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AIRBORNE DUSTS

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OVERVIEW

Exposure to airborne dusts has long been known to cause illness. Ramazzini wrote that measurers and sifters of grain were at risk for respiratory problems and irritation of the eyes in his book *De morbis artificum*, published in 1713.[1]

Hypersensitivity pneumonitis (HP) in farmers was formally described in modern times by Campbell, in the year 1932. He recognized the relationship between exposure to spoiled hay and a febrile illness with cough and an interstitial pattern on chest X-ray.

HP is a disease about which much is known. A variety of etiologic agents and measures for treatment and prevention have been identified. However, a great deal still remains to be learned about this disease.

Organic dust toxic syndrome (ODTS), originally called pulmonary mycotoxicosis, is a disorder that was first recognized in the 1970's in dairy farmers after heavy exposure to moldy silage.[3] The disorder was called "silo unloaders' syndrome" when it was recognized that the symptoms likely were not caused by fungal poisoning.[4]

A similar illness, originally called grain fever, was seen after exposure to dust from stored grain.[5] ODTS shares many features with acute hypersensitivity pneumonitis but is without clearly identified long-term sequelae.

Most studies have shown that chronic bronchitis is more common among farmers than in the general population.[6-11] The majority of farmers with chronic bronchitis have a history of exposure to grain dust, which has been linked to this problem in grain workers,[12] or of work in animal confinement units. However, not all researchers agree that exposure to airborne dust places farmers at increased risk for chronic bronchitis.[13]

Exposure to grain dust causes cough, chest tightness, and dyspnea in some individuals.[14-17] The environment of swine confinement units causes cough, chest tightness and dyspnea acutely in many individuals who are without chronic symptoms.[18-25] It is unclear if there is a relationship between repeated exposures to airborne dust followed by symptoms suggesting acute airway inflammation and the subsequent development of chronic bronchitis.

It has long been known that individuals with asthma become more symptomatic after exposure to airborne dusts. Charles Thackrah, a British physician, described a relationship between asthma and inhalation of corn dust in a book published in 1832.[26] A variety of organic dusts have been associated with the onset of asthma symptoms.[27-34] Whether exposure to these dusts can actually cause asthma remains controversial.

Eye, throat, and nasal symptoms, termed mucous membrane irritation, are experienced after exposure to airborne dusts, including grain dust, as well as to the environment of dairy barns and swine confinement units. Mucous membrane irritation symptoms have been mentioned but not described in great detail.[35]

HYPERSENSITIVITY PNEUMONITIS

Hypersensitivity pneumonitis is the best characterized of the disorders described after airborne dust exposure in the agricultural setting.[36] Acute HP is an immunologic reaction to antigens present in organic dust. It has the following clinical features: fever, chills, muscle aches, a dry cough, and malaise experienced four to eight hours after exposure to a causative antigen.

Laboratory and X-ray findings include hypoxemia, leukocytosis, infiltrates on chest X-ray, and restriction and a low diffusing capacity for carbon monoxide (DLCO) on pulmonary function testing. The symptoms usually improve over 12-24 hours. Repeated exposures to the offending antigen may lead to further attacks. A small number of the individuals at risk for this disease actually develop HP. At this time, there is no predictor for susceptibility to this disorder.

Occasionally, HP presents as a subacute process, lasting for weeks. The course of this illness can be shortened using systemic corticosteroids. Rarely, HP leads to pulmonary fibrosis and respiratory failure.

At this time, it is not possible to identify those individuals with HP who are at risk for pulmonary fibrosis. There are no firm recommendations for surveillance programs, using pulmonary function testing or other means, for identifying those who are likely to have this outcome with continued exposure to the offending antigens.

The cause of HP is known to be repeated exposure to antigens from a variety of substances, including the microorganisms *Faeni rectivirulga* (previously known as *Micropolyspora faeni*), *Thermoactinomyces* and *Aspergillus spp.* and others that are found in spoiled hay and grain as well as in silage. Avian proteins, including those from chickens, and wheat weevils have also been implicated as causes for HP.

The dairy farm is an environment where HP is common. However, this problem is also seen in other agricultural settings, including farms where grain is stored in drying bins, in poultry houses, and in mushroom growing facilities. Estimates of prevalence of HP, or farmer's lung, on dairy farms range from 1/1,000 to 2 to 4/10,000.[37,38] Epidemiologic studies remain to be done to determine the prevalence of this problem in other farm settings.

Epidemiologic studies are complicated by a lack of definitive means of making a retrospective diagnosis. Many farmers do not seek medical care for episodes of HP, so that there is no supportive information available from medical records.

Serum allergic precipitins identify individuals who have been exposed to antigens that can cause HP, but do not point to the subjects who have the disease. Serum allergic precipitins may have become negative after a bout of HP experienced in the remote past. Open lung biopsy reveals characteristic findings in the presence of the disease, but should not be performed routinely for this problem.

Additional difficulties are posed by the similarity between the clinical picture of acute HP and that of ODTS.[37-39] In absence of a clear history of repeated episodes of illness and supportive laboratory and X-ray information, it is often impossible to determine which disorder is or was present.

Recently, a study was published that indicated that use of corticosteroids shortens the course of subacute HP.[40] However, there is no agreement on the dose and duration of treatment required.

