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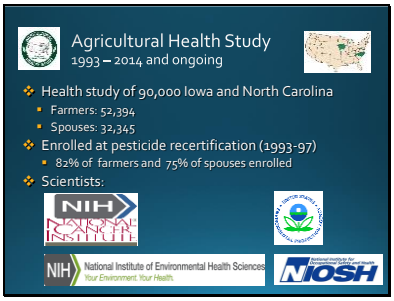
Slide 2



The Agricultural Health Study (AHS) is a long-term health study of 90,000 private pesticide applicators & spouses in Iowa and North Carolina. Participants were enrolled at pesticide recertification classes (1993-97) with 82% of farmers and 75% of spouses enrolled.

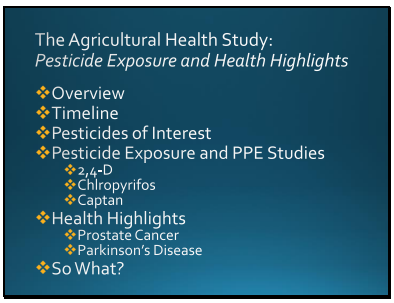
The AHS is conducted by scientists from: the NCI; the NIEHS; the USEPA; and NIOSH.

[Further breakdown of participants from NC (33%): Farmers (20,518) and Spouses (10,574). And from IA (67%): Farmers (31,876), Spouses (21,771), and Commercial applicators (4,916).]

Slide 3

If you are a participant in the AHS you may have received a mailing or a phone call from the study last fall. So far, ~40,000 individuals, ages 40 – 100, have completed the survey. **If you have not completed your survey, please do so today! A family member may assist you. You may participate by mail, phone, or online.**

Slide 4

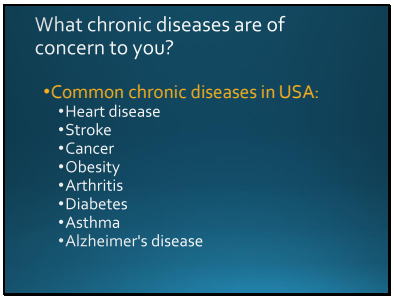


Today's presentation will cover:
An overview of the Agricultural Health Study (AHS),
The Study Timeline and Pesticides of Interest,
Some Pesticide Exposure measurement and PPE Studies of 3 pesticides on IA and NC farms: 2,4-D, Chlropyrifos, Captan
And cover Health Highlights for Prostate Cancer and Parkinson's Disease
We'll end with the most important question: "So What?"And ask you to think about your own PPE use and other safety and health practices.

Slide 5

The Agricultural Health Study asks the question: What exposures of (*click for animation)
*daily work and life on the farm
*are **associated** with
*chronic disease?

Slide 6

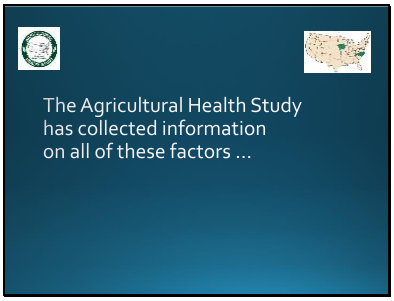


What chronic diseases are of concern to you? [Ask the audience members first, before showing the list of common chronic diseases.]

Slide 7

What contributes to disease risk? [Ask the audience members first, before showing the list.]

Slide 8



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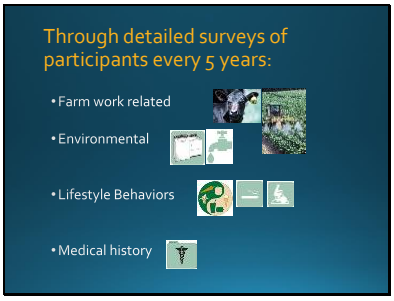
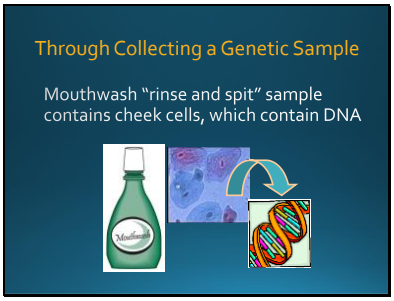


