The Agricultural Health Study

https://aghealth.nih.gov

The Agricultural Health Study (AHS) is a long-standing collaboration of the NIEHS and NCI. Scientists from the US EPA and NIOSH previously participated in study leadership and supported discreet exposure assessment efforts.

AHS Executive Committee

NIEHS
Dale P. Sandler
Christine G. Parks
National Cancer Institute
Laura Beane Freeman
Jonathan Hofmann

Overview

The Agricultural Health Study (AHS) is an ongoing prospective study of cancer and other health outcomes in a cohort of licensed pesticide applicators and their spouses from Iowa and North Carolina, and commercial applicators from Iowa enrolled in 1993-1997. Designed to investigate the health effects of specific pesticides and other agricultural exposures, the study has generated or contributed to over 400 peer-reviewed publications to date, showcasing the work of investigators and collaborators from numerous intramural and extramural institutions. Add-on and nested studies focused on specific outcomes or exposures have enriched the cohort. As the cohort ages, the value of continued follow-up is manifest through new research on chronic diseases and conditions that become more prevalent with age.

Figure 1 provides an overview of major data collection efforts to date. The study enrolled over 89,000 participants between 1993 and 1997 (Phase 1). Since enrollment, the cohort has been actively followed, including four cohort-wide surveys (Phases 2 through 5). Phases 1 through 3 collected extensive data on use of specific pesticides and other exposures, personal health risk factors, and disease-related symptoms and diagnoses. Phases 4 and 5, carried out by NIEHS, focused primarily on non-cancer health outcomes. At the first follow-up (Phase 2), buccal cells and diet history questionnaires were also collected. The cohort is passively followed for mortality and cancer incidence through regular linkages to vital statistics, state cancer registries, and other databases. Periodic linkage to the US Renal Data System (for end-stage renal disease) and Medicare claims data facilitate studies of non-cancer health outcomes.