There is some evidence that episodes of HP may be prevented by the use of dust masks or full-face respirators.[41] In spite of being aware of the potential benefit of wearing protective devices, farmers often fail to do so.

Reasons given include lack of comfort as well as excessive expense. There is a need for better designed devices to reduce exposure to airborne dust as well as formal testing of the efficacy of these products. In addition, it is possible, though still unproven, that improved ventilation in farm structures will decrease the risk for HP.

ORGANIC DUST TOXIC SYNDROME

ODTS is a febrile illness associated with myalgias, malaise, dry cough, chest tightness, and headache, which begin 4-12 hours after exposure of large amounts of organic dust.[3-5,38,42-53] Common causes of ODTS include uncapping of silos on dairy farms, cleaning of grain bins and moving moldy grain. Recently, it was also described as being common in swine confinement workers.[54] It is possible that it will be identified in other farm settings as well.

The exact incidence of ODTS is unknown, because of difficulties similar to those for HP in making a retrospective diagnosis results of previous studies conducted in Scandinavia indicate that the incidence of ODTS ranges from 10 to 190/10,000.[54] A more complete understanding of the epidemiology of ODTS, as well as other disorders caused by airborne dust, has been hampered by a lack of validated questionnaires tailored for use in the farm environment. A recently published questionnaire designed specifically for evaluating organic dust exposure likely will help solve this problem.[55]

ODTS may occur without prior sensitization, which is required for HP. Laboratory findings are notable for the presence of leukocytosis but an absence of hypoxemia, restriction, and a reduced DLCO on pulmonary function tests and infiltrates on chest X-ray. However, there is a need for more specific diagnostic tests indicating the presence of this disorder.

Farmers with ODTS have been studied with bronchoscopy and bronchoalveolar lavage, revealing neutrophilic airway inflammation.[46,52] A neutrophilic lower respiratory tract inflammation is also seen in acute HP.[56]

However, the mediators of inflammation present in the lung, or systemically, have not been identified. Organic dust toxic syndrome typically resolves in 24 hours, but may last 2-5 days. Therefore, it can cause significant morbidity and time lost from work. Corticosteroids have been used as treatment in several patients with ODTS, but little is known about their efficacy in this disorder.[57]

There have been no sequelae described for ODTS, unlike for HP. However, farmers

with bronchial hyperactivity often attribute the onset of their asthma to an organic ODTS-like episode occurring after an abnormally severe dust exposure. Others date the onset of their chronic bronchitis or an increased susceptibility to having respiratory symptoms back to an episode which may have been ODTS.

A small study published recently did not definitively establish a connection between airway disease and a history of ODTS.[58] More work needs to be done to determine if a relationship exists between ODTS and chronic pulmonary disease.

Farmers are often told to wear dust masks to prevent ODTS when heavy exposure to airborne organic dust is anticipated. However, there are no studies published that attempt to answer the question of whether or not ODTS can be prevented by wearing dust masks. Again, improved ventilation may reduce the amount of airborne dust present and, therefore, might decrease the risk for developing ODTS.[59-61]

The component(s) of airborne organic dust that causes ODTS remains controversial. There is strong evidence that endotoxin causes ODTS, as it is present in high levels in the environments where ODTS is common.[62-68] In the laboratory setting, endotoxin has been shown to cause fever and neutrophil influx into the lung.[66,69] However, there has been a study suggesting that the risk for ODTS did not correlate well with endotoxin levels.[70] Since ODTS is often reported after exposure to moldy organic material, mycotoxins must also be considered as potential causes of ODTS.[71]

Tannins are polyphenols present in various plant materials. Work done with tannins found in cotton bract has demonstrated their ability to cause neutrophilic lower respiratory tract inflammation, raising a question of their potential contribution of the inflammatory changes seen in ODTS.[72]

CHRONIC BRONCHITIS

Chronic bronchitis, defined as bringing up phlegm on most days for at least three months per year for at least two consecutive years, has been shown to be more common in farmers than in the general population.[6,7] In several studies, a two- or three-fold difference is demonstrated. The healthy worker effect may help lower the number of farmers with chronic bronchitis after airborne dust exposure as well as other pulmonary disorders, leading to an underestimation of the problem.

Extensive epidemiologic work done with subjects exposed to airborne grain dust has indicated that this likely is a factor in the causation of chronic bronchitis in farmers.[2-12,73] However, their airborne dust exposures are more heterogeneous than those of grainworkers, creating difficulties when attempts are made to determine the precise cause of the airway inflammation.

At this time, it is not possible to identify those individuals who are at risk for the development of chronic bronchitis caused by inhalation of airborne dust. The role of airway hyperactivity as a predictor of chronic bronchitis remains controversial. Other tests, such as measuring the group-specific component, may prove useful in the future.[74]

Many farmers have exposures to airborne dust in animal confinement units as well as from working with grain. Recent studies conducted in Iowa swine confinement workers indicate that up to 25 percent of these individuals suffer from chronic bronchitis.[75]

Gases present in confinement units, including ammonia and hydrogen sulfide, may contribute to the symptoms observed.[18, 19, 24] The airborne dust in swine confinement units is heterogenous, consisting of feed particles, animal dander, bacteria, and endotoxin.[76] Identifying a component of hog dust which is particularly noxious is difficult.