Through detailed surveys at enrollment and every 5 years after. The scientists are currently in the 4th round of follow-up of study participants. Surveys include questions about farm work related exposures and practices *such as pesticides and application methods used, crops and livestock raised and safety practices * environmental exposures, such as their * source of drinking water, laundry and house cleaning practices and the location of their home in relation to fields, *lifestyle habits, like *diet, smoking, alcohol consumption and physical activity, and *personal and family medical history, *such as whether they had been diagnosed with cancer,

arthritis or Parkinson's disease and information about any symptoms they may have experienced, such as those related to asthma, numbness or vision problems. Women provided information about their menstrual cycles and pregnancy history. All of the information collected from or about participants is kept confidential. [BACKGROUND for agent info or to answer questions:]

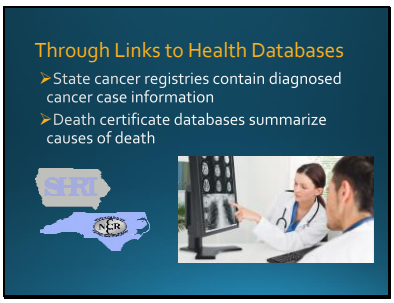
- Reliability Studies have shown that:
- Farmers provide reproducible reports of pesticide use
    - Specific chemicals and application methods
    - Agreement 80-95% for questionnaires 1 year apart
- Accurate information on duration of use
    - Most applicators (>95%) provided information on lifetime use of pesticides consistent with market data

Slide 10



Another strength of the study is that participants volunteered to provide a genetic sample. In the "rinse and spit" method, the mouthwash collects cells from the inner lining of the mouth. Like every cell in our bodies, these cells contain DNA, our genetic blueprint. Scientists will use these samples to learn more about how genetic factors interact with exposure to contribute to illness.

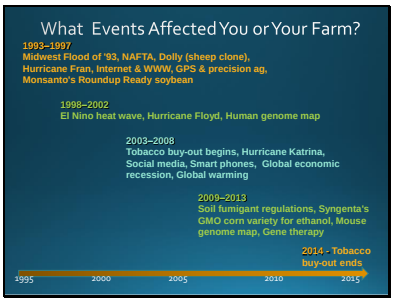
Slide 11



Through the links to Health Databases: IA and NC both maintain medical records of cancer cases among residents of their states. Regularly, AHS scientists check the IA and NC cancer registries for newly diagnosed cases of cancer among the study participants. They also check death certificate databases to learn causes of death. All of the information collected from or about participants is kept confidential.
[Background: IA Cancer Registry is part of the State Health Registry of IA. The NC Central Cancer Registry is part of the NC State Center for Health Statistics]

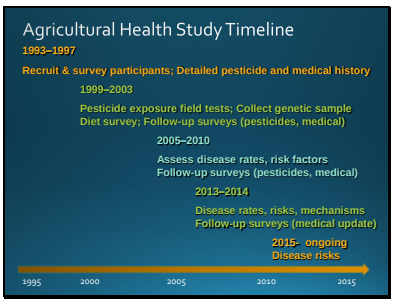
Slide 12

Slide 13



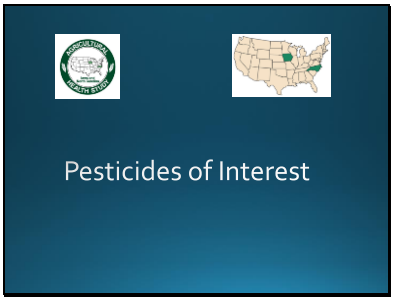
The Agricultural Health Study began in 1993 and continues today. What key events and scientific advances have affected agriculture, health research, and our daily lives since 1993?
1993- 1997:
Midwest Flood of '93, etc., etc.

Slide 14



From 1993 to the present, the AHS has kept up with all of the changes in ag production through surveys of participants on their pesticide use and any new medical information every five years. In addition, they have taken advantage of scientific and communication technology advances to make the most of their scientific investigations, including collecting a genetic sample. Today, we will talk about: 1. pesticide exposure field tests, 2. studies of prostate cancer, and, 3. studies of Parkinson's disease based on information gathered in each of the first 3 phases of the study up to 2010.