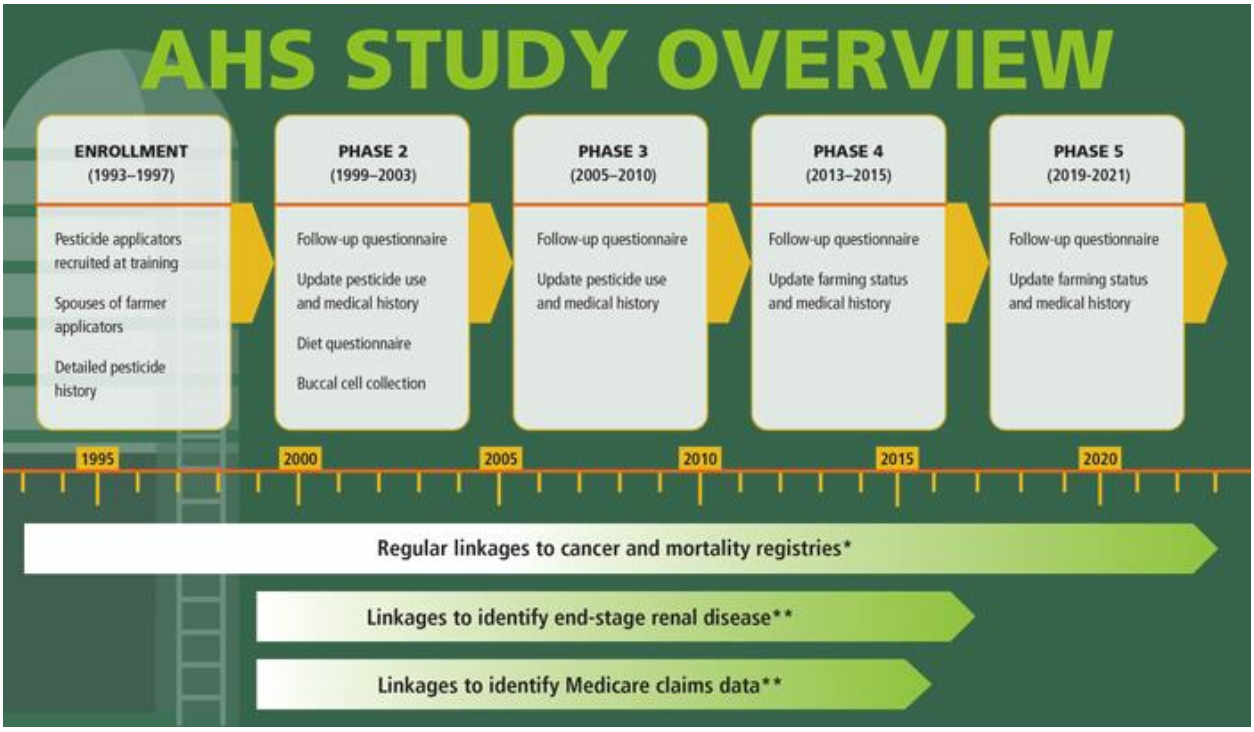

Figure 1. Enrollment and follow-up of AHS study participants: in addition to survey follow-up data, the cohort is periodically linked to identify incident cancer and mortality (*state cancer registries and the National Death Index), end-stage renal disease (**United States Renal Data System), and other diseases (***Medicare claims data).

Population

The AHS cohort consists of licensed private pesticide applicators (mainly farmers) and their spouses from Iowa and North Carolina (NC) and commercial pesticide applicators in Iowa, enrolled in 1993-1997. Pesticide applicators were recruited when they attended pesticide training classes to obtain or renew a license to apply restricted-use pesticides. Spouses of private applicators were recruited via questionnaires brought home by the applicator or, occasionally, through direct outreach using information provided by the applicator at enrollment. Over 80% of the licensed private pesticide applicators recruited were enrolled, along with 75% of the spouses of the married private applicators. The response rate for commercial applicators was lower (47%). A total of 89,655 individuals enrolled in the AHS (52,394 private applicators; 32,345 spouses; and 4,916 commercial pesticide applicators).

Table 1 shows selected demographic and farming characteristics of the cohort at enrollment. The average age of private applicators and their spouses was 47 years, while commercial applicators were on average 9 years younger. Two thirds of participants were from Iowa. Most licensed applicators reported personally mixing or applying pesticides (99% of private applicators, 92% of commercial applicators), as did nearly half (56%) of the spouses.

Even with the inclusion of NC, selected for its tradition of farming in the African American community, less than 3% of the cohort reported their race as something other than White. To increase representation of non-white racial groups in the study, a supplementary cohort of 1,198 African American/Black individuals who currently or previously worked on a farm (66% female), recruited through churches in eastern NC in 1995-1996. Those in the add-on study were older

than in the main cohort and most were not licensed pesticide applicators. Due to differences in characteristics and in pesticide data, this sample was not actively followed, except for 9 licensed applicators who were also recruited to join the main cohort. Members of this supplementary cohort have been followed through mortality, cancer, and renal disease registry linkages.

Table 1. Characteristics of the Agricultural Health Study Cohort at Enrollment

		Private Applicators (N=52,394)		Commercial Applicators (N=4,916)		Spouses (N=32,345)	
Age (years)	mean, SD	47.1	13.3	38.0	11.5	46.9	12.1
		N	%*	N	%*	N	%*
Sex							
	Male	51,036	97	4,712	96	219	1
	Female	1,358	3	204	4	32,126	99
Self-reported race							
	White	49,762	97	4,855	99	30,921	98
	Other	1,514	3	26	1	552	2
State							
	Iowa	31,876	61	4,916	100	21,771	67
	North Carolina	20,518	39	0	___	10,574	33
Education							
	≤High School	29,285	59	2,197	46	12,917	46
	>High School	20,708	41	2,557	54	15,177	54
Smoking status							
	Never smoked	26,937	53	2,312	48	21,997	72
	Past smoker	15,514	31	1,245	26	5,324	17
	Current smoker	8,047	16	1,282	26	3,179	10
Mix or apply pesticides							
	Ever (since age 18)	50,620	99	4,475	92	17,628	56
	Years mixed or applied**						
	1 year or less	1,614	3	849	10	15,018	56
	2-10 years	13,040	26	2,147	47	6,096	22
	11-20 years	15,987	33	1,071	23	3,079	11
	21+ years	18,166	37	534	11	2,786	10

*Percentages of N responding to the question. **Among those who mixed/applied pesticides.

