



# Wave IV Biomarkers – Overview

- Types + updates
- Measures & Classification + updates
- Collection Sequence
- Collection Methods
- Central Labs
- QA/QC + updates
- Discussion



## Wave IV Biomarkers – Types

- Cardiovascular
- Anthropometric
- Metabolic
- Immune
- Inflammatory
- Genetic
- **Hematologic**
- [Pharmacologic]



## Wave IV Biomarkers – Measures

- Cardiovascular
  - Primary
    - systolic blood pressure (SBP)
    - diastolic blood pressure (DBP)
    - pulse rate (PR)
  - Secondary
    - pulse pressure ( $PP = SBP - DBP$ )
    - mean arterial pressure ( $MAP = [SBP + 2 \cdot DBP] \div 3$ )



## Wave IV Biomarkers – Measures

- Cardiovascular
  - Classified according to Joint National Committee VII guidelines\*
    - $< 120/80$  mm Hg                      Normal
    - 120-139/80-89 mm Hg                  Pre-Hypertension
    - 140-159/90-99 mm Hg                Stage 1 Hypertension
    - $\geq 160/100$  mm Hg                  Stage 2 Hypertension

\*The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7). Hypertension 2003;42:1206.



## Wave IV Biomarkers – Measures

- Anthropometric
  - Primary
    - weight
    - height
    - waist circumference (waist)
  - Secondary
    - body mass index ( $\text{BMI} = \text{weight in kg} / \text{height in m}^2$ )



## Wave IV Biomarkers – Measures

- Anthropometric
  - Classified according to NHLBI Evidence Report\*
    - $< 18.5 \text{ kg/m}^2$  Underweight
    - $18.5\text{-}24.9 \text{ kg/m}^2$  Normal
    - $25.0\text{-}25.9 \text{ kg/m}^2$  Overweight
    - $30.0\text{-}34.9 \text{ kg/m}^2$  Obesity, Stage I
    - $35.0\text{-}39.9 \text{ kg/m}^2$  Obesity, Stage II
    - $\geq 40.0 \text{ kg/m}^2$  Obesity, Stage III

\*Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults – the evidence report. Obesity Res 1998;6(S2):51S-210S.



## Wave IV Biomarkers – Measures

- Metabolic, lipids\*
  - Primary
    - total cholesterol (TC)
    - high density lipoprotein cholesterol (HDL-C)
    - triglycerides (TG)
  - Secondary
    - low density lipoprotein cholesterol ( $\text{LDL-C} = \text{TC} - \text{HDL-C} - \text{TG} / 5$ )<sup>†</sup>
    - TC:HDL-C ratio ( $\text{TC:HDL-C} = \text{TC} / \text{HDL-C}$ )
    - non-HDL-C ( $= \text{TC} - \text{HDL-C}$ )

\*Random. †The Friedwald (1972) equation applies when  $\text{TG} < 400$ .





## Wave IV Biomarkers – Measures

- Metabolic, lipids\*
  - Classified according to National Cholesterol Education Panel Adult Treatment Panel III guidelines<sup>†</sup>

• TC (mg/dL)	< 200	desirable
	200-239	borderline high
	≥ 240	high
• HDL-C (mg/dL)	< 40	low
	≥ 60	high
• LDL-C (mg/dL)	< 100	optimal
	100-129	near optimal
	130-159	borderline high
	160-189	high
	≥ 190	very high
• TG <sup>‡</sup> (mg/dL)	< 150	normal
	150-199	borderline high
	200-499	high
	≥ 500	very high

\*Random. <sup>†</sup>Third Report of the National Cholesterol Education Program (NCEP) on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). <sup>‡</sup>Spuriously high in the non-fasting state.

## Wave IV Biomarkers – Measures

- Metabolic, glucose homeostasis\*
  - Primary
    - glucose
    - glycosylated hemoglobin (HbA1c)
  - Secondary
    - mean plasma glucose ( $\text{MPG} = 35.6 \text{ HbA1c} - 77.3$ )<sup>†</sup>
    - estimated average glucose ( $\text{EAG} = 28.7 \text{ HbA1c} - 46.7$ )<sup>‡</sup>

\*Random. †Rohlfing et al. Diabetes Care 2002;25(2):275-278. ‡Nathan et al. Diabetes Care 2008;31(8):1-6.