Slide 15



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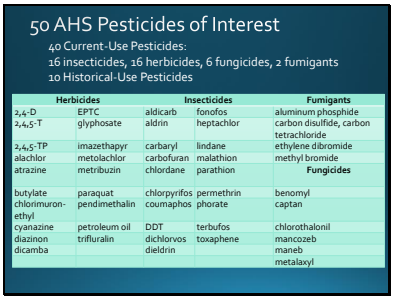

Herbicides		Insecticides		Fumigants
2,4-D	EPTC	aldicarb	fonofos	aluminum phosphide
2,4,5-T	glyphosate	aldrin	heptachlor	carbon disulfide, carbon tetrachloride
2,4,5-TP	imazethapyr	carbaryl	lindane	ethylene dibromide
alachlor	metolachlor	carbofuran	malathion	methyl bromide
atrazine	metribuzin	chlordane	parathion	**Fungicides**
butylate	paraquat	chlorpyrifos	permethrin	benomyl
chlorimuron-ethyl	pendimethalin	coumaphos	phorate	captan
cyanazine	petroleum oil	DDT	terbufos	chlorothalonil
diazinon	trifluralin	dichlorvos	toxaphene	mancozeb
dicamba		dieldrin		maneb
				metalaxyl

AHS scientists are interested in learning if particular pesticides cause long-term health problems, such as cancer, over a lifetime of exposure. When applicators enrolled in the study between '93 and '97, they provided detailed information about their use of 50 pesticides, including 40 current-use pesticides and 10 historical-use pesticides no longer available. The 50 pesticides were selected because 1) they have a history of wide use or 2) previous studies indicated the pesticides may be associated with health concerns.

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Top 11 out of 40 Current-Use Pesticides
(as of 1993-1997)

North Carolina		Iowa	
PESTICIDE	TYPE	PESTICIDE	TYPE
Glyphosate	H	2,4-D	H
2,4 D	H	Glyphosate	H
Atrazine	H	Imazethapyr	H
Chlorpyrifos	I	Atrazine	H
Methyl bromide	FUM	Dicamba	H
Carbaryl	I	Metolachlor	H
Metolachlor	H	Trifluralin	H
Chlorothalonil	FG	Chlorpyrifos	I
Metalaxyl	FG	Cyanazine	H
Alachlor	H	Terbufos	I
Malathion	I	Alachlor	H

Out of the 40 pesticides in current use listed on the enrollment surveys, these are the top 11 pesticides used by applicators in the study in IA and NC during '93-'97. [ASK AUDIENCE]: What do you notice about the differences between pesticides used in IA and NC? Are these pesticides still widely used today? You will notice that herbicides were predominant in IA, while a diverse group were used in NC. I've highlighted 2,4-D and chlorpyrifos, because those were the pesticides selected for exposure measurement studies on farms. [H=herbicide; I=insecticide; FUM=fumigant; FG=fungicide]

Slide 18

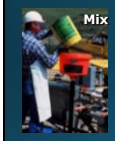
New Pesticides Reported
(2005-2010)

- 48 additional pesticides have been reported by applicators and spouses
  - 30 herbicides
  - 15 insecticides
  - 2 fungicides
  - 1 fumigant

Because agricultural practices change over time, scientists are interested in learning how pesticide use changes. Follow-up surveys conducted every 5 years have asked applicators and spouses to provide information on *all* of the pesticides they used during the most recent growing season, not just the 50 pesticides of interest in the first survey. In addition to the 40 original pesticides, the AHS now has information about 48 additional widely used pesticides, including 30 H, 15 I, 2 FG, and 1 FUM.