Cohort Follow-up

Active follow-up has included four contacts to date. Phase 2 (1999-2003) updated pesticide use and health histories and included the collection of buccal cells and a diet history. Eligibility for the Phase 3 (2005-2010) follow-up was limited to participants who had completed at least one prior cohort activity besides the on-site enrollment questionnaire (i.e., applicator take-home questionnaire or Phase 2, see data collection below). As a result, 8,000 private applicators were

excluded from further follow-up. Commercial applicators were also dropped from active follow-up but continue to be tracked for mortality and cancer incidence. Participants eligible for Phase 3 and non-deceased at the time of subsequent follow-ups, were also considered eligible for Phases 4 (2013-2015) and 5 (2019-2021), regardless of their participation in Phase 3. Phases 4 and 5 also collected data from proxy respondents for recently deceased or incapacitated participants. The number of participants and response among eligible participants are shown in Table 2. Only 1% of the cohort has refused further contact and one person has requested the full removal of their records.

Table 2: AHS Cohort-Wide Data Collection and Response among Eligible Participants

	Enrollment	Follow-up questionnaires							
	Phase 1 1993-1997	Phase 2 1999-2003		Phase 3 2005-2010		Phase 4 2013-2015		Phase 5 2019-2021	
	N	N	%*	N	%*	N	%*	N	%*
Private Applicators	52,395	33,457	69	24,171	60	24,145	60	18,206	48
Spouses	32,347	23,796	76	19,959	66	18,186	61	13,973	48
Commercial Applicators	4,916	2,885	59	NA	NA	NA	NA	NA	NA
Total	89,658	60,138		42,052		42,331		32,179	

*Percentages shown are among those eligible for follow-up.
NA: Commercial applicators were not interviewed after Phase 2.

All participants enrolled in the study (including the main cohort and the African American sub-cohort), are followed for cancer incidence and mortality through regular linkages with data (currently available through 2021). The cohort has been linked twice to the US Renal Data System to identify cases of end stage renal disease (with data available through 2018). Participants in the main cohort over age 65 years (between 1999 and 2016) have been linked to Medicare administrative healthcare claims data to identify or confirm diagnoses based on inpatient and outpatient care and filled prescription medications. Through an extramural project (PI: Honglei Chen, Michigan State University) recently funded by the National Institute on Aging (NIA), the cohort is being linked to updated Medicare records, also including managed care data, for research on neurologic diseases of aging, including Parkinson's disease and dementia.

Subsets of the cohort have been invited to participate in add-on studies (see below), including collection of biological or environmental samples. NIEHS investigator Stephanie London carried out research on asthma, and NIEHS has been the main AHS collaborator for extramurally funded studies of Parkinson's disease, dementia, asthma, and neurobehavioral function. Self-reported non-cancer conditions (Parkinson's disease, thyroid disease, macular degeneration, rheumatoid arthritis, systemic lupus erythematosus, and Sjögren's disease) have been confirmed and validated through additional participant screening and medical records review.

Data Collection

Questionnaires from enrollment through Phase 5, survey details, and overall response rates are available on the AHS website (https://aghealth.nih.gov/collaboration/questionnaires.html).

At enrollment self-administered questionnaires collected detailed information on lifetime pesticide use, demographics, and medical history. Applicators were asked to complete two questionnaires, one at a pesticide training/licensing location and a second to be filled out at home and mailed back. Over 80% of licensed private applicators recruited were enrolled in the study by completing the on-site questionnaire, but only 44% returned the take-home questionnaire. Some details of medical history and covariates, other farming tasks, and occupational exposures were only obtained in the take-home questionnaire. Additionally, information on the frequency and duration of use of certain pesticides (e.g., banned organochlorines or herbicides) for which ever-use was ascertained on the on-site enrollment questionnaire were also only available for those who completed the take-home questionnaire. Married private applicators (mostly farmers) also took home a questionnaire for their spouses, of whom 75% completed the questionnaire by mail; a small percentage of spouses in Iowa were contacted by telephone to enroll. Spouses provided information on their own use of pesticides, though in less detail than the applicators. They also provided demographic, lifestyle, and health information as well as information on off-farm exposures. Women who enrolled (both spouses and female applicators) were also asked to complete a Female and Family Health questionnaire including reproductive histories and information about children; 60% of female participants completed this questionnaire. In total 89,655 participants enrolled in the study, including 52,394 private applicators, 32,345 spouses, and 4,916 commercial applicators.