Poultry farmers also appear to have respiratory risks, similar in symptoms to those of the swine confinement workers.[77] Dust, endotoxin, and ammonia have also been implicated as a cause.

Pulmonary function tests performed on farmers with chronic bronchitis do not reveal the presence of severe obstruction in most individuals unless they are cigarette smokers. However, farmers in swine confinement units do have small decreases in FEV1 and FVC values over a workshift.

Confinement units are a relatively new innovation in farming, so no individuals have had a lifetime of exposure to airborne dust and fumes in this setting. It remains to be seen if significant airway obstruction develops in farmers who have been exposed to this environment for their entire working life.

Cigarette smoking is the most common cause of chronic bronchitis. It is likely, but not definitively proven, that exposure to grain dust or the swine confinement environment in addition to cigarette smoke works addictively to cause airway obstruction.[20, 24, 78] The mechanisms of this interaction are unknown.

Several forms of pharmacologic treatment have been approved for use in chronic bronchitis, including inhaled corticosteroids and ipratropium bromide. It has not been demonstrated whether or not these drugs are useful for the treatment of chronic bronchitis caused by organic dust.

The components of airborne dust that cause chronic bronchitis are largely unknown. It may be speculated that endotoxin, mycotoxins and tannin play a role. Plant lectins have been isolated from grain dust.[81] Lectins cause lymphocyte proliferation, which could contribute to elevated airway immunoglobulin levels seen in individuals acutely exposed to grain dust.[82]

Most of the work done in the laboratory looking at the effects of inflammatory dust has been done with grain dust extracts.[83] Repeated inhalation challenge of rabbits with grain dust extracts causes lower respiratory tract infiltration with macrophages.

Macrophages are known to release a variety of mediators of inflammation, which could play a role in the development of chronic bronchitis.[84] Neutrophils, present in increased numbers in the airway of many individuals with chronic bronchitis, could function in a similar way.[84]

ACUTE BRONCHITIS

The acute pulmonary effects seen after airborne dust exposure include dyspnea, chest tightness, and a cough, which may or may not be productive of sputum. In the non-atopic subject, these symptoms are consistent with acute bronchitis. This has been described in grain farmers as well as in swine confinement workers.

A preliminary study done in grain farmers during harvest using bronchoscopy with

BAL revealed evidence of airway inflammation without changes in spirometry.[85] One study has described signs of lower respiratory tract inflammation in swine confinement workers by also using bronchoscopy with bronchoalveolar lavage.[86]

Farmers symptomatic after other types of occupational airborne dust exposure have not been studied in this way. It might be useful to better characterize any changes in the lower respiratory tract in order to find therapy specific for these problems. Therapies that could be used prophylactically would be optimal.

The components of airborne dust that cause acute pulmonary effects have not been identified. Endotoxin is again suspected to play an important role. However, it has been shown that giving an inhalation challenge of grain dust extract to guinea pigs causes greater acute neutrophilic lower respiratory tract inflammation than a challenge with endotoxin alone, given in an amount equivalent to that present in the grain dust extract (unpublished data).

When added to cultures of bronchial epithelial cells, grain dust extracts also cause cell death and the release of neutrophil chemotactic factors.[87] Whether or not these observations help explain the presence of acute pulmonary symptoms after airborne dust exposure in the farm setting remains unknown.

ASTHMA

Exacerbation of asthma by airborne dust is a well-described phenomenon, both as a response to specific allergens and as a nonspecific reaction.[34, 88, 89] A host of substances present in the farm setting contain antigens that trigger asthma. These include animal dander, pollen, storage mites, and grain. There is no consensus, however, regarding the ability of these substances to cause asthma in the farm setting in a subject who has no have previous exposure to them.

A host of substances present in the farm setting contain antigens that trigger asthma.

Ethical considerations complicate studies designed to answer the question raised above. Specific antigen challenges, using extracts made from airborne dusts, can be given in the laboratory in order to help determine the cause of asthma in farmers suspected of having occupational causes for their bronchospasm.

There is some evidence that farmers have increased bronchial reactivity presumably related to airborne dust exposures.[25,90] More work remains to be done relating bronchial reactivity to acute and chronic respiratory symptoms in farmers.

MUCOUS MEMBRANE INFLAMMATION

Symptoms of eye and nasal irritation as well as dry throat are common after exposure to airborne dust. This is a common reaction to airborne dust in subjects with allergic rhinitis. However, symptoms of mucous membrane irritation are also seen in individuals without a history of atopy.

With some grain dusts, the offending agent appears to be a part of the plant, which causes mechanical irritation. However, endotoxin and mycotoxins must also be

considered as possible causes for this problem.

> The presence of inflammation is a common theme in these disorders.

It has not been demonstrated that wearing respirators commonly in use in the farm settings reduces incidences of these complaints. Also, no pharmacologic therapy has been found for these symptoms. Attempts should be made to find agents that prevent as well as treat the symptoms.

Little work has been done in the laboratory to further define the problems described. It has been shown that aerosol challenge of human volunteers with grain sorghum dust extract causes an influx of neutrophils into the nose, as demonstrated with nasal lavage.[91]

SUMMARY

A variety of disorders are associated with exposure to airborne dust in the farm setting. These include hypersensitivity pneumonitis, organic dust toxic syndrome, chronic bronchitis, acute pulmonary symptoms, asthma, and mucous membrane irritation. Better ways of preventing these problems must be found, through the use of protective devices and agricultural engineering innovations, as well as perhaps by pharmacologic means.