Slide 19

Long Term Exposure =
Days/Year x Years x Exposure Intensity


Mix

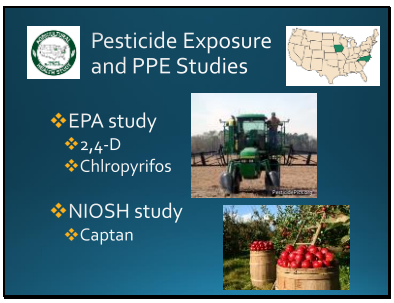
+ Apply

+ Repair

X PPE
(0.1 to 1)

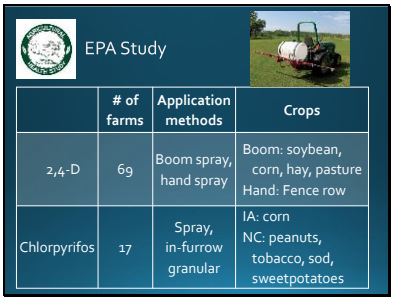
The AHS estimates long-term exposure for each participant using the days/year of pesticide use, the number of years of pesticide use, and the exposure intensity. Based on many scientific studies, exposure intensity is determined by whether the applicator mixes or not, what type of application method is used, whether the applicator repairs equipment, and what combination of PPE the applicator uses. The AHS is the first health study to use this comprehensive way of estimating pesticide exposure, and it is one of the strengths of the study.

Slide 20



To test this formula for estimating exposure and to learn more about what safety practices are most effective, the AHS conducted real-world exposure measurements on farms in NC and IA using 2,4-D, Chlorpyrifos and Captan. [BACKGROUND INFO:] AHS Pesticide Exposure Study, led by USEPA Scientist Kent Thomas. AHS Orchard Fungicide Exposure Study, led by NIOSH Scientist Cynthia Hines.

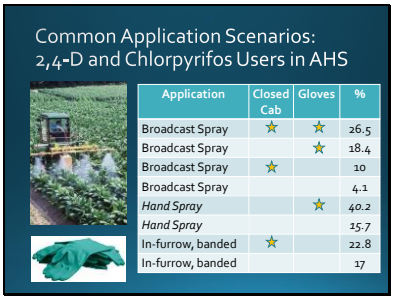
Slide 21



	# of farms	Application methods	Crops
2,4-D	69	Boom spray, hand spray	Boom: soybean, corn, hay, pasture Hand: Fence row
Chlorpyrifos	17	Spray, in-furrow granular	IA: corn NC: peanuts, tobacco, sod, sweetpotatoes

EPA measured 2,4-D exposure on 69 farms in NC and IA using boom sprayers on soybean, corn, hay, and pasture crops and using hand sprayers for fence-row weed control. Chlorpyrifos exposure was measured on 17 farms in NC and IA using boom sprayer or in-furrow granular applications for corn in IA and on peanuts, tobacco, sod, and sweet potatoes in NC.

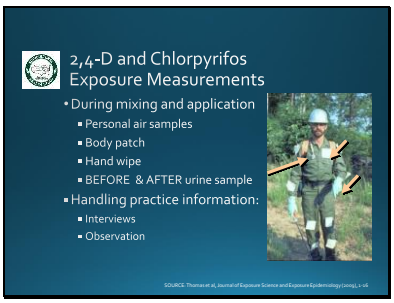
Slide 22



Application	Closed Cab	Gloves	%
Broadcast Spray	★	★	26.5
Broadcast Spray		★	18.4
Broadcast Spray	★		10
Broadcast Spray			4.1
Hand Spray		★	*40.2*
Hand Spray			*15.7*
In-furrow, banded	★		22.8
In-furrow, banded			17

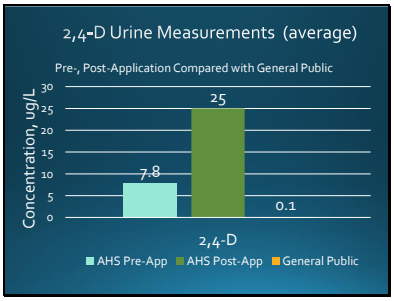
Here you can see the combinations of PPE or other safety practices among Ag Health Study participants using 2,4-D and Chlorpyrifos.
About one-fourth of those using broadcast spray application used both gloves and an enclosed cab, while about 20% used gloves, but no cab. About 10% of applicators used only a closed cab, while 4% used no gloves or cab at all. For those using hand sprayers, 40% used gloves, while 16% used no PPE or cab. About 23% used in-furrow/banded applications with a closed cab, while 17% did not use gloves and applied without a closed cab.