The ***Phase 2*** follow-up questionnaires were administered using computer assisted telephone interviews. These collected detailed information on current pesticide use practices, potential confounders, and medical history, and were completed by 60,137 (67%) of participants. Exposure questions were similar for applicators and spouses. Health questionnaires varied slightly by age and sex (and menopause status for females at enrollment). Those who completed the Phase 2 interview were asked to complete and return by mail a self-administered food frequency questionnaire (the NCI Diet History Questionnaire with added items on cooking practices); approximately 37% of applicators and 49% of spouses completed the diet questionnaire. Participants were also asked to collect buccal cell samples (via mouthwash rinse) for DNA, and samples were returned by 38% of applicators and 46% of spouses. Buccal cell samples continued to be collected for specific cancers (and other outcomes such as Parkinson's disease as part of validation efforts) during follow-up.

Phase 3 also employed a computer-assisted telephone interview to collect updated information on pesticide use practices, potential confounders, and health. This phase was completed by 44,129 participants (60% of eligible applicators and 66% of eligible spouses, representing 49% of the baseline cohort). A common instrument was used for all participants (applicators and spouses) to allow better integration of data for combined analyses, while women received additional questions on reproductive histories. Eligibility for Phase 3 was limited to private applicators and spouses who had completed either the applicator take-home questionnaire or Phase 2 questionnaire.

Phase 4 data collection, using a common instrument for both applicators and spouses, included paper, telephone, and a pilot web version of the questionnaire. Eligibility criteria were the same as for Phase 3 (i.e., who had completed either the applicator take-home questionnaire or Phase 2 questionnaire). This phase was completed by **42,331** participants (61% of eligible participants or proxies, which is 47% of the baseline cohort). The survey focused on health changes, updating farming status, and important covariates such as smoking and family history of disease. Special topics included depression symptoms and sleep. Next-of-kin provided proxy interviews

(8%) for participants previously known or discovered to be incapacitated or deceased, to recover crucial data on health status.

Phase 5 focused on updating health conditions, farming status, and covariate data. Special topics included pain and medication use, farming-related and other stressful life events, social support, and perceived stress. Eligibility criteria were the same as Phase 4, excluding those known to be deceased. A total of **30,920** participants completed Phase 5 (50% of the eligible sample, which is 36% of the baseline cohort). Data collection, using a common instrument for both applicators and spouses, included paper, web-based, and telephone options. A shorter version of the questionnaire, primarily focused on health outcomes and farming status, was offered to proxy respondents. In total, proxies completed 12.6% of surveys.

Exposure Assessment

The detailed assessment of pesticide exposures is a unique feature of the AHS. Pesticide exposure metrics have been created by integrating self-reported use information with expert judgment and literature reviews on exposure intensity based on application methods and the use of personal protective equipment. Because they buy and apply the pesticides themselves, farmers and other licensed applicators are more likely to provide accurate information about pesticide exposure than other pesticide-exposed individuals, such as farmworkers.

At **enrollment**, applicators provided information on duration (years) and frequency (days per year) of use for 50 common pesticides, which were used to calculate lifetime days of use for each of these 50 pesticides. Applicators also reported their pesticide mixing habits, application methods, use of personal protective equipment, and whether they repaired their pesticide equipment. This information was used to assign exposure intensity weights, so individuals most likely to experience personal pesticide exposures (e.g., those who did not use personal protective equipment) had their lifetime exposure days weighted more heavily than those who applied pesticides with lower exposure possibility. This algorithm has been validated in field studies conducted by EPA and NIOSH. Spouses were asked about ever mixing or applying pesticides generally, including ever use, the duration (years), and frequency (days per year) of use, and ever use of 50 common pesticides (but not duration or frequency), and non-specific household pesticide treatment practices.