## Wave IV Biomarkers – Measures

- Metabolic, glucose homeostasis\*
  - Classified according to American Diabetes Association and Endocrine Society guidelines†
    - fasting glucose
      - $\geq 126$  mg/dL      diabetes
      - 100-125 mg/dL      impaired
      - $\leq 99$  mg/dL      normal
    - random glucose
      - $\geq 200$  mg/dL      diabetes
    - HbA1c
      - $\geq 6.5\%$       diabetes
      - 5.7-6.4%      increased risk for diabetes

## Wave IV Biomarkers – Measures

- Immune / Inflammatory
  - Epstein-Barr virus antibody titer (EBV)
  - high sensitivity C-reactive protein (hsCRP)
    - classified according to Centers for Disease Control / American Heart Association guidelines\*
      - low < 1 mg/L
      - average 1-3 mg/L
      - high > 3 mg/L

\*Pearson et al. Markers of inflammation and cardiovascular disease. Application to clinical and public health practice. A statement for healthcare professionals from the CDC and AHA. *Circulation* 2003;107:499-511.



## Wave IV Biomarkers – Measures

- Hematologic
  - Hemoglobin (Hb)
    - gender-specific classification

	<u>Females</u>	<u>Males</u>
– low	< 12.0 g/dL	13.5 g/dL
– average	12.0-16.0 g/dL	13.5-17.5 g/dL
– high	> 16.0 g/dL	17.5 g/dL
    - above, if conversion of OD → g/dL possible