Slide 23



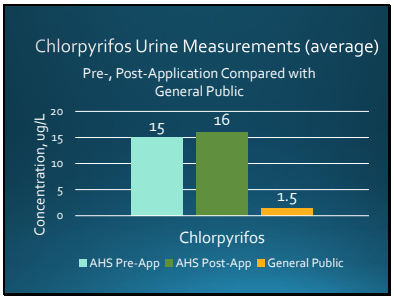
EPA scientists measured exposure to 2,4-D and chlorpyrifos in these situations by taking (*click):
1- * personal air samples, 2-* patch samples on arms, chest, and legs,
3- * hand wipe samples, and
4- urine samples before and after application. Handling and safety practices were determined through interviews with the applicators and observations.

Slide 24



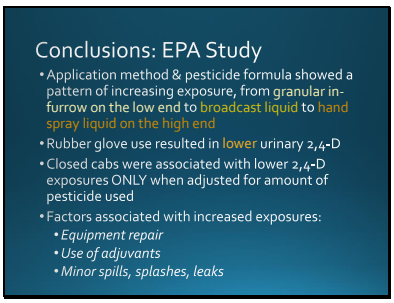
2,4-D in urine shows that farmers had some 2,4-D in their bodies prior to application. The avg. (specifically, geometric mean) concentration in the urine was 7.8 micrograms (ug) per liter. The avg. concentration level in their urine after application was about 4x higher, or 25 ug per liter. While this graph shows averages, there was a wide range overall. Farmers using different equipment and PPE or safety practices had very different urine levels, some with extremely high levels, up to 1000x the avg. level (data not shown). Before application, farmers in this study had 80x the 2,4-D levels in their urine as the general public.

Slide 25



[Ask audience]: What do you notice about pre- and post-application Chlorpyrifos levels? Why do you think they are so similar? What could other sources of exposure be? Avg. Chlorpyrifos urine concentrations in farmers is 15-16 ug per liter, 10x greater than the general population, at 1.5 ug per liter. Chlorpyrifos levels in the farmers in the study varied greatly, ranging up to 100x the avg. levels, so some farmers using different safety practices had much higher levels than the avg. Chlorpyrifos exposure in farmers was possibly due to dietary or home exposures, in addition to crop protection.

Slide 26

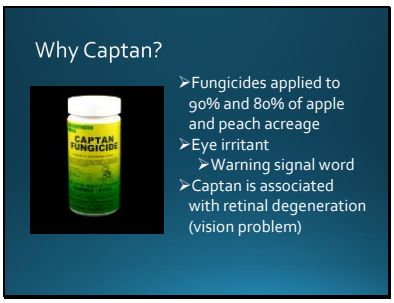


Based on tall the exposure measurements, EPA concluded that: Application method & pesticide formulation showed a pattern of increasing exposure, from granular in-furrow on the low end to broadcast liquid to hand spray liquid on the high end; *Rubber glove use resulted in **lower** urinary 2,4-D, that is lower internal exposure; *Closed cabs were associated with lower 2,4-D exposures ONLY when adjusted for amount of pesticide used, that is, a closed cab is not necessarily a silver bullet; and *Factors associated with increased exposures included: *Equipment repair*, *Use of adjuvants*, *Minor spills, splashes, and leaks.*
[ASK AUDIENCE]: Why would use of adjuvants result in greater exposures? Do you have PPE (at least gloves) available for use during equipment repair?

Slide 27

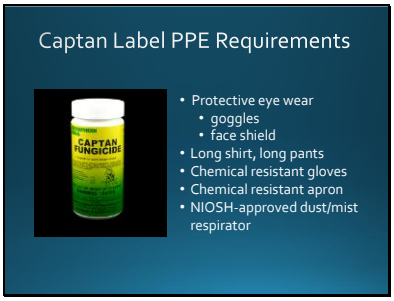
A study conducted by NIOSH measured Captan exposure on 74 NC and IA apple and peach farms participating in the AHS. Farmers were using air blast and hand spray application methods. Similar to the EPA study, air, hand rinse and patch samples were collected during mixing and application, and a urine sample was collected before and during application. Applicators were observed to see what safety and handling practices they used.

