are treated separately in this section. As noted at the beginning of this chapter, one common problem in evaluating cancer and pesticide relationships, particularly in children, is the relative rarity of cancer diagnoses.<sup>18,20</sup>

Several meta-analyses and systematic reviews have been published on the association between pesticide exposure and cancer. In most instances, these analyses and reviews serve as the primary source of information for the sections below on childhood and adult cancers.

#### **Associations between Childhood Cancer and Pesticides**

Relationships between childhood cancers and pesticides were summarized in two review articles, the first by Zahm and Ward in 1998, and an update published in 2007 by Infante-Rivard. The pediatric cancer types with the most compelling evidence for an association with pesticides are leukemia and brain tumors. Of note, in most of the studies reviewed, all forms of leukemia were considered in one group because of insufficient numbers of certain types of leukemia – e.g., acute lymphocytic leukemia (ALL) or acute myelocytic leukemia (AML). There were a few studies of sufficient size that were able to evaluate ALL separately. Brain tumors are also reported as a group rather than by individual tumor types as they are even rarer than childhood leukemia.<sup>18,20</sup>

#### **Associations between Pesticides and Cancer in Adults**

Bassil et al. conducted a systematic review of cancer and pesticides, which included studies of children and of adults. Each study was evaluated for methodological quality by two trained reviewers using a standardized assessment tool with a high inter-rater reliability. Only studies with a global rating of 4 or higher were included in the review.<sup>17</sup>

Many of the studies evaluating relationships between cancers in adults and pesticides are conducted in the occupational setting. Associations between pesticide exposure and the development of leukemia and non-Hodgkin lymphoma were noted in most studies. Solid tumors of the prostate, pancreas, kidney and breast were among the more consistently reported findings in studies of adults. As was noted in numerous studies of childhood outcomes, ascertainment of whether exposure actually occurred and the amount of exposure are recurring weaknesses in adult studies.

### ENVIRONMENTAL ENDOCRINE DISRUPTOR EFFECTS

Over the last 15 years there has been increasing interest in the ability of environmental chemicals to disrupt endocrine systems. Many pesticides, pesticide vehicles and contaminants have endocrine-disrupting properties based on in vitro and animal studies. While data on human effects remain somewhat fragmentary and inconclusive, the weight of evidence from multiple lines of investigation appears to support the concern for human effects. The cellular biology of endocrine disruption is very complex and has been extensively reviewed. While the details are beyond the scope of this manual, the reader is directed to one of several reviews for more specific information.<sup>21,22,23</sup> As a group, exogenous agents including pesticides that affect the endocrine system have been labeled endocrine disruptive chemicals (EDCs). Several basic mechanisms have been identified, including direct interaction with nuclear receptors (NR), disturbance of NR signaling and changes in hormone availability. In vitro evidence of the latter exists for several pesticides, by alteration of P450 enzyme activity that influences the availability of steroid hormones either by increasing or decreasing the rates of metabolism. For instance, methoxychlor has been shown to interfere with 5 $\alpha$ -deiodinase in the liver.<sup>24</sup>

#### **Human Outcomes Related to Pesticides**

**Precocious Puberty.** DDE has been linked to precocious puberty in one study of immigrant females in Belgium.<sup>25</sup> Though estrogenic pesticides have been proposed as a contributor to premature thelarche (the onset of secondary (postnatal) breast development), the evidence to date is not conclusive.

**Altered Lactation.** A negative correlation has been shown in several cohorts between DDE and duration of lactation.<sup>26</sup>

**Breast Cancer.** There is considerable interest in this outcome because of animal studies and the estrogenic activities of pesticides such as DDT, DDE, endosulfan and atrazine. Though atrazine is not a direct mimicker of estrogen, in some models it induces aromatase formation, which converts testosterone to estradiol.<sup>27</sup> This effect is not consistent in all cell lines or animal models. Despite the evidence that estrogen is a promoter of breast cancer, the role of these pesticides in breast cancer remains unclear at this time. A U.S. EPA review in 1998 concluded that the association between organochlorines and PCBs was not sufficient to conclude that they were likely causes of breast cancer.<sup>28</sup> A review by The Endocrine Society in 2009 concluded there was sufficient evidence that endocrine disruptors altered mammary gland morphogenesis in humans, making them more prone to neoplastic development.<sup>29</sup>

**Female Fertility.** There is limited evidence that female fertility may be decreased in women occupationally exposed to pesticides.<sup>30</sup> However, this evidence has not been linked to specific pesticide exposures.