The presence of inflammation is a common theme in these disorders. Researchers are faced with a variety of challenges in better defining the inflammatory changes. In particular, the causative components in the airborne dust and the mediators of inflammation must be better described so that specific therapies can be identified.□

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INFECTIOUS DISEASES

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INTRODUCTION

The infectious diseases associated with farming and agricultural practices are broad in terms of diversity and—owing to general health improvements and significance of reductions of livestock zoonotic diseases—minimal in terms of morbidity. Nevertheless, there are continuing infectious disease problems, mostly sporadic in nature and occasionally episodic, that affect agricultural workers and occasionally, via the food chain, their urban counterparts.

Many excellent disease-specific reviews are available to interested parties for further study.[1,2] This review, while not comprehensive in nature, is offered to define the scope of current problems as reported and investigated by public health workers and health care givers. Much of this information was obtained through a recent survey of state epidemiologists and related staff.[3]

The review will be divided into four major groups of infectious conditions by nature of source or form of transmission: interpersonal illness, food-borne illness, environmental and vector-borne disease, and zoonoses (not covered in the aforementioned groups). Comment on improved management of these conditions and exposures will be provided, as well as recommendations for improved prevention and control, including research needs to address these problems more effectively.

INTERPERSONAL ILLNESS

This category focuses almost exclusively on migrant farm workers (MFWs) and will be confined primarily to human-host illness. Tuberculosis and sexually transmitted diseases (STDs) are both problems in migrant worker populations.

California reports a recent outbreak of chancroid in a migrant camp in Orange County.[4] STD problems were the fourth most prevalent problem at two migrant health clinics in Maryland.[5]

Tuberculosis (TB) remains a serious public as well as personal health problem in MFWs. Ciesielski and colleagues[6] reported on a large random-sample population-based 1988 study of farm workers (n=543) in three North Carolina counties and demonstrated that skin-test positivity ranged from 33 percent in Hispanics to 54 percent in US-born blacks and 76 percent in Haitians. Active tuberculosis disease occurred in 3.6 percent of US-born blacks (300 times the average U.S. rate) and 0.47 percent of Hispanics.

This investigation indicates that TB among MFWs is an occupational problem, not an imported one. Among black American migrant farm workers, risk factors associated with farm work and years of such work were far more important than age, gender, and history of familial TB. These investigators offer strategies to control tuberculosis among MFWs, including:

1. Adhere to recommendations of the Strategic Plan for Elimination of Tuberculosis in the U.S. and TB Among Foreign-born Persons Entering the United States.[7,8]
2. In states with large migrant populations, establish a separate registry, e.g. Florida's special registry.
3. Increase funding for migrant health-care centers.
4. To avoid false negatives, consider use of recall antigens when administering skin tests among high-risk groups.
5. Regulate labor contracts more closely.
6. Occupational Safety and Health Administration (OSHA) should promulgate regulations addressing TB control.

During August 1990, the Wisconsin Department of Health investigated an outbreak of gastrointestinal illness affecting an undisclosed number among approximately 1,000 MFWs and their families residing in 40 camps in 3 counties.[9] Some infections were due to *Giardia* and appeared to spread through migrant day care centers (DCC).

Initial infection is postulated to originate from exposure to contaminated water from a sewer back-up into the shower of the residence of the index case. Known symptomatic cases totaled 21. Other cases of illness in this population were due to *Shigella flexneri* 1 and 2 and, owing to limitations of obtaining accurate history and limited microbiological studies of food and water, the exact chain of infection could not be established.

Enterically transmitted viral and bacterial diseases among MFWs do occur at about 10 times the rate of the general population. This can be attributed to a variety of factors, but primarily to poor water and toilet hygiene.

Outbreaks subsequently can affect consumers of the produce. In August 1990, an outbreak of *Salmonella javiana* in Minnesota was associated with the consumption of contaminated raw tomatoes from a South Carolina distributor.

Mary Proctor, an epidemiologist with the Wisconsin Division of Health, has reviewed the literature and cites reports implicating hepatitis A with frozen raspberries and fresh lettuce.[11] *Shigella* infections have also been implicated in commercially distributed lettuce which were thought to be contaminated at the harvest site.

In 1979, Iowa and several other states with Amish settlements sustained polio transmission in these agri-populations; no transmission to surrounding communities was reported.[12] More recently, rubella has been reported in Amish settlements in Tennessee.[13]

In addition to the diseases mentioned, a variety of personal health problems in MFWs and their families are also reported; these problems are influenced by substandard living and working conditions, and include parasitic infections, urinary tract infections, gynecological problems, respiratory infections, and pediatric infections.[14,15] Migrant and farm workers also have a higher percentage of children not immunized against vaccine-preventable diseases.[16]

FOOD-BORNE ILLNESS

Improvements in food processing and packaging, coupled with livestock disease control programs, have reduced many zoonotic diseases formerly affecting consumers.[17] Examples include tuberculosis, brucellosis, and trichinosis. Since a great deal of this reduction has been effected through improved processing and pasteurization, many pathogens continue to infect farm workers who consume produce without adequate safeguards or preparation.