Slide 28



[ASK AUDIENCE] Why Captan? Several reasons:
Captan is a widely used fungicide, not only on peaches and apples, but many other fruits. Fungicides in general are applied to over 80% of apple and peach acreage.
Captan is an eye irritant; this is one reason it has a Warning signal word. Captan was found through the AHS to be associated with a vision problem called retinal (or macular) degeneration.

Slide 29



The Captan label requires the following PPE:

- Protective eye wear
- Long shirt, long pants
- Chemical resistant gloves
- Chemical resistant apron during mixing/loading, cleaning equipment, spill clean-up, etc. and
- Respirator

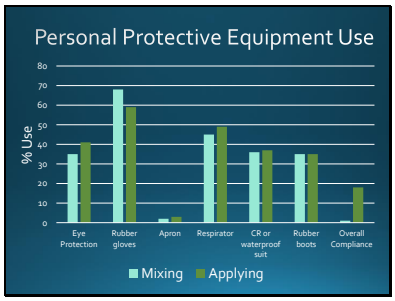
Slide 30

Of the farms in the study: 136 were low density orchards (<200 trees/acre); and generally had 2.6 acres sprayed at one time; and 11 were high density orchards (>200 trees/acre); and generally had 6 acres sprayed at one time. Two main application methods were used on the farms in the study: air blast (53%) and hand spray (44%). Only 1% used a mist blower/fogger. The same applicator did both the mixing and spraying practically all of the time. Mixing was done outdoors 83% of the time, and in a shed 17% of the time. Because farm sizes varied, so did the # of tank mixes sprayed in a day, with: 1 tank/day (48% of farms); 2 -3

tanks/day (38% of farms); and, 4-12 tanks/day (14% of farms)

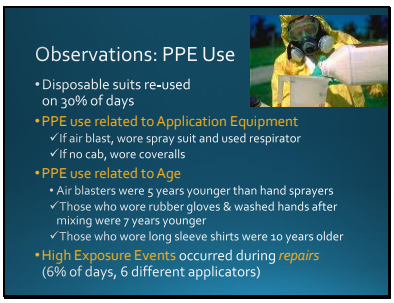
For both air blast and hand spray methods, a tractor (or other vehicle) was used while spraying 76% of the time. However, only 17% of these tractors had an enclosed cab. The applicator did some kind of equipment repair or cleaning 18% of the time during mixing and 33% of the time during application. Water soluble packages were opened about 1/3 of the time, negating the protective feature of the packaging. [ASK AUDIENCE:] Why do you think this was done? Possibilities include: unaware of water soluble feature, packaging doesn't always dissolve and clogs equipment, smaller amount needed for application.]

Slide 31



This chart shows actual PPE used during mixing or applying for the PPE required on the Captan label. The apron was almost never used. Rubber boots, chemical resistant or waterproof coveralls, and eye protection were used about 40% of the time. Respirators were used about 45% of the time. Rubber gloves were used about 65% of the time. Farmers were in compliance with all label requirements less than 20% of the time during application and 0% during mixing.

Slide 32



Disposable suits were re-used on 30% of days. PPE use was related to the application equipment used:

If air blast, farmers wore spray suit and respirator;

If no cab, farmers wore a coverall or chemically-resistant suit.

PPE use and application method was related to age of the farmer:

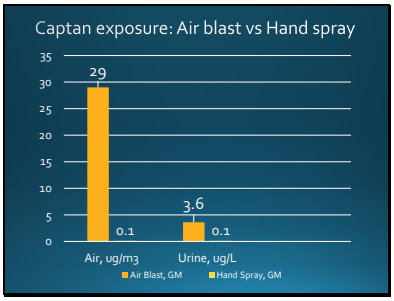
Air blasters were 5 years younger than hand sprayers;

Those who wore rubber gloves & washed hands after mixing were 7 years younger than those who did not.

However, those who wore long sleeve shirts were 10 years older than those who wore short sleeve shirts.