**Semen Quality.** Decreased semen quality has been noted in individuals exposed to dioxins and PCBs, which are persistent organic compounds considered related to organochlorine pesticides.<sup>29</sup> Two agents, chlordecone and DBPC (dibromochloropropane), have been shown to affect male fertility by direct testicular toxicity at high levels of exposure.<sup>31,32</sup> However, there is not strong evidence for a relationship between organochlorine pesticides and semen quality. On the other hand, there is significant evidence from epidemiology that non-persistent pesticides may alter semen quality. This has been documented by the relationship between pesticide metabolites measured in men and their semen quality. Among the compounds implicated, some with stronger evidence than others, are alachlormercapturate, atrazine mercapturate

continued on page 14

## ■ Chronic Effects of Pesticide Exposure continued from page 13

and some metabolites of diazinon, chlorpyrifos and carbaryl.<sup>29,33,34,35,36,37,38,39,40,41</sup>

### Male Urogenital Tract Malformations.

There is limited evidence that exposure to chemicals, including DDT, is associated with increased rates of cryptorchidism and hypospadias. In some studies there appears to be a weak association between these entities and maternal serum concentrations of these chemicals. There is also epidemiological evidence suggesting a relationship between parental or community exposure to pesticides and these malformations without clear evidence for which pesticides are responsible.<sup>29</sup>

### Prostate Cancer and Prostatic Hyperplasia.

It is well accepted that endocrine status strongly affects the development of both prostate cancer and prostatic hyperplasia. Both androgens and estrogen have been shown to promote cancer and hyperplasia of the prostate. Likewise, antiandrogens and surgical castration can arrest or regress prostate cancer. It seems reasonable then that endocrine-active pesticides would play a role in recent increases in the rates of these

problems. Epidemiologic studies have shown increased rates of prostate cancer in farmworkers. A direct link has been shown between methyl bromide exposure and prostate cancer in farm workers.<sup>42,43</sup> In addition, though arsenical pesticides are in limited use today, arsenic has been associated with prostate cancer.<sup>43</sup> See the Cancer subsection of this chapter for additional information.

**Antiandrogens.** The active ingredients vinclozolin and DDT, along with DDE (the primary metabolite of DDT), are known to be antiandrogens. The effect of DDE and DDT on hypospadias and cryptorchidism is described above, but other antiandrogenic effects of these agents in humans are unclear at this time.

### Reproductive Neuroendocrine Systems.

There is a considerable amount of evidence in laboratory animals that pesticides may disrupt reproductive systems and affect sexual behavior. As noted above, vinclozolin has been shown to alter sexual behavior in rats. However, there are limited human data to support such effects in children or

adults.<sup>29</sup>

**Thyroid Function.** In the Agricultural Health Study, an association was shown between pesticide exposure and thyroid disease in female spouses of farm workers. Increased odds ratios ranging from 1.2-1.5 for hypothyroidism were seen with organochlorines including aldrin, DDT, heptachlor, lindane and chlordane, although only chlordane (OR = 1.3) was statistically significant. Benomyl (3.1) and paraquat (1.8) also had significantly elevated rates of hypothyroidism. Interestingly, maneb/mancozeb appeared to be related to both hypothyroidism and hyperthyroidism.<sup>44</sup> In a study of Inuit adults, negative associations were observed between some organochlorine pesticides and thyroid hormone levels.<sup>45</sup>

The science is rapidly advancing in this field, as most studies in human populations have been published relatively recently. Endocrine disruption continues to be the subject of intense research at a pace suggesting significant discovery in the coming decade.

## ASTHMA

The role of pesticides in the development of and/or exacerbation of asthma has been hypothesized and is under investigation. Pyrethrins have some potential as an allergic sensitizing agent, with reports of contact dermatitis, asthma and anaphylactic reactions occurring following exposure.<sup>46,47,48</sup> Organophosphates appear to have mechanisms that could impact the development or exacerbation of asthma. Toxicological studies demonstrated that subcutaneous injection of the organophosphates chlorpyrifos, diazinon and parathion caused airway hyper reactivity in guinea pigs via inhibition of M2 muscarinic receptors.<sup>49,50</sup> Additional studies suggest an organophosphate exposure may induce lipid peroxidation, which will result in oxidative stress.<sup>51,52</sup> Organophosphates may also play a role in the immunological sensitization of individuals to asthma. In a cohort of women farm workers and their infants, maternal agricultural work was associated with a 26% increase in proportion of T-helper 2 (TH-2) cells, the phenotype associated with atopic disease, in their 24-month-old infants' blood samples. The percentage of TH-2 cells was associated with both physician-diagnosed asthma and maternal report of wheezing in these infants.<sup>53</sup>



**continued on page 15**



■ **Chronic Effects of Pesticide Exposure** continued from page <None>

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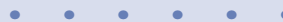
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