In the **follow-up phases**, pesticide questions were open-ended, allowing for the characterization of changes in pesticide use practices over time. Applicators and spouses were asked the same questions on pesticide use since enrollment. In Phase 2, 6,585 pesticide names were reported corresponding to 1,878 unique standard names, which in turn were associated with 403 unique active ingredients. Pesticides classified by their active ingredients were used to assign pesticide exposure in Phases 2 and 3. For applicators, this information is combined with data from enrollment to calculate lifetime days of exposure to a pesticide active ingredient. For those who did not complete the Phase 2 follow-up interview, exposure information has been imputed. Similarly, Phase 2 data have also been used to impute missing data from the baseline take-home questionnaire. Pesticide exposures in spouses, who are less likely to report occupational use of pesticides, have been recently addressed through the development of an algorithm estimating lifetime use based on take-home (applicator), residential use, and agricultural drift.

In Phases 4 and 5, questions included an update of farming status and the general use of agricultural pesticides. The Phase 5 questionnaire asked about high pesticide exposure events and the specific chemical involved in the most recent incident.

In addition to pesticide information, data on other agricultural and occupational exposures and activities were collected, including various types of field work and use of different types of fertilizer and farm equipment. Information on specific crops and livestock raised was collected and updated throughout all follow-up phases. At enrollment (in the take-home questionnaire) and in Phase 3, non-farm occupational histories were collected from both applicators and spouses. In Phases 4 and 5, off-farm work histories were updated. Data on the longest off-farm job at enrollment have been classified using standardized industry and occupation coding, and 19 occupational exposures were queried (some the same as on-farm tasks, e.g. welding, and others, including exposure to wood and cotton dust, asbestos, silica dust, pneumatic drills).

Outcome Ascertainment

Information on cancer and causes of death is routinely obtained by linkage to state cancer registries, state vital statistics, and the National Death Index. Other passive follow-up includes linkage to identify cases of end-stage kidney disease through the US Renal Data System, and for participants aged 65 and older between 1999 and 2016, linkage to Medicare administrative healthcare data, which was completed for 46,689 (98% of eligible participants).

Non-cancer outcomes (e.g. cardiovascular, neurological, kidney, endocrine, autoimmune, and reproductive outcomes) are typically ascertained based on participant self-report of a doctor's diagnosis. Questionnaires include information on age at onset, and sometimes symptoms or other disease characteristics which help to confirm (or refute) the self-reported information. In Phase 3, extensive data on respiratory and allergic conditions were collected. The Phase 4 follow-up extended the collection of data on the incidence of many of the same outcomes and added more questions on symptoms or conditions related to aging, including potential pre-motor signs of Parkinson's disease. Phase 5 follow-up updated health conditions and symptoms, with an added focus on stress-related outcomes, including symptoms of perceived stress and depression, unintentional injuries, chronic pain, and pain medication use.

Biological Specimens

Biological specimens were collected from study participants in Phase 2 and in focused add-on studies. Individuals who completed the Phase 2 telephone interview were asked to provide a buccal cell sample using a rinse-and-spit kit. Both the cells and the supernatant were stored for future analyses. Approximately 40% of the eligible cohort provided a buccal specimen. In addition to this cohort-wide collection, several add-on studies have collected either blood or saliva samples as a source of DNA. NCI has collected additional buccal cell samples from NHL as well as prostate, breast, and lung cancer cases diagnosed since enrollment, and blood specimens in the Biomarkers of Exposure and Effects in Agriculture study. NIEHS and collaborators collected biological specimens for DNA and other measures from Parkinson's disease cases and controls and participants in the neurobehavioral testing study. Blood and urine were collected in the AHS Lung Health Study. To date, the AHS has source material for DNA for ~35,000 participants, including buccal cells and specimens from the add-on studies.