Unpasteurized milk is a vehicle that still infects large numbers of farmers and their guests. Potter and Currier have summarized the hazards of raw milk, but episodes continue to occur.[18,19]

A report by Blazer describes an outbreak of *Campylobacter* infection in a fraternity group which visited a member's farm family.[20] In this outbreak, 22 of 25 students (88 percent) who consumed raw milk for the first time became infected; two who had not consumed raw milk were not infected.

Residents of the farm were not affected by virtue of long-term raw milk consumption, and had elevated levels of *Campylobacter*. Jejuni-specific serum antibodies provided apparent immunity to symptomatic infection. Numerous episodes and case reports exist in the literature of *Campylobacter* outbreaks in children and visitors touring farms and dairies where unpasteurized milk consumption resulted in infection.

Salmonella infections have also been associated with numerous episodes where raw or inadequately pasteurized milk was consumed. It is reasonable to assume that families and workers on dairy farms experience related illness, although less frequently from raw milk.

In 1987, Vogt reported a case of listeriosis in a 76-year-old female who lived on a dairy farm. Blood culture isolated *L. monocytogenes*.[21] Isolates subsequently obtained from two cows and the bulk tank were identical to the patient's, as characterized by isoenzyme typing and ribosomal RNA typing.

The patient regularly consumed raw milk from her farm on her cereal each morning but consumed no other food products from her farm. In addition, North Dakota health officials are currently investigating a case of *E. coli* 0157:H7 transmitted through raw milk to a farm patient.[22]

In the past 5 years, eggs have been implicated in numerous cases and episodes of gastroenteritis due to *Salmonella enteritidis*.[23] The role eggs play and the extent to which they cause salmonellosis in farm workers are unclear.

Brief reports and unpublished investigations have implicated ungraded farm eggs in "home-made ice cream" in transmitting salmonellosis.[24] These incidents may attest to the lack of understanding farm workers and families have concerning basic food hygiene, and may contribute directly or indirectly to the larger problem.

Trichinosis continues to decline in the United States, but in any given year the rate of cases may double or triple as influenced by one or two community episodes. A large outbreak affecting 15 of 25 individuals from four related farm families in Nebraska was investigated in 1973.[25] Source of infection was uncooked pork-beef sausage from two pigs and one

beef animal; these animals were raised in open lots or pastures on the farms and were slaughtered on the premises.

Again, there was an apparent lack of concern for trichinosis owing to tradition. During 1990, 90 cases of trichinosis in central Iowa were traced to raw pork consumption from a locally procured carcass attesting to the disease's continued presence in swine.[26] In many states, expanded garbage feeding practices, although well regulated, may serve to enhance transmission to pigs.

Overall, food-transmitted illness to farmers is isolated, sporadic and perhaps not always recognized. It points to the need for educating these producers about risks, food sanitation, and desirability of consuming adequately processed, pasteurized, or cooked food. It is conceivable that elderly persons on farms, very young children, and farmers with coexistent health problems would be at increased risk of infection or its complications.

ENVIRONMENTAL AND VECTOR-BORNE ILLNESS

Farmers and farm workers pursue their activities in a diverse environment of landscapes, buildings and livestock collections. Vector-borne disease does present occasional risks to farm workers in outdoor settings.

Sylvatic plague, Rocky Mountain Spotted fever, Colorado tick fever, and tularemia (tick and deer fly transmitted) are infrequently transmitted to farm and ranch workers during ordinary work activities. Oregon and Utah report recent isolated cases of arthropod-borne tularemia in farm and ranch workers.[27,28]

More recently, Lyme disease is being recognized in some farm workers in upper Midwest states. Concern exists not only for exposure to deer ticks in field settings, but also exposure to infected cattle.

In a Wisconsin study (to be published later), of 246 dairy workers tested using CDC ELISA, 21 (8.5 percent) had significant *B. burgdorferi* antibody levels, while 6 (4.9 percent) of the 123 crop farmers were seropositive ($p < 0.2$).[9] Concern exists for the role of spirochetes in cattle urine splash as a means of Lyme transmission. Additional studies are planned.

In another Wisconsin seroprevalence survey conducted in 1987 at the Marshfield Clinic on asymptomatic residents of north central Wisconsin, the seropositivity rate for farmers was 32 percent versus 16 percent in non-farmers.[29] Obviously, farm workers are at increased risk from Lyme disease where vectors and conditions favor its presence, and it should to be included in differential diagnoses.

Malaria is of greater concern, especially since this disease had been eliminated from the United States in the 1940's. California reports increased activity relating to MFWs. A summary of the California experience from its state morbidity report is provided verbatim:

Since 1950, California has experienced 16 episodes of introduced autochthonous malaria (malaria acquired by mosquito transmission in an area where malaria does not occur regularly) accounting for 120 cases, all due to *P. vivax*. Ten counties have been the sites of exposure with 7 in the Sacramento Valley and adjacent Sierra Foothills (Butte, El Dorado, Glenn, Nevada, Sacramento, Sutter, and Yolo), 2 in the San Joaquin Valley (Fresno and

Kings) and San Diego County along the state's southernmost coast. Only 2 counties have experienced more than 1 episode, Sutter (4 episodes), and San Diego (4 episodes).