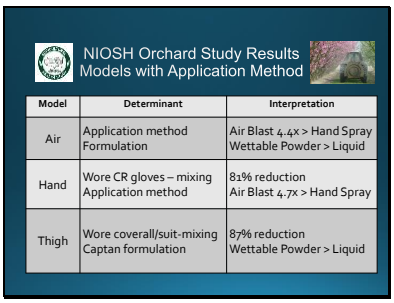
High Exposure Events occurred on 6% of application days with 6 different applicators during equipment repairs.

Slide 33



Both air and urine samples showed much greater exposure on avg. for those applicators using air blast application. Only one-third of hand spray exposure measurements were above the detection limit. Personal air samples of those using air blast were an avg. concentration of 29 micrograms per cubic meter (ug/m3) and ranged from 8 to 1500, so some farmers were receiving very high levels of air exposure, up to 1000x the avg. Air exposure for hand sprayers was far less on average (0.1 ug/m3) and comparing the range of values, ranging from 12 to 120 ug/m3. Urine concentration levels of the Captan metabolite (THPI) for those using air blast averaged 3.6 ug/liter and ranged from <1 to 21. Although detected less frequently in hand sprayers, where Captan was detected in the urine, the levels were in the same range as the air blasters. Hand and thigh levels for both application methods were also very high. We do not have any Captan levels in the general public for comparison.

Slide 34



Model	Determinant	Interpretation
Air	Application method Formulation	Air Blast 4.4x > Hand Spray Wettable Powder > Liquid
Hand	Wore CR gloves – mixing Application method	81% reduction Air Blast 4.7x > Hand Spray
Thigh	Wore coverall/suit-mixing Captan formulation	87% reduction Wettable Powder > Liquid

NIOSH scientists took all of the Captan measurements and the handling observations to make conclusions about what factors *determined* exposures. For air exposure, the application method and the formulation were the determining factors, with air blast 4.4x greater than hand spray, and wettable powder greater than liquid formulation. For hand exposure, chemical resistant gloves provided an 81% exposure reduction. Air blast resulted 4.7x greater exposure to the hands than hand spray application. Exposure to the thighs was high, but wearing a coverall suit while mixing resulted in 87% exposure reduction. Exposure to the legs was greater with wettable powders vs. liquid formulations.

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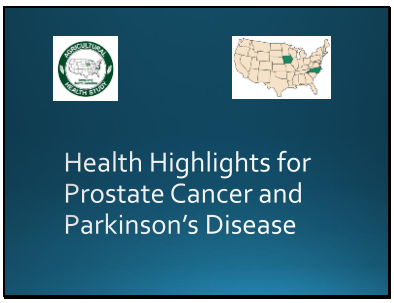
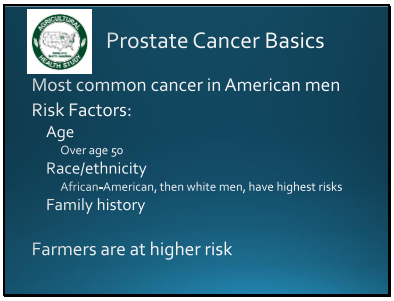
In conclusion, the NIOSH scientists determined that Captan was detected most frequently on hands, forearms, and thighs of applicators. They recommended that elbow-length chemical-resistant gloves and a chemical-resistant apron (or alternative to cover the thighs) be used to reduce these exposures.

Slide 36



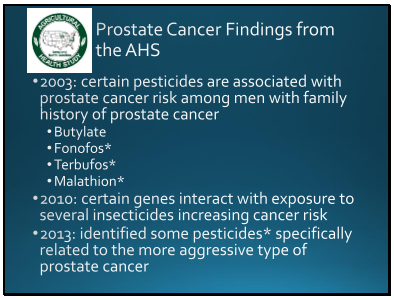
As of December 2014, over 200 scientific papers on a range of health outcomes in relation to pesticide use and other farming exposures have been published by AHS scientists. Researchers and Extension specialists at NCSU are working to make sense of all these results and create a meaningful summary for farm families. Today, we will focus on what AHS scientists have learned about prostate cancer and Parkinson's disease.

