



National Health and Nutrition Examination Survey (NHANES)

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History and Accomplishments



An Evolving Survey Since 1959



History of NHANES

Survey	Dates	Ages
NHES I	1959 – 62	18 – 79 years
NHES II	1963 – 65	6 – 11 years
NHES III	1966 – 70	12 – 17 years
NHANES I	1971 – 75	1 – 74 years
NHANES II	1976 – 80	6 months – 74 years
HHANES	1982 – 84	6 months – 74 years
NHANES III	1988 – 94	2 months +
NHANES	1999-Present	All Ages

NHES = National Health Examination Survey; NHANES = National Health And Nutrition Examination Survey; HHANES = Hispanic Health And Nutrition Examination Survey

Accomplishments – Nutrition

- NHANES identified low iron levels as a serious problem especially for women of childbearing age, preschool children, and the elderly. As a result, the government decided to fortify grain and cereal with iron.
- NHANES data informed a 2016 U.S. Food and Drug Administration (FDA) decision to **permit fortification of corn masa flour with folic acid** to address neural tube birth defects particularly among the nation's Hispanic population.

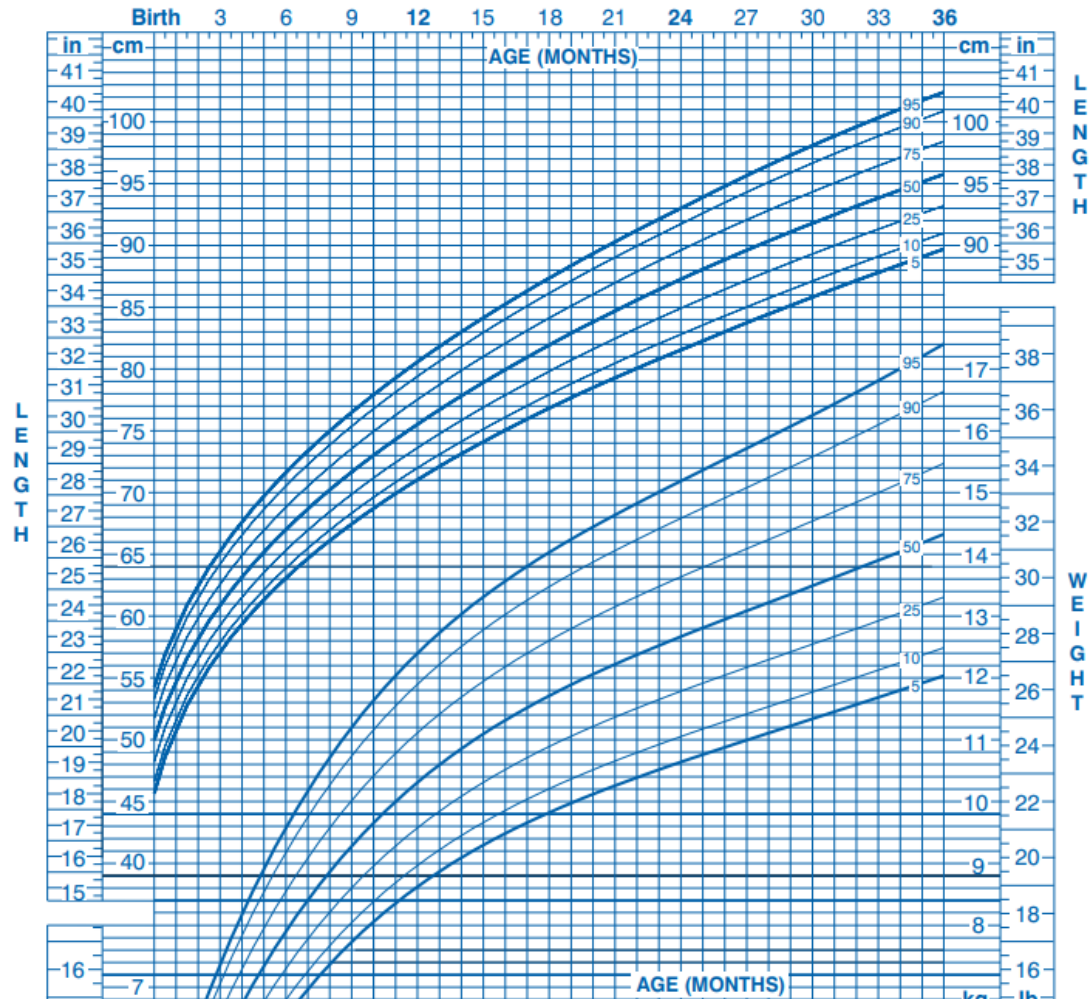
Accomplishments – CDC Growth Charts

Birth to 36 months: Boys

Length-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____

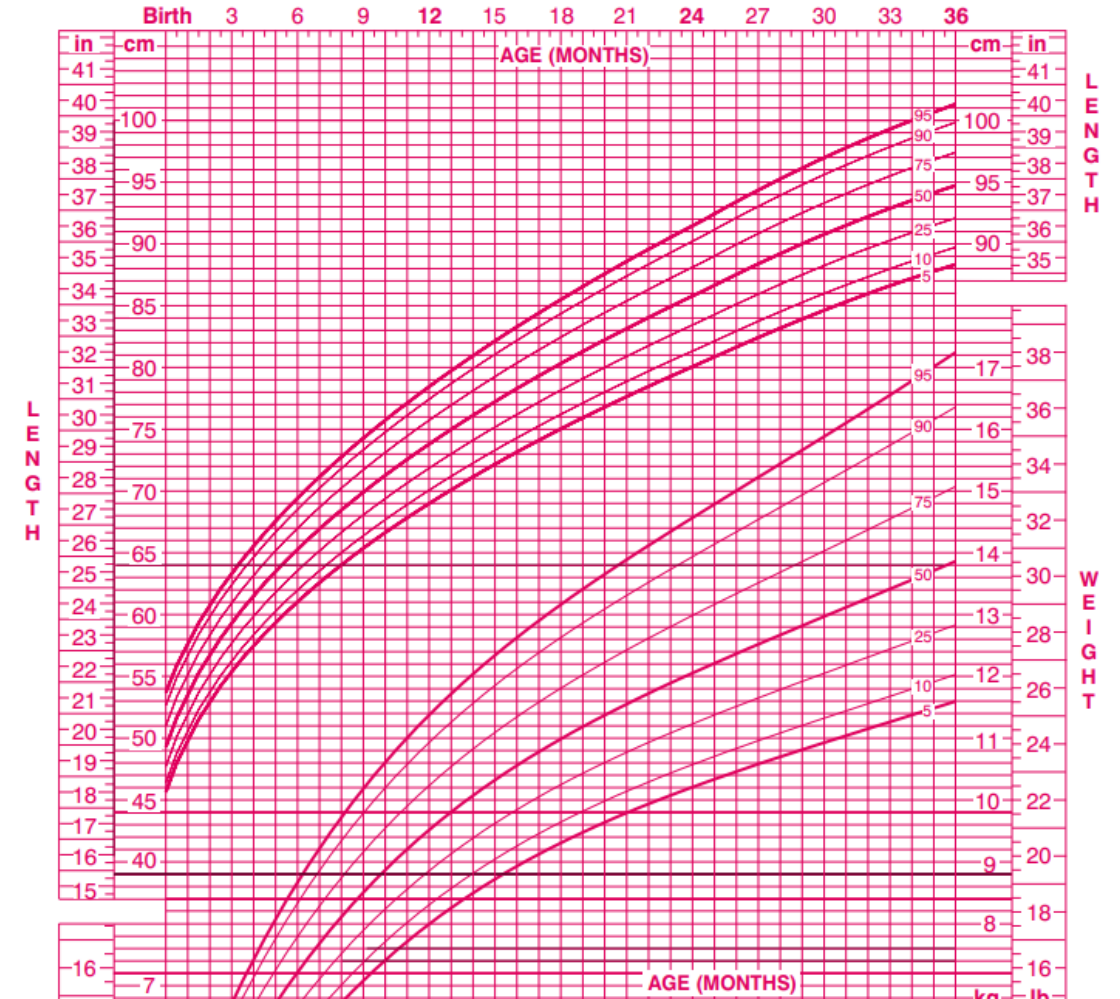


Birth to 36 months: Girls

Length-for-age and Weight-for-age percentiles

NAME _____

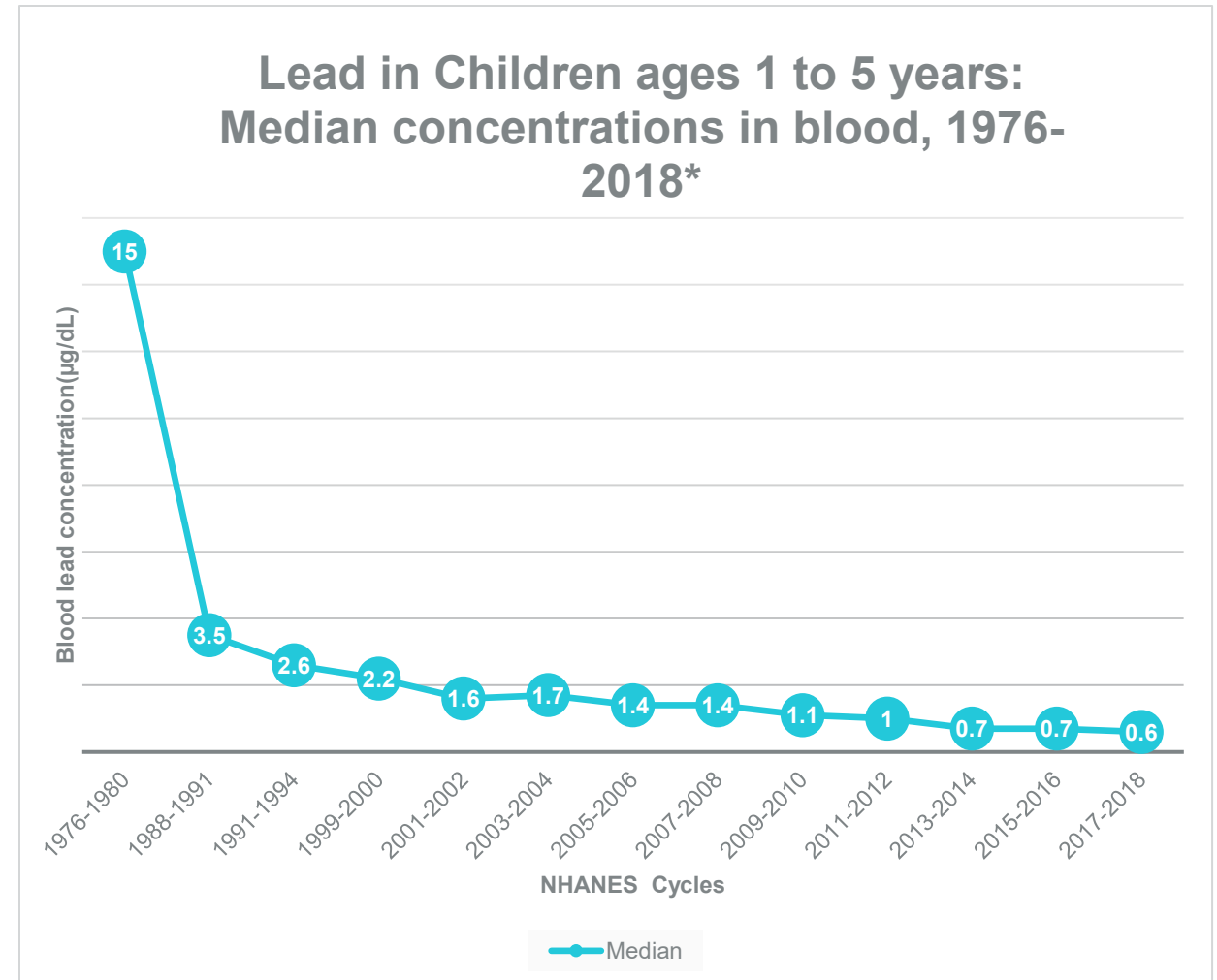
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➤ Used nationally by pediatricians to evaluate children's growth