The confirmed or presumptive sources of introduction were an army veteran just returned from Korea and agricultural workers from India (4 episodes) or Mexico (8 episodes). In 3 introductions, the source cases were uncertain but most likely from India or Mexico. Transmission of malaria occurred from May to September, with 3 anopheline species being the likely vectors (*An. freeborni* and *An. punctipennis* in the central valley and *An. hermsi* in San Diego County).

The largest of these outbreaks was in 1952 when 35 cases occurred in a group of Campfire Girls exposed in Nevada County. The second and third largest episodes were in 1986 and 1988 involving 27 and 30 cases, respectively, in San Diego County. The remaining 13 introductions resulted in 1 to 5 cases each.

Since 1986 there have been several important changes in the epidemiology of introduced malaria in California. The incidence of introductions has risen sharply; 9 (56 percent) of the 16 introduced episodes since 1950 have occurred in the last 4 years. Before 1986 all episodes (7) had occurred in Sacramento County northward and in 5 (71 percent), the source(s) of introduction were associated with immigrants recently arrived from northern India.

Since 1986, activity has shifted with 6 of the 9 (67 percent) introductions occurring south of Sacramento County and 8 of 9 (89 percent) being associated with MFWs from Mexico. Until 1986 all outbreaks of mosquito-transmitted malaria had involved only permanent California residents. Since 1986, the great majority of cases (59/71) have occurred in migrant workers though local residents have also been involved in all outbreaks.

Paralleling these trends in the epidemiology of introduced malaria in California has been a sharp rise in the incidence of malaria in Mexico and the number of imported malaria cases in persons entering the State from that country. Malaria cases reported in Mexico have risen steadily from 25,774 in 1980 to 166,271 in 1988 (>6 fold increase) while the number of California malaria cases reported in travelers and immigrants from Mexico has risen steadily from 12 in 1980 to 83 and 81, respectively, in 1988 and 1989 (>6 fold increase).

The episodes of local mosquito transmitted vivax malaria since 1986 (particularly in San Diego County) have features in common which include:

1. Remotely located encampments.

2. Inadequate shelters for MWs residing in areas with Anopheles mosquito vectors capable of transmitting malaria.

3. The reluctance of MWs to seek medical care because of limited access and concerns about being identified as undocumented aliens.

Once a parasitemic individual introduces malaria in such settings, these factors allow substantial transmission of malaria to evolve before outbreak foci can be identified and control measures instituted.

Mosquito transmitted viral encephalitis also presents risks to farm workers and

rural residents. St. Louis encephalitis (SLE) and western equine encephalitis (WEE) are transmitted by vector mosquitoes that breed in field irrigation runoff pools. During 1989, California reported 29 confirmed cases of SLE but no cases of WEE.[31] While specific occupation was not recorded, cases tended to be older, live closer to fields, and were more likely to be outdoors in the evenings (when mosquitoes are active) prior to illness when compared to cases of viral CNS disease who were seronegative for SLE.

Other environmental exposures focus on fungal diseases. Histoplasmosis is frequently diagnosed in farm personnel cleaning up litter and debris from poultry houses, sheds, and barns.

A recent outbreak occurred in Iowa during a family reunion, when attendees retreated to a seldom-used barn to seek refuge from a thunderstorm. Old debris and the presence of droppings from birds gaining access through broken windows provided a milieu for the fungus to flourish, and when disrupted by guests, resulted in 10 cases of histoplasmosis among 25 guests exposed to the barn.[32]

Coccidioidomycosis, or valley fever, is endemic in arid rural areas of western states, particularly California. The ratio of infections that cause clinical disease is very small; children and adolescents display milder illness than adults, and African-Americans, Latinos, and Filipinos tend to have more serious disease when it occurs.

New residents in endemic areas are more apt to become ill than permanent residents. Roberto reports that immigrants, especially Philippine natives from cocci-free areas of the world who are employed in farming in the Central Valley of California, may develop severe illness and chronic complications.[4]

Injury incidental to farming activities often results in cellulitis and at least suggests the need for tetanus-toxoid immunization among adult farm workers—a group that may not be current on vaccine history. Kansas reports three recent adult cases of tetanus in rural/farm individuals.[33]

In Iowa, the special class of farm injury relating to inadvertent syringe needle sticks incidental to livestock health programs was studied in 1990.[34] A total of 28 exposures were recorded; 10 involved sticks to legs or feet and 18 sustained injury to hand, wrist, or arm. One involved anaphylactic reaction to blood drawn from a vein. Hospitalization was required for another case of cellulitis of the leg from a syringe stick.

While most of these exposures resulted in cellulitis, it is also worth noting that animal vaccines often contain very irritating adjuvants that enhance tissue injury. There is a definite need for a compendium of patient-management guidelines for individuals with syringe stick exposures to veterinary injectables.

In summary of this segment, environmental contaminants do play a role in infectious disease of farm workers. Frequently infections secondary to injury from a variety of sources are the mechanism of transmission.

Arthropods also serve to expose farm-ranch workers to disease agents, but are geographically localized and generally sporadic-to-rare in incidence. Systemic fungal diseases also occur, are often episodic, and primarily affect new residents or nonresident workers in agriculture settings.

NON-VECTOR-BORNE ZOONOSES

This is a broad, diverse group of disease-causing organisms. Tuberculosis due to *M. bovis* is functionally eliminated from domestic livestock, and does not present a threat to farm workers or related personnel.