Slide 37



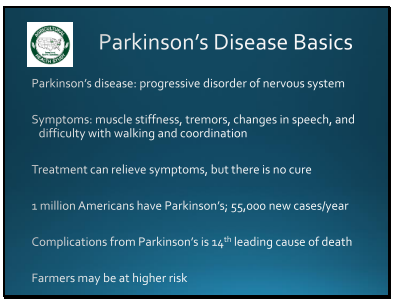
Other than skin cancer, prostate cancer is the most common cancer in American men. Age, race/ethnicity, and family history increase the risk of prostate cancer. Risks are greatest among African-American men, than white men, compared with Asian-Americans and Latinos. Prostate cancer is very rare in men younger than 40, but the chance of having prostate cancer rises rapidly after age 50. 60% of prostate cancer cases are found in men over 65. Having a father or brother with prostate cancer more than doubles the risk of developing this disease. AHS data indicate that farmers are at higher risk, 14% higher than the general population.

Slide 38

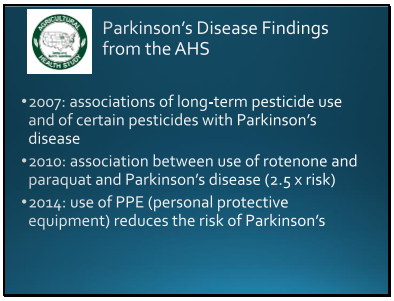


AHS investigators have learned more about prostate cancer as the study has progressed. In 2003, study scientists learned that certain pesticides were associated with risk among men with family history of prostate cancer. The pesticides included butylate, fonofos, terbufos, and malathion. In 2010, study scientists learned that certain genes modified the effects of several insecticides. In 2013, study scientists identified pesticides (fonofos, terbufos, and malathion) specifically related to the more aggressive type of prostate cancer. The longer the follow-up, the better we can determine the underlying mechanisms.

Slide 39

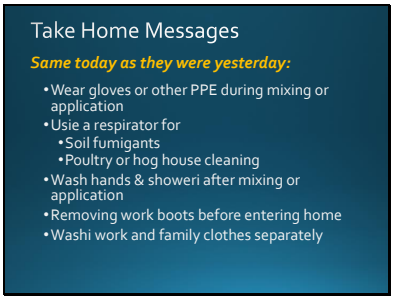


Slide 40



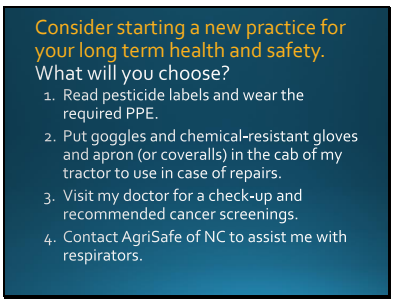
2007: associations of long-term pesticide use (cumulative # of days of use) and of certain pesticides with Parkinson's disease.
2010: association between use of rotenone and paraquat with Parkinson's disease (2.5x risk)
2014: use of PPE (personal protective equipment) reduces the risk of Parkinson's

Slide 41



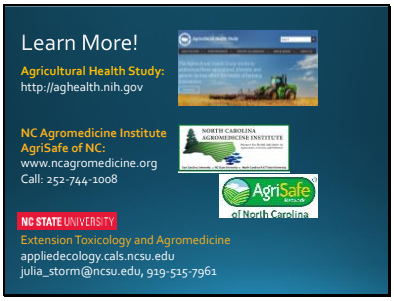
Although the early health findings from the study call for no *new* health or safety recommendations, the take home message is the same as it has always been (and what you are expected to be doing as a Private Pesticide Applicator).

Slide 42



Hopefully, this presentation will serve as a reminder to reevaluate your health and safety practices. In particular, follow the pesticide label, paying attention to PPE requirements. Use chemically-resistant gloves and have PPE available in the field should you need to make equipment repairs. Make sure you fit test your respirator before use. Ask your doctor about: prostate cancer screening; lung health screening, medical clearance, and respirator fit testing (or visit an AgriSafe provider).

Slide 43



Slide 44

Close with a repeat of Slide 3.