Accomplishments – Lead

- Since 1976, blood lead levels in the U.S. population are measured in NHANES gave the first clear-cut evidence that Americans had too much lead in their blood.
- This led Congress, the Environmental Protection Agency, and others to phase out the use of lead as an additive in gasoline.



*Source: <https://www.epa.gov/americaschildrenenvironment/biomonitoring-lead>

Goals



Goal of NHANES

- To produce population-based prevalence estimates and trends on:
 - Health conditions and risk factors
 - Nutrition status and diet behavior
 - Prescription medication and dietary supplement use
 - Environmental exposures
- To establish and maintain a biospecimen program

Sampling Design



NHANES – Nationally Representative

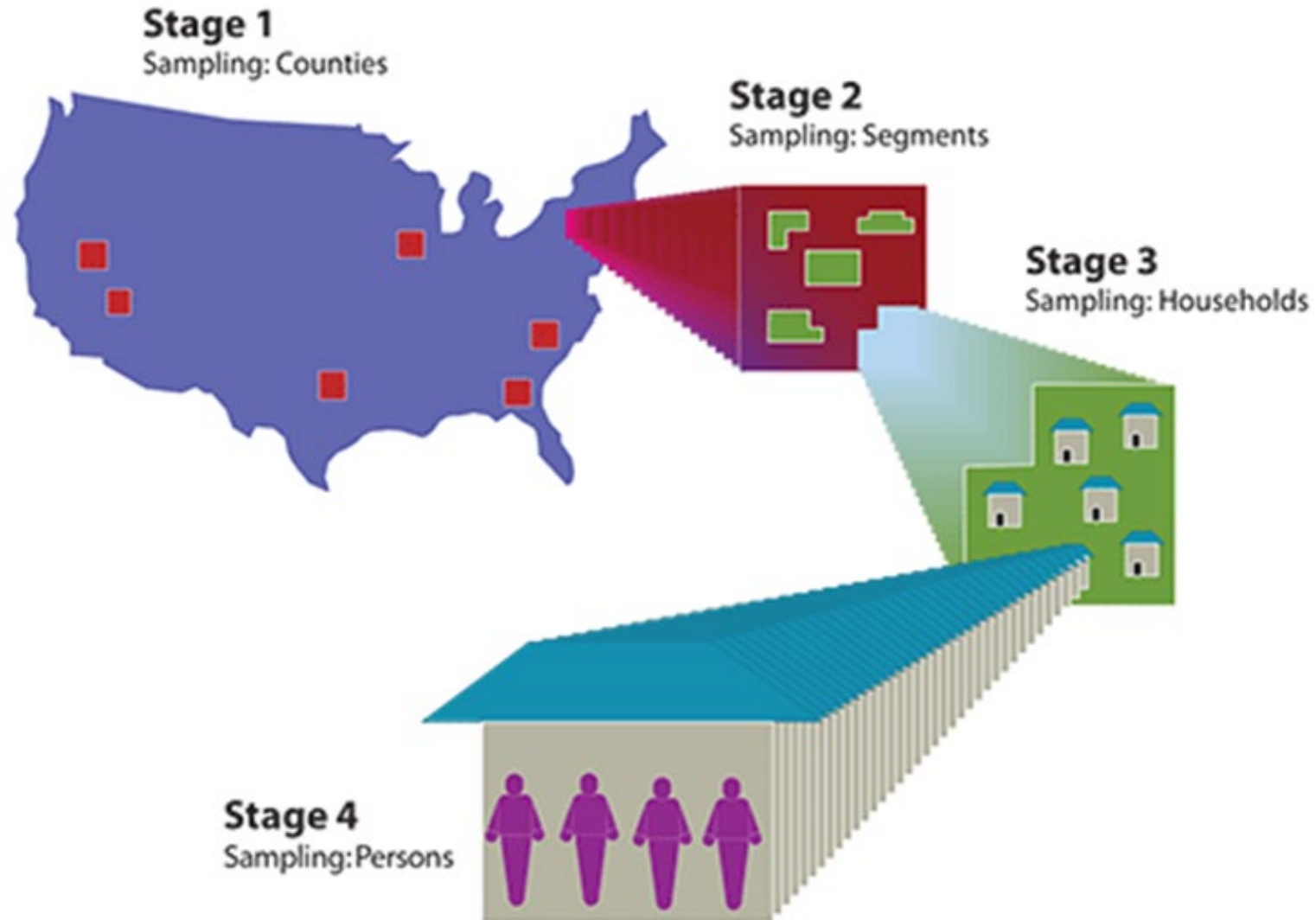


Overview

- Cross-sectional
- Noninstitutionalized civilian resident population
- Information is collected through:
 - In-person home interviews
 - Health examinations
- Target sample: 5,000 individuals examined annually
- Previously oversampled groups:
 - Non-Hispanic Black, Asian, Hispanic
 - Aged 80+ years
 - Low-income non-Hispanic White
- Data released in 2-year cycles