Nevertheless it should be noted that certain wild or exotic species (e.g., bison, feral swine, and non-human primates) may still be infected and potentially serve as reservoirs for reinfecting cattle.[35] This reality speaks to the need for ongoing surveillance programs to monitor potential introductions.

Also of concern is the increased commerce in wild exotic animals that may be infected. During the past 3 years an eastern Iowa family unsuccessfully managed and finally depopulated their llama herd due to *M. bovis* infection.

Brucellosis has been greatly reduced these past 40 years through livestock control programs.[36] Total U.S. cases for 1989 were 95.[17]

Earlier employment of the milk ring test that monitors producing dairy herds has eliminated "undulant fever" in mostly farm-family consumers of raw milk; pasteurization assured safe milk for consumers even before herd eradication schemes were successful. During the 1970's and early 1980's, swine brucellosis was eradicated and cattle brucellosis eliminated in all but a few southern states.

Wild animal foci of brucellosis also exist, e.g., among bison, elk (Yellowstone National Park), and feral swine.[37] It appears that most recent brucellosis cases remain confined to packing-house workers and international travelers exposed to contaminated foods. Farm workers are rarely still infected from handling aborted feti and placental membranes from infected cows.

Standard febrile agglutinin tests are available to diagnosticians who are evaluating farm workers with fevers of unknown origin. Serology and often blood culture are of critical importance to early diagnosis and, thus, effective treatment of this disease.

Exacerbation of earlier infections still occurs, often decades later, especially in older farmers infected with *B. suis*. Other infections may result from *B. abortus*, Strain 19 vaccine from inadvertent syringe sticks, and splash in the eye.

These events still occur and call for prophylactic treatment with tetracycline or one of its analogues and streptomycin.[36] The exact number of human brucellosis cases by occupational category is not conveniently available.

Leptospirosis cases for 1989 totaled 93, reflecting sporadic incidence except for Hawaii, which contributed 69 cases to the total.[17] Over the past five years (1986-1990), there have been 192 cases of leptospirosis reported in Hawaii, including five fatalities.

For this period, 18.75 percent of the cases were in agricultural occupations, while 20.8 percent of the cases had agricultural exposure and 9.9 percent had agriculture-related exposures (gardening, yard work).[38] Again, as in brucellosis, serology is critical to establishing the diagnosis and optimal treatment.

Tularemia, as noted earlier, when transmitted by arthropods can result in transmission to farmers. Rare and isolated cases of pneumonic tularemia from grain dust aerosols presumably contaminated with rodent excreta have been recently recorded from Iowa and Oregon.[39] Here, too, appropriate cultures and especially serology are critical to diagnosis and effective treatment.

Chlamydial bacterial infections (psittacosis) are occasionally recognized in farm workers incidental to exposure to pigeons and domestic fowl, especially turkeys. Interestingly, turkey psittacosis may result in explosive outbreaks in poultry-plant workers after stress of transport and slaughtering processes creates infectious aerosols. Rarely is illness recognized in personnel at the turkey grower-sites of infected flocks.

Q fever, anthrax, erysipelas, and other bacterial zoonoses are very infrequently diagnosed in farm workers nationally. Sporadic cases of Q fever have been reported from Arizona in personnel handling aborted feti and bagging sheep manure for commercial sale as fertilizer.[41]

Parasitic zoonoses are an eclectic group of minor problems. *Giardia* infections have resulted from servicing irrigation systems in Utah.[28] Echinococcosis, introduced to western sheep-raising states by immigrant shepherds, has been eliminated.

Beef cattle infected with cycticerci from *Taenia saginata* continue to be recognized by federal meat inspection service. The occasional recognition of "measly beef" at slaughter speaks to the need of adequate toilet facilities for MFWs in feedlots and cattle production operations.

There are no known cases of recent transmission of these tape helminths to farm personnel (or consumers). Anecdotal cases of cryptosporidiosis have occurred in farm personnel and are of minor significance to immunocompetent individuals.[42]

Viral zoonoses, especially rabies, continue to result in exposures to farm workers. Cattle pose special risks, are highly susceptible to rabies, and are rarely immunized for the disease. When cattle are unwittingly cared for during clinical rabies, extensive exposure to saliva may occur and prompt need for immunoprophylaxis. This is especially true for registered breeding-cattle that often are valued at multiples of market price.

During January 1991 in Iowa, a registered beef bull with rabies and a dairy cow with the disease used in an ovum transplant program resulted in 26 farm workers' and veterinarians' being administered vaccine boosters or full immunoprophylaxis.[43] During the period 1985-1989, laboratory diagnoses of cattle rabies in the U.S. ranged from 150-200 cases.[44]

An earlier Illinois study estimates a ratio of one farm worker's being prophylaxed for each case of cattle rabies.[45] The last recognized case of rabies in a farm worker from cattle exposure occurred in California in 1939.[46]

The real significance of cattle rabies is the uncertainty and anxiety of exposure that prompt farm workers to receive costly—and probably unnecessary—immunoprophylaxis. In Iowa, cats—especially rural and farm cats-are serious vectors of human exposure since these animals frequently exhibit furious behavior and are prone to bite. Farm family members are the single

largest occupational group exposed to this species.[47]

Other viral zoonoses exist that occasionally infect farmers, including orf and swine influenza. Specific surveillance information is unavailable and precludes meaningful comment. Other retroviruses and lentiviruses infect a broad range of animals maintained on farms, e.g. bovine leukemia, feline leukemia, etc. Their role in any human illness is conjectural at this time and remains to be demonstrated if it exists.