Add-on Studies

The AHS executive committee encourages the use of add-on studies to leverage the cohort for new research. Studies have been carried out by both intramural and extramural investigators. Studies involving NIEHS investigators in leadership or key collaborative roles include:

Farming and Movement Evaluation Study
PI: Caroline Tanner, The Parkinson's Institute
NIEHS Collaborators: Freya Kamel, Jane Hoppin, Dale Sandler, David Umbach

The Farming and Movement Evaluation (FAME) study is a case-control study of Parkinson's Disease nested within the AHS. Home visits were conducted to perform structured neurologic examinations, draw blood, and collect dust. Movement disorder specialists confirmed the PD cases; 115 confirmed PD cases and 383 controls were included in this study which was funded by an R01 grant to Dr. Tanner, supplemented with Epidemiology Branch funds.

Neurobehavioral Testing Study
PI: Fred Gerr, University of Iowa
NIEHS Collaborators: Jane Hoppin, Freya Kamel (retired), Dale Sandler

This study, funded through an R01 grant to Dr. Gerr, was designed to assess the impact of chronic organophosphate pesticide exposure on neurobehavioral function. Standardized neurobehavioral testing was conducted on 701 farmers in the AHS from November 2006 to March 2008. Participants were selected based on lifetime use of organophosphate insecticides, with individuals with greater use oversampled to enrich for higher exposures. At the time of testing, a questionnaire was administered, and blood was drawn for genetic and other analyses.

Agricultural Lung Health Study
PIs: Stephanie London, NIEHS (retired); Jonathan Hoffmann, NCI (since 2025);
NIEHS Collaborators: Jane Hoppin (NC State University), Christine Parks, Dale Sandler, David Umbach

The Agricultural Lung Health Study is a case-control study of current asthma at Phase 3. Cases were identified based on responses to the Phase 3 follow-up interview; controls were selected from those who completed the Phase 3 interview and did not report respiratory conditions. At home visits, lung function tests were conducted, height and weight were measured, and biological and environmental samples were collected, along with questionnaire data on early life factors and other exposures. Data collection began in February 2009 and was completed in September 2013, for a final sample size of 3,301. This study was funded through the American Recovery and Reinvestment Act of 2009.

Biomarkers of Exposure and Effect in Agriculture
PI: Johnathan Hoffman, NCI
NIEHS Collaborators: Dale Sandler, Christine Parks

The Biomarkers of Exposure and Effect in Agriculture (BEEA) study was designed to facilitate molecular epidemiologic research to address the relationship of pesticides with cancer and other health outcomes. The study sample includes male applicators over age 50 who completed AHS questionnaires in Phases 1-3. Data collected in home visits included an interview on recent agricultural exposures and health status, blood, urine, and house dust specimens (since 2013). Data collection began in 2010-2018, including 1,681 AHS applicators, and 211 demographically similar male non-applicator controls identified using state voter rolls in Iowa and North Carolina.

AHS Memory and Aging (AHS-MA)
PI: Brenda Plassman, Duke University
NIEHS Collaborators: Christine Parks, Freya Kamel (retired), Honglei Chen (Michigan State University)

The AHS Memory and Aging study, funded by an R01 grant to Dr. Plassman, is focused on understanding risk factors for the development of symptoms of cognitive decline and Alzheimer's disease in the AHS. The study sample included living male AHS participants (private applicators) aged 70 and older who completed questionnaires in Phases 3 and 4. Data were first collected on cognitive status using a validated telephone questionnaire, in 2015-2017 with a total of 2,622 participants enrolled. Those with suspected dementia based on screening were further evaluated through 294 in-person visits and 100 proxy phone interviews. Blood was collected from 281 participants for DNA analyses and to measure selected organochlorines.

AHS Pesticides and Sense of Smell (PASS)
PI: Honglei Chen, Michigan State University
NIEHS Collaborators: Dale Sandler, Christine Parks

The AHS – Pesticides and Sense of Smell (PASS) Study (funded by an NIEHS RO-1 to Dr. Chen aims to investigate whether chronic and acute high-level pesticide exposures are associated with olfactory impairment in farmers, as an indicator of potential prodromal neurodegeneration. Eligible participants included AHS farmers who reported a poor sense of smell at the AHS Phase 4 survey and a random sample of those who reported normal olfaction. From March 2020 through July 2021, 2,545 participants were enrolled and completed a mailed kit for assessment of sense of smell. A subset of ~600 aged 60-79 was selected for a clinical assessment of neurodegeneration via video telemedicine, starting Fall 2021. Supported by a recently funded RO1 by the National Institute on Aging, in March 2025, Dr. Chen has initiated an expanded study called PASS – Memory & Aging, which will include linkage of the entire AHS cohort to Medicare data and collect additional data on select-PASS participants on olfaction, cognition, and other prodromal symptoms of Alzheimer's disease and related neurodegeneration, as well as blood-based biomarkers of Alzheimer's disease in 800 participants from the original PASS study.