Multistage Probability Sampling Design



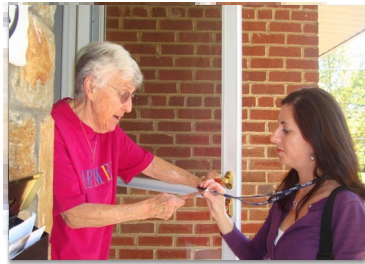
Data Collection



From Sample Selection to Examination



U.S Population



Screening at Household Doorstep



Household Interview



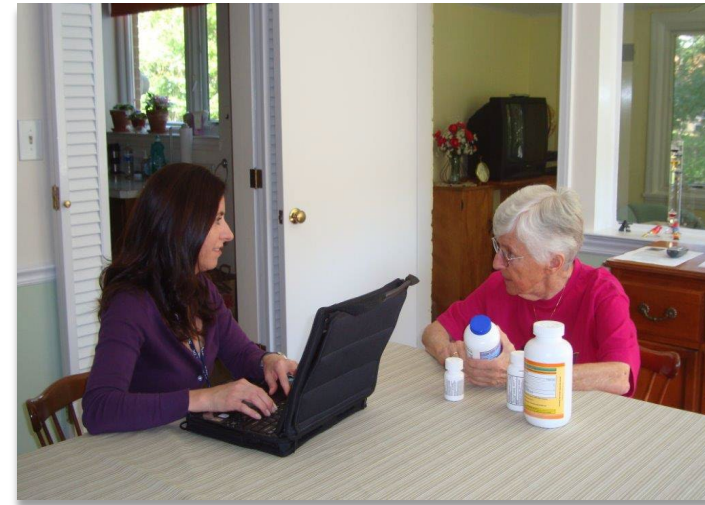
**Examination at
Mobile Examination Center (MEC)**

Consent
obtained for
Interview

Consent obtained
for examination,
future studies ie
DNA (past years)

Home Interview

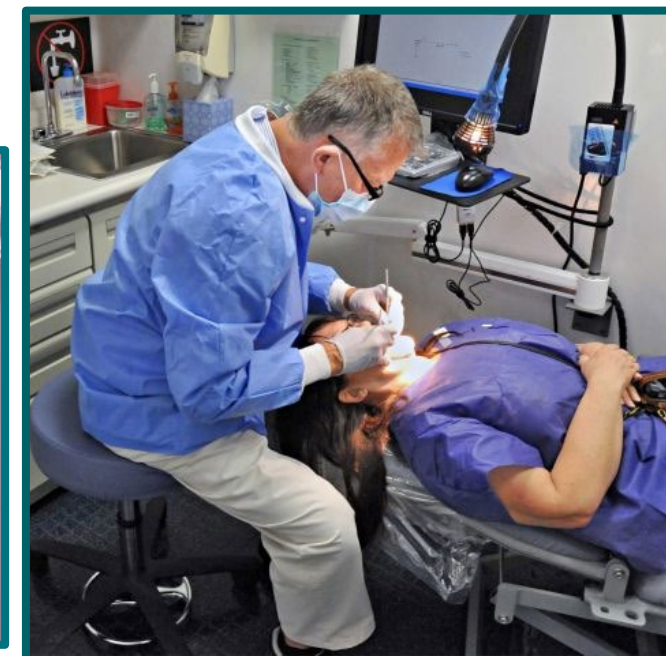
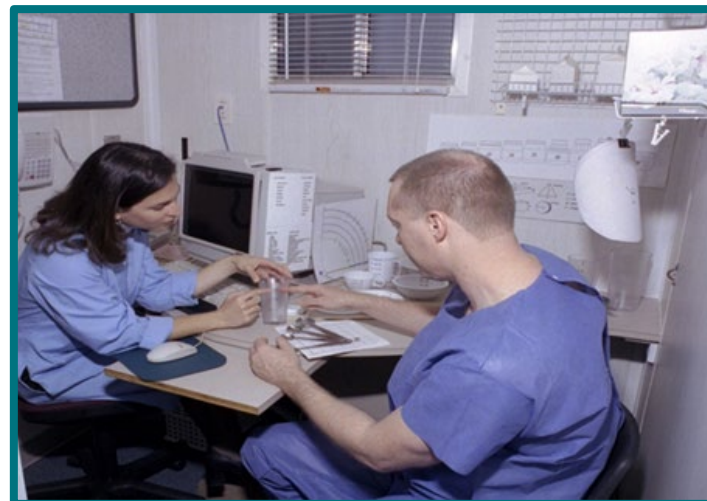
- Demographic information
- Health conditions
- Health insurance and healthcare use
- Prescription drugs and dietary supplements use



Mobile Examination Center



MEC Examinations



Exam measures differ by age and survey year

Table 3. Examination components: National Health and Nutrition Examination Survey, 1999–2022



		Component or laboratory test conducted on original sample description Change from original sample description Component or laboratory test not conducted											
Component	Sample description	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014	2015–2016	2017–2018	2019–2020	2021–2022
Arthritis body measures	20–69 years												
Audiometry	1/2 sample (20–69 years)												
Balance	1/2 sample (40–69 years)												
Bioelectrical impedance analysis	8–49 years												
Blood pressure	8 years and over												
Body measurements	All ages												
Cardiovascular (CV) fitness	12–49 years												
Cognitive functioning	60 years and over												
Dermatology	20–59 years												
Dietary	All ages												
Dietary supplement	All ages												
Dual energy x-ray absorptiometry	8 years and over												
Abdominal aortic calcification	40 years and over												
Body composition	8 years and over												
Bone density—Hip and spine	8 years and over												
Vertebral fracture assessment	40 years and over												
Grip strength test	6 years and over												
Liver ultrasound transient elastography	12 years and over												
Lower extremity disease	40 years and over												
Peripheral neuropathy	40 years and over												
Peripheral vascular disease	40 years and over												
Ophthalmology	40 years and over												
Retinal photo	40 years and over												
Visual fields	40 years and over												
Oral health	2 years and over												
Dental fluorosis imaging	6–19 years												
Physical activity monitor	6 years and over												
Muscle strength	50 years and over												