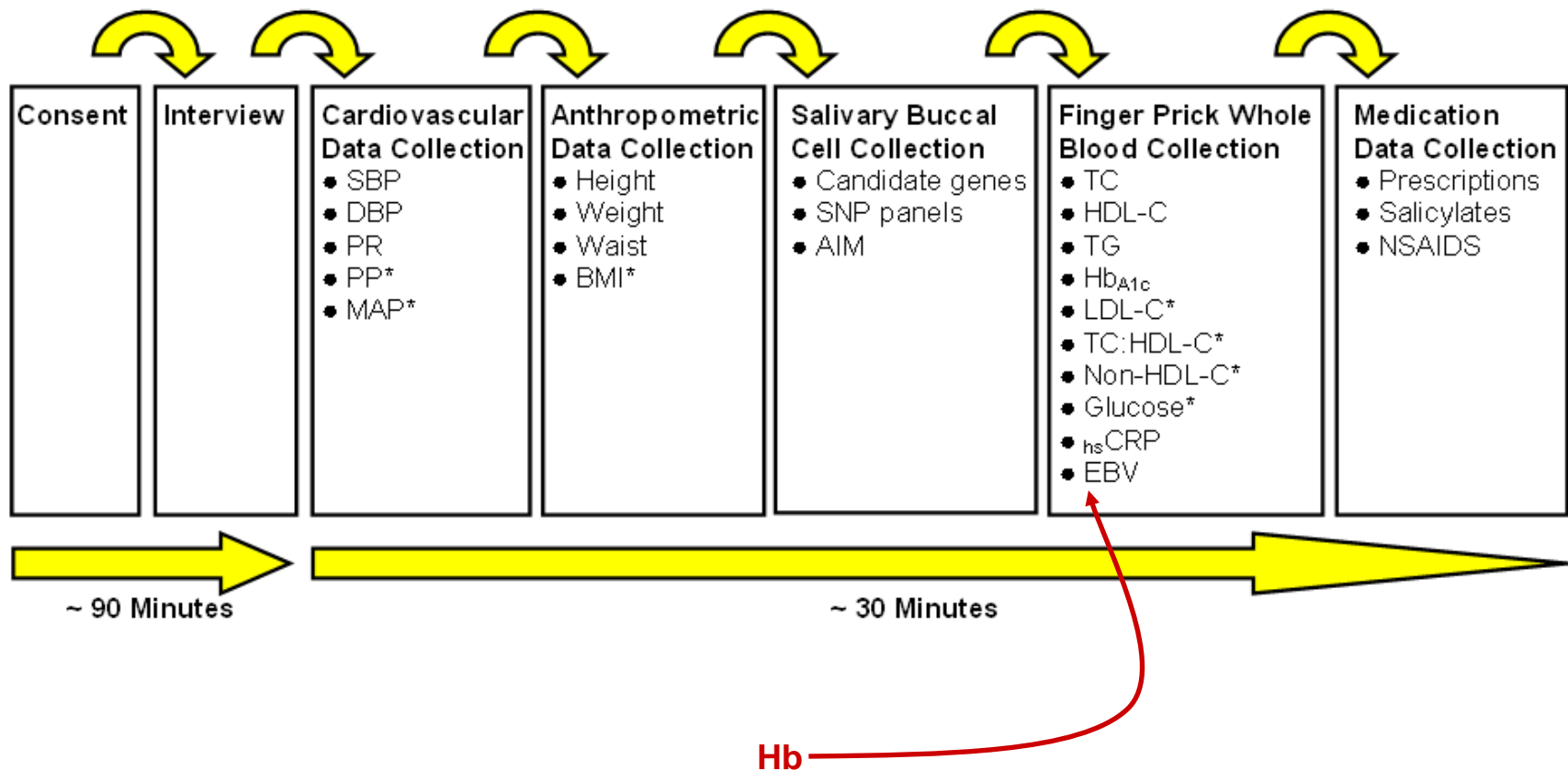
## Wave IV Biomarkers – Measures

- Genetic
  - candidate gene loci & SNP panels } focusing on DA, 5-HT & NA neurotransmission systems with known roles in behavior and health
  - ancestry informative markers (AIM)
  - **10<sup>6</sup> SNPs**
- Pharmacologic
  - prescription medications
  - select over-the-counter medications (salicylates & NSAIDS)
  - classification according to Multum therapeutic category
    - examples

lisinopril ACEI	metoprolol BB
nifedipine CCB	hctz DIURETIC
clonidine CASM	
hydralazine VASODILATOR	




# Wave IV Biomarkers – Collection Sequence



\*Secondary

# Wave IV Biomarkers – Collection Methods

- Cardiovascular Data Collection Equipment

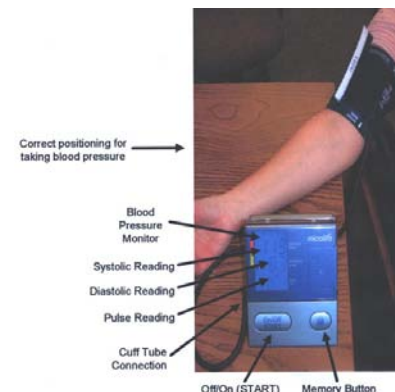
Measures	Equipment	Picture	Specifications
SBP	MicroLife		30-280/40-200 BP/PR range
DBP	3MC1-PC_IB		1-unit graduations
PR	Oscillometric		198 measure recall
PP*	BP		3 mmHg accuracy
MAP*	Monitor		5 beat pulse accuracy
			BHS-approved
			4 "AA" battery-powered
			w/ AC adapter + USB cable
			2 cuffs (24-41 cm)
			160 x 140 x 98 mm
			735 g (w/ batteries)
			< \$65

\*Secondary





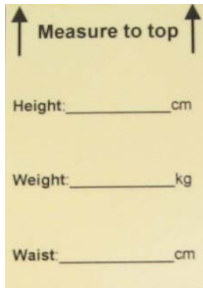
# Wave IV Biomarkers – Collection Methods

- Cardiovascular Data Collection Protocol
  - trained & certified staff
  - resting & seated respondents
  - cuff matched to arm circumference
  - SBP, DBP & PR
    - measure 3X
    - @ 30-sec intervals
    - double enter
    - automatically average over last 2




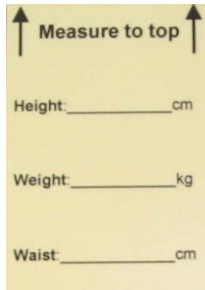
# Wave IV Biomarkers – Collection Methods

- Anthropometric Data Collection Equipment

Measure	Equipment	Pictures	Specifications
Height	Carpenter's Square		portable light weight inexpensive true 90 angle
	Tape Measure		10 ft steel tape
	Post-it Notes		adherent pre-labeled


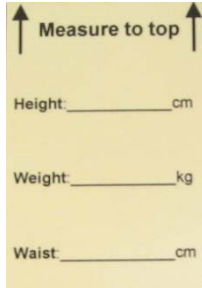
# Wave IV Biomarkers – Collection Methods

- Anthropometric Data Collection Equipment

Measure	Equipment	Pictures	Specifications
Weight	Health-O-Meter 844KL High Capacity Digital Scale	 	<b>4-point load cell</b> <b>digital display in lb / kg</b> <b>440 lb maximum</b> <b>0.1 lb graduations</b> <b>long life Li<sup>++</sup> battery</b> <b>low battery warning</b> <b>1-year warranty</b> <b>12.6 x 12.6 in</b> <b>4.5 lb</b> <b>&lt; \$70</b>

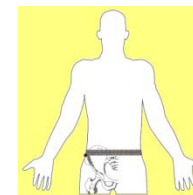