COMMENT

Infectious diseases unique or incidental to agricultural activity can be conveniently divided into migrant-worker-related illness and a variety of zoonoses. In the former category, many of these MFW illnesses—often episodic—are human host infections that may relate to country of origin (e.g., malaria and echinococcosis) or to substandard living or working conditions (e.g., tuberculosis and *Shigella* dysentery).

All these illnesses pose risks to the non-agricultural community through personal contact and potential contamination of foods or environments. For these reasons, as well as for humanitarian considerations, migrant farm workers need resources of improved medical care, education, and adequate living and working accommodations to reduce their burden of morbidity and suffering.

The second category mentioned above is infectious disease incidental to farm environmental exposures, primarily zoonoses. Since their occurrence is often sporadic and generally infrequent, problems of recognition and optimal management are obvious. Clearly they are underdiagnosed and underreported. Primary care givers should improve diagnostic acumen through more active consultation with infectious disease specialists and increased use of microbiologic studies, especially serology.

RECOMMENDATIONS

1. Migrant worker health concerns are paramount, as noted in this review. Clearly OSHA should exercise more authority in this sector of agricultural activity to assure adequate living and working standards for migrant and non-migrant or permanent employees.

2. Migrant worker health clinics are now networked, which facilitates follow-up of diagnostic and treatment services, particularly tuberculosis. States with large migrant populations should maintain a separate TB registry such as Florida's. All states should adhere, as much as practical, to CDC published guidelines for TB control in general and foreign-born cases in particular.

3. USDA should improve regulation of food production and harvesting to assure field sanitation measures are adequate to assure wholesome product. Indirectly, this would increase incentives for producers to provide improved working conditions for both domestic employees and MFWs.

4. Where not already accomplished, state and local health agencies should establish regulatory standards and inspection services addressing minimal living and healthcare accommodations for MFWs, including day care centers.

5. State-federal minority health programs should also include components targeted to MFWs.

6. Conference of State and Territorial Epidemiologists and CDC should require "occupation" on all investigative surveillance reports. Summaries should include categories of farm workers, farm service personnel and MFWs.

7. Enhanced recognition of agriculturally related infections through increased utilization of serology is needed. This educational role can be best instituted by state health agencies and laboratories.

8. Since many agricultural disease problems are localized or exist in specific regions (e.g., leptospirosis in Hawaii), federal research grants to study these problems should be targeted to state-level health agencies. This is currently being done by CDC for Lyme disease. Examples of possible research projects include[42]

a. What is the potential for transmission of enteric pathogens such as *Salmonella, Yersinia, and Campylobacter* between animals and animal caretakers?

b. What is the role of urine shedding, if any, in Lyme disease transmission between cattle and humans?

c. What is the character of viral shedding of rabies in cattle and horses (to facilitate meaningful quarantine or observation periods)?

d. What is the role of stray and rural farm cats in terms of health risks, e.g., rabies, toxoplasmosis, and visceral larva migrans?

9. Federal agencies which license injectable veterinary biologics (USDA) and drugs (FDA) should require manufacturers to distribute specific management guidance to all poison control centers concerning accidental exposures.

10. In at least one state, there has been an increasing trend of using treated sewage effluent for irrigation of crops.[43] Outbreaks of gastrointestinal illness have occurred in Israel from this practice. Specific surveillance studies of enteric illness in personnel exposed through employment or food consumption of produce from this practice would be indicated.

11. Indirectly, infectious disease in farm workers and family members may be adversely influenced by several psychological and economic factors. Many individuals who live on farms are less able to afford health care due to lack of health insurance. Most are self-employed without sick leave and workers' compensation, as noted. Also, the availability of health care may be limited or difficult to access. Sociological and epidemiology studies are needed to put these issues and concerns in perspective to reduce morbidity and its attendant cost.[45]

12. State-federal regulation of commerce in exotic and wild animals should be increased to assess presence of infectious diseases or vectors among livestock that may adversely affect domestic livestock and their handlers, ultimately including the consumer. Economic studies are needed to determine feasibility of indemnity payments for depopulation programs.

13. Enhanced research on farming practices that increase the risk of food-microbial contamination and/or may enhance risk of human exposure to infectious diseases should be implemented. Positive developments should be published for the agricultural community.

SUMMARY

Infectious disease remains a serious problem in U.S. agriculture in two distinct populations:

• Migrant farm workers experiencing human-host illnesses, often episodic and exacerbated by substandard living and employment conditions.

• All other farm workers experiencing sporadic, isolated illness that is most frequently zoonotic, vector-borne, or environmentally acquired in nature.

Both populations may present risk of exposure to the non-farm population through personal contact, indirect exposure (environment or vector), or contamination of food produce. Obvious innovations and technologies exist to improve disease recognition, management, and control for both groups specifically, and non-farm individuals generally. The broad and varied scope of this problem is presented, including areas that should be targeted for additional research or enhanced program support.□

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