Complete list available:
<https://wwwn.cdc.gov/nchs/data/nhanes/survey-contents-508.pdf>



Laboratory Tests

- In a 2-year cycle, NHANES runs ~500 assays in over 22 laboratories
- Each assay is run at only one lab to minimize method effects
- Examples include:
 - Environmental exposures such as lead, arsenic, mercury, pesticides, & flame retardants
 - Infectious disease profiles such as Hepatitis B and C, HIV, chlamydia, & cytomegalovirus
 - Nutritional biomarkers such as Vitamin D, retinol, fatty acids, and folate
 - Chronic disease profiles such as urine albumin for kidney disease, TSH for thyroid disease, hemoglobin A1C for diabetes, and a lipid profile for cardiovascular disease

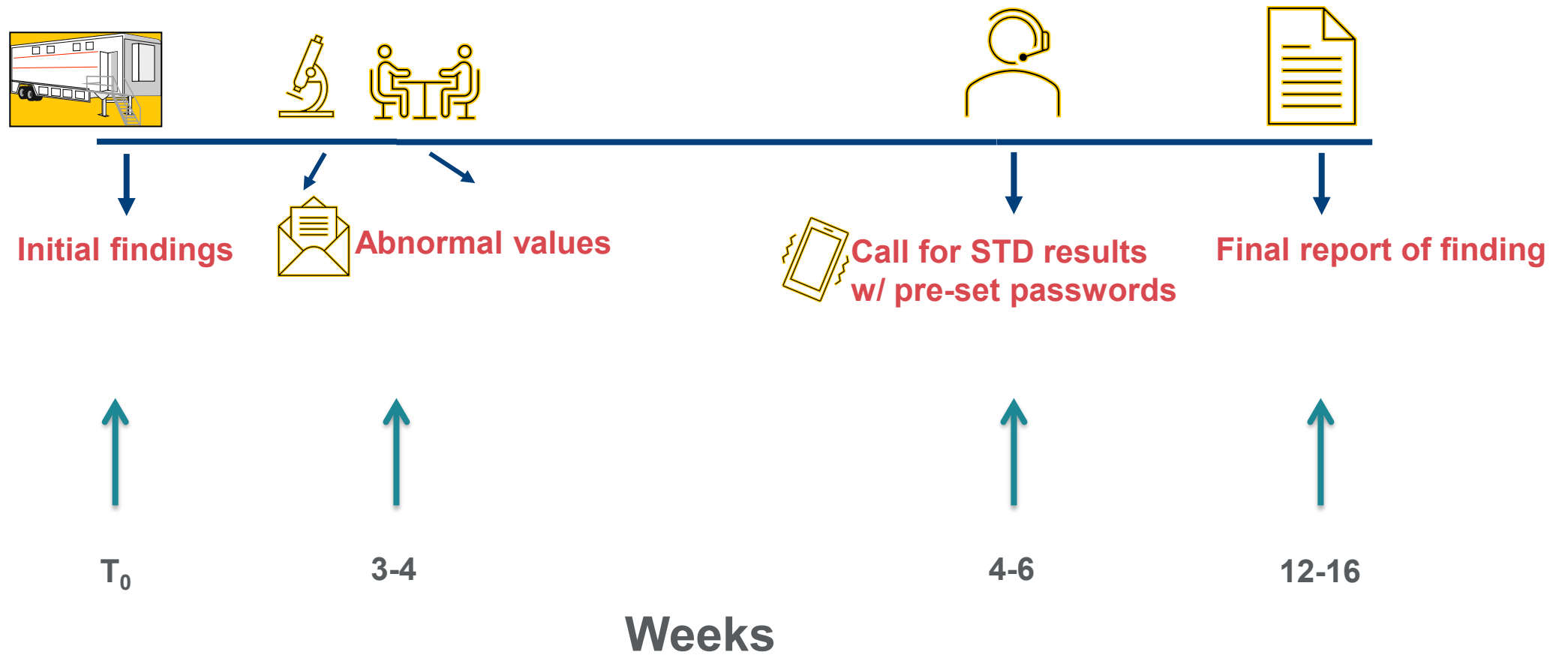
Report of Findings



Current Standard for Report of Findings Determination

- For an NHANES result to be reported, it must be “clinically actionable” for participant and/or medical provider
 - The findings are valid and, in the case of laboratory tests, done by a Clinical Laboratory Improvement Amendments (CLIA)-certified laboratory;
 - The findings may have significant implications for the subjects’ health concerns; and
 - A course of action to ameliorate, or treat the concerns is readily available.

Timing for Report of Findings



What's in the Final Report of Findings?



The final report of findings includes all clinically actionable findings and is mailed within 12-16 weeks following the participants' exams

Results Provided:

- Identifying information
- Height and weight
- Blood pressure & Heart Rate

These measurements were obtained as part of a survey and do not represent a medical diagnosis.
Interpretation of these measurements must be made by a physician.

Date of Examination:	DATE
Participant Name:	Participant
Participant Age at Interview:	xx years
Participant Age at Exam:	xx years
Participant Gender:	Female
SP ID:	123456

Body Measurements

Height:	5 ft. 4 in.
Weight:	122.9 lbs.