Study Governance

The AHS is a collaboration currently including partners from NCI and NIEHS. Cohort maintenance and passive follow-up are funded jointly by the NIEHS and the NCI, managed through a contract with Westat, Inc. The Phase 4 and 5 follow-up interviews, focused on non-cancer health endpoints of interest to investigators in the NIEHS Epidemiology Branch, were funded by NIEHS and managed through its support contract with DLH, LLC.

The AHS Executive Committee makes joint decisions on the study, and reviews and approves data requests, add-on studies, and manuscripts prior to submission. Development of outside proposals and collaboration is encouraged; information on collaboration and other study policies can be found on the AHS website (www.aghealth.org). Executive Committee members serve as liaisons to outside investigators working with AHS data or who wish to contact AHS participants for add-on studies. The AHS uses a project management website (www.aghealthstars.com) to track data requests, add-on studies, and manuscripts arising from these projects. An interagency exposure assessment working group coordinates the development and interpretation of exposure metrics for the study. The study also has an outside advisory group consisting of scientists, community representatives, and state farm agency representatives.

AHS Collaborators and Trainees

NIEHS Collaborators

Michael Fessler*	Clinical Research Branch
Symielle Gaston*	Epidemiology Branch
Stavros Garantziotis*	Immunity, Inflammation, and Disease Laboratory
Chandra Jackson*	Epidemiology Branch
John House	Biostatistics and Computational Biology Branch
Freya Kamel	Epidemiology Branch (retired)
Stephanie London*	Epidemiology Branch (retired)
Mikyeong Lee*	Epidemiology Branch
Lisa Rider*	Clinical Research Branch
David Umbach*	Biostatistics and Computational Biology Branch
Shanshan Zhao*	Biostatistics and Computational Biology Branch

NIEHS Fellows and Trainees (current/recent position)

Brittney Baumert	Post Baccalaureate Fellow (Postdoctoral Fellow, USC, CA)
Megan Carnes	Postdoctoral Fellow (OmniSoft)
Dazhe Chen*	Postdoctoral Fellow (Michigan State University)
Katherine Dalton*	Postdoctoral Fellow (University of Iowa)
Melissa Furlong	Special Volunteer (UNC doctoral student; now Univ. Arizona)
Kevin Guo*	NIH Academic Internship program (Duke undergraduate)
Ameena Hester*	Scholar's Connect Fellow (Master Public Policy, UNC)
Thanh T. Hoang*	Postdoctoral Fellow (University of Texas, Houston)
John Beard	Postdoctoral Fellow (Brigham Young University, UT)
Jill Lebov	UNC Doctoral Student (Research Triangle Institute, NC)
Mark Park*	Postdoctoral Fellow (University of Arkansas)
Martha Montgomery	Post-Baccalaureate Fellow (MD Wake Forest; CDC, Atlanta, GA)
Jessica Rinsky	Summers of Discovery Student (NIOSH, CDC)
Tina Saldana	Postdoctoral Fellow (DLH, LLC)
Anne Starling	Special Volunteer (UNC doctoral student, now University of Colorado)
Srishti Shrestha*	Postdoctoral Fellow (University of Mississippi)
Anisha Singh*	Postdoctoral Fellow (DTT, NIEHS)
Jenna Waggoner	ASPH Fellow (Westat, Inc.)
Emily Werder	Postdoctoral Fellow (University of North Carolina)
Julie D. White*	Postdoctoral Fellow (Research Triangle Institute, NC)