Blood Pressure & Heart Rate

ADULT (ages 18 years and up)		Normal
Systolic Blood Pressure:	118 mm Hg	< 120
Diastolic Blood Pressure:	76 mm Hg	< 80
Resting Pulse Rate:	88	
Cuff Size:	Adult	

Your blood pressure today is within the normal range based on the American Cardiology Association (ACC) and the American Heart Association (AHA) Hypertension Guidelines for Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. American Journal of Hypertension, 2018; 31 (2):133-135.

CHILD (ages 8-17 years)	
Systolic Blood Pressure:	105 mm Hg
Diastolic Blood Pressure:	65 mm Hg
Resting Pulse Rate:	94
Cuff Size:	Child

Your child's blood pressure today is within the normal range based on the American Academy of Pediatrics (AAP) Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Pediatrics 2017; 140 (3):e20171904

What's in the Final Report of Findings?



Results Provided:

- Complete blood count

Complete Blood Count

	Result	Units	Flag	Reference Range
White Blood Count	7.0	$\times 10^9/L$		4.1 - 12.9
Lymphocytes	21.8	%		14.1 - 47.6
Monocytes	4.7	%		3.8 - 11.6
Neutrophils	56.6	%		39.8 - 78.1
Eosinophils	0.6	%		0.6 - 7.3
Basophils	1.4	%		0.1 - 1.7
Red Blood Count	4.7	$\times 10^{12}/L$		3.6 - 5.2
NRBC	0.0	$\times 10^{12}/L$		0.0 - 0.3
Hemoglobin	12.7	g/dL		10.6 - 15.6
Hematocrit	38.0	%		32.0 - 45.9
MCV	80.8	fL		74.6 - 98.2
MCH	26.0	pg		24.3 - 33.8
MCHC	33.4	g/dL		32.1 - 35.3
RDW	14.5	%		11.4 - 16.3
Platelet Count	360	$\times 10^9/L$		168 - 441



--- Test not done
A/A/W Results still pending
<<< Lower than the limit of detection
>>> Above the limit of detection
v/vv Delayed results

Number of hours fasted prior to blood draw: 22

What's in the Final Report of Findings?

Results Provided:

- Blood Tests



Blood Tests

	Result	Units	Flag	Reference Range
Glucose	85	mg/dL		60 - 109
Hemoglobin A1c	4.6	%		< 6.5
ALT	10	IU/L		< 31
AST	11	IU/L		< 31
Alkaline Phosphatase	60	IU/L		39 - 117
Albumin	3.3	g/dL		3.2 - 5.2
Bicarbonate	20	mmol/L	Low	22 - 29
BUN	7	mg/dL		6 - 19
Calcium	10.0	mg/dL		8.4 - 10.2
Cholesterol	182	mg/dL		< 200
CPK	30	IU/L		22 - 199
Triglycerides	87	mg/dL		< 150
HDL	66	mg/dL		> 39
Phosphorus	4.1	mg/dL		2.6 - 4.5
Sodium	136	mmol/L		133 - 145
Potassium	4.00	mmol/L		3.30 - 5.10
Chloride	102	mmol/L		96 - 108
Total Protein	6.9	g/dL		5.9 - 8.4
Uric Acid	3.7	mg/dL		2.4 - 5.7
Bilirubin	0.2	mg/dL		0.0 - 1.0
Serum Folate	48.8	nmol/L		10.5 - 90.7
RBC Folate	1610	nmol/L		640 - 2006
Serum Ferritin	48	µg/L		15 - 150
Iron	63	µg/dL		22 - 163
Total Iron Binding Capacity (TIBC)	344	µg/dL		250 - 450
Transferrin Saturation	18	%	Low	20 - 50
Lead	0.5	µg/dL		0.0 - 10.0
Vitamin D	vvv	µg/dL		
Cadmium	0.1	µg/L		0.3 - 1.2
Total Blood Mercury	0.6	µg/L		< 5.7
Testosterone	500	µg/dL		250-1100
Thyroglobulin	5	ng/ml		1.5-29.2
TSH	4	mIU/dL		0.45-4.12
Follicle Stimulating Hormone	12	mIU/mL		Varies individually
Lutenizing Hormone	15	mIU/mL		Varies individually

--- Test not done
 A/A/ Results Still Pending
 <<< Lower than the limit of detection
 >>> Above the limit of detection
 vvv Delayed Results

Number of hours fasted prior to blood draw: 22

What's in the Final Report of Findings?



Results Provided:

- Urine Tests
- Kidney Health

Urine Tests

	Result	Units	Flag	Reference Range
Albumin Creatinine Ratio - 1st Collection	7.17	mg/g		< 30.00
Total Arsenic	---	µg/L		
Urinary Nickel	---	µg/L		

Kidney Health

Your kidneys filter your blood and help control blood pressure. We checked how healthy your kidneys are by calculating your estimated glomerular filtration rate (eGFR). This is not a meaningful test if you are very muscular.

Your estimated glomerular filtration rate (eGFR) was 120 mL/min/1.73m²

This indicates normal function

This value is not meaningful for pregnant women, individuals with acute kidney failure, people with extreme body size or muscle mass (such as individuals who are bodybuilders, extremely obese or severely malnourished), and people on vegetarian or low-meat diets or taking creatine dietary supplements.

--- Test not done
A/A/A/ Results Still Pending
<<< Lower than the limit of detection
>>> Above the limit of detection
vvv Delayed Results

What's in the Final Report of Findings?

Results Provided:

- Body Composition
- Liver Elastography
- Balance



Body Composition

The whole-body scan provides information on your percent body fat.

The body composition exam results showed that your total body fat is ____%.

We do not know exactly what percent body fat is considered healthy for your age and gender. Researchers are working to define the healthy ranges for the public. You may want to discuss this result and your body measurement findings (page 1) with your doctor to find out what they mean for you. Too much body fat can increase a person's risk of getting diabetes or heart disease.

Liver Elastography

Liver elastography measures the stiffness of your liver. In general, having liver stiffness may indicate liver damage.

Information from your liver ultrasound exam showed a value of 3.60 kiloPascals (kPa).

A scoring system (1), was used to interpret your result. Using this recommended scoring system, the result showed you have little or no liver stiffness. No additional follow-up regarding this test is recommended at this time.

1. Published in GASTROENTEROLOGY 2005;128:343–350.

Balance

You performed a Modified Romberg test for balance during your examination. This screening test is listed by the Centers for Medicare and Medicaid (CMS) Physician Quality Reporting System for fall risk assessment.



Returning Results - Additional notes

- NHANES has limited short-duration contact with participants (i.e., NHANES initiates its last contact with participants ~12-16 weeks following the exam)
- The mobile examination center is not a treatment facility and no health care is provided
- NHANES prepares lists of local clinics in advance of operations and provides recommendations for referral, if necessary
- NHANES does not pay for any follow-up health care

Future Direction



Looking to the future



National Health and Nutrition Examination Survey

New Content and Proposal Guidelines

[Print](#)

July 26, 2022

The Division of Health and Nutrition Examination Surveys has moved into the next phase of the 2024 NHANES redesign. If you have been invited to submit a full examination or laboratory proposal for consideration, please use these [Proposal Guidelines](#).

At this time, we have not yet sent out invitations for submission of full proposals involving only questionnaire component(s). Anticipated timeframe for questionnaire proposal invitation is the second week of August.

If you have any questions about the Proposal Guidelines or the process, please email us at DHANES_PB@cdc.gov.

Sincerely,

David A. Woodwell
Chief, Planning Branch
Division of Health and Nutrition Examination Surveys
National Center for Health Statistics
Centers for Disease Control and Prevention

- In summer 2022, NHANES began solicitation of interview, exam, and lab content for its next data collection cycle
- This workshop will inform incorporating genomics into NHANES future data collection cycles



NHANES Website:
<https://www.cdc.gov/nchs/nhanes/index.htm>

Thank you



Biospecimen Program

Alan E. Simon, MD

Director, Division of Health and Nutrition Examination Surveys

National Center for Health Statistics

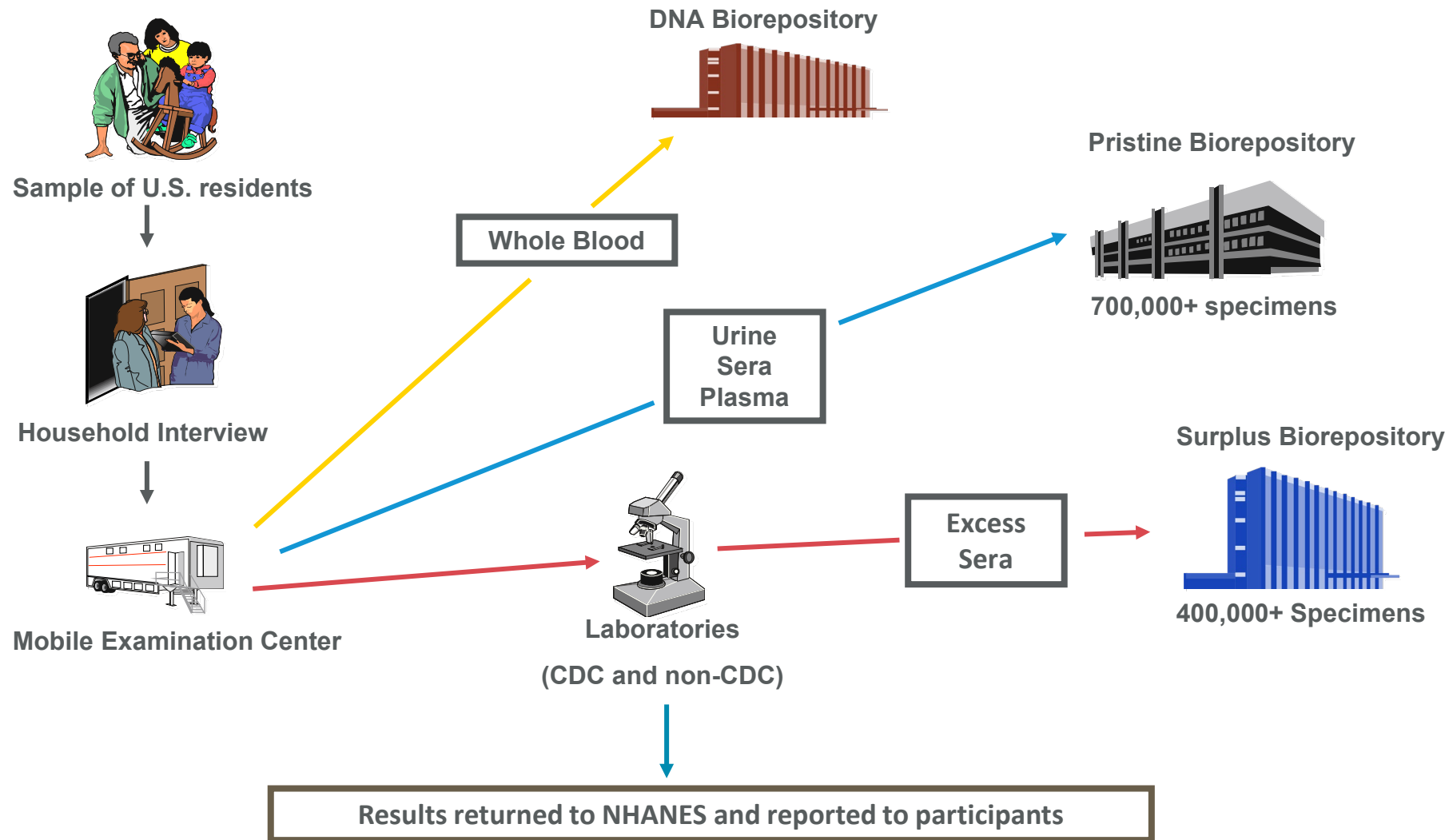
NHANES Biospecimen Program

- Prospectively, extends the life of the survey by providing resources for future research.
- Retrospectively, allows for understanding of emerging infections and chemical exposures.