NCI collaborators

Michael Alavanja	National Cancer Institute (retired)
Paul Albert*	National Cancer Institute
Gabriella Andreotti*	National Cancer Institute
Laura Beane Freeman*	National Cancer Institute
Aaron Blair	National Cancer Institute (retired)
Jared Fisher*	National Cancer Institute
Melissa Friesen*	National Cancer Institute
Jonathan Hofmann*	National Cancer Institute
Lauren Hurwitz*	National Cancer Institute
Rena Jones*	National Cancer Institute
Alex Keil*	National Cancer Institute
Stella Koutros*	National Cancer Institute
Mary Ward*	National Cancer Institute (emerita)

External (non-NIEHS) collaborators

Nino Abadashidze*	University of Wyoming
Matthew Bonner	SUNY, Buffalo
Marianne Chanti-Ketterl*	Duke University
Honglei Chen*	Michigan State University (formerly NIEHS)
Karen Costenbader*	Harvard Medical School
Meghan Davis	Johns Hopkins University
Nicole Deziel*	Yale University
Lawrence Engel*	University of North Carolina, Chapel Hill
Marie Gaine*	University of Iowa
Frederick Gerr	University of Iowa
Samuel Goldman	The Parkinson's Institute
Whitney Goldner	University of Nebraska Medical Center
Paul Henneberger	NIOSH, CDC
Ghassan Hassan*	DLH, LLC
Cynthia Hines	NIOSH, CDC (retired)
Jane Hoppin*	North Carolina State University (formerly NIEHS)
James Kestner	NIOSH, CDC
Ellen Kirrane	EPA
Darya Leyzarovich	DLH, LLC
Charles Lynch	University of Iowa (deceased)
Michele Marcus	Emory University
Armando Meyer	Federal University of Rio de Janeiro, Brazil
Emma Moynahan*	Exponent (former trainee Johns Hopkins)
Camille Pouchieu	Université of Bordeaux, France
Brenda Plassman*	Duke University Medical Center
Leorey Saligan*	Rutgers University
Paul Romitti*	University of Iowa
Jennifer Rusiecki	Uniformed Sciences University
Gurumurthy Ramachandran*	Johns Hopkin's University
Aline Santos*	Federal University of Rio de Janeiro, Brazil
Caroline Tanner	University of California San Francisco
Kent Thomas*	EPA (retired, 2024)
Peter Thorne	University of Iowa
Scott Weichenthal	Health Canada
Andrea Wendt*	German Federal Institute for Occupational Safety and Health
Jessee Wilkerson*	DLH, LLC

*New, recent, or active NIEHS-led or collaborative research since 2021

Publications

Since 1993, over 400 papers using AHS data have appeared in the peer-reviewed scientific literature. A complete list of publications since 1993 can be found at Publications | Agricultural Health Study (nih.gov). NIEHS investigators collaborate on papers related to cancer and lead research on non-cancer health effects. Research by NIEHS investigators since 2021 has focused on end-stage renal disease, inflammatory bowel disease, mortality (overall, cause specific, permethrin), neurologic symptoms (dream enacting behaviors, olfactory impairment, predictive value for Parkinson's disease), respiratory function, shingles, systemic autoimmune diseases (rheumatoid arthritis, systemic lupus erythematosus, Sjögren's disease).

NIEHS Authored or Coauthored AHS Publications Since October 2021

1. Ammons S, Madrigal JM, Manley CK, Spaur M, Hofmann JN, Sandler DP, Freeman LEB, Ward MH, Jones RR. Nitrate and disinfection by-products in drinking water and risk of ovarian cancer. Environ Epidemiol. 2025;9(3):e382. Epub 20250513. doi: https://doi.org/10.1097/ee9.0000000000000382. PMID: 40370528; PMCID: PMC12077550.
2. Chang VC, Ospina M, Xie S, Andreotti G, Parks CG, Liu D, Madrigal JM, Ward MH, Rothman N, Silverman DT, Sandler DP, Friesen MC, Beane Freeman LE, Calafat AM, Hofmann JN. Urinary biomonitoring of glyphosate exposure among male farmers and nonfarmers in the Biomarkers of Exposure and Effect in Agriculture (BEEA) study. Environ Int. 2024;187:108644. Epub 20240411. https://doi.org/10.1016/j.envint.2024.108644. PMID: 38636272; PMCID: PMC12406715.
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