Overview



Mobile Examination Center to Biorepository



Biospecimen Program

- Sera, Plasma and Urine
 - Over 1 million samples available
 - NHANES III to present
 - Age 3+
- DNA
 - Available from 20,000+ participants
 - NHANES III, 1999-2002 and 2007-2012
 - Ages 20+
- An approved proposal is required to obtain samples
 - Over 135 proposals since 1993 for serum, plasma, urine specimens
 - Over 28 proposals since 2000 for DNA specimens

Proposal Process



Proposal Process

- Submit proposal to NHANES
- Scientific Review
 - NHANES Project Officer
 - Technical Panel – Scientific and technical merit
- Institutional Review
 - NCHS Human Subjects Contact
 - NCHS Confidentiality Officer
 - NCHS Research Ethics Review Board
- Distribute Specimens

Proposal Process - Caveat

- Only proposals with test results that are determined *not* to have clinical significance for participants will be accepted.
- One Clinical Significance Criterion
 - For serum, plasma, urine: Findings valid, done by CLIA-certified laboratory
 - For DNA: included as part American College of Medical Genetics and Genomics (ACMG) recommendations for reporting secondary findings.

Resulting Data



Resulting Data from Biospecimen Program

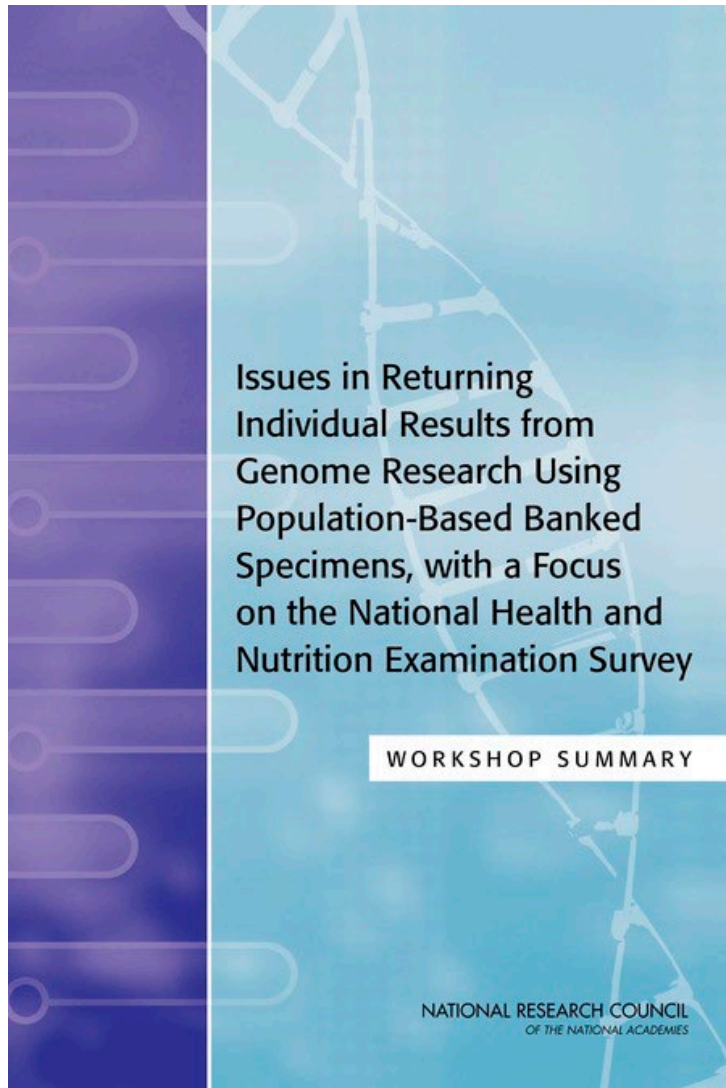
- Public Use
 - Available online with data documentation
- Limited Access
 - PII, indirect PII and sensitive data
 - Examples: genetic variants, geocoded, adolescents STI/STD
 - Available in the NCHS Research Data Center

2014 Workshop: Issues in Returning Individual Results from Genome Research Using Population-Based Banked Specimens, with a Focus on the National Health and Nutrition Examination Survey

Statement of Task

How population surveys should address implementation of reporting of results from genomic research using **banked specimens**, identify options for reporting results and their advantages and challenges.

Results for NHANES



- In 2016 based on discussions from the previous workshop, NHANES provided new requirements for proposals using the DNA repository:
 - New DNA research could not generate clinically significant results, based on the most recent American College of Medical Genetics and Genomics (ACMG) recommendations
 - However, NHANES did not resolve the issue of informed consent and returning results for large-scale genetic testing during active data collection

Take away



NHANES is seeking to understand how to approach reporting of genomic results to participants.

NHANES is seeking to better understand how to address consent and return of results as we store DNA for future research.

NHANES Biospecimen Program Website:
<https://www.cdc.gov/nchs/nhanes/biospecimens/biospecimens.htm>

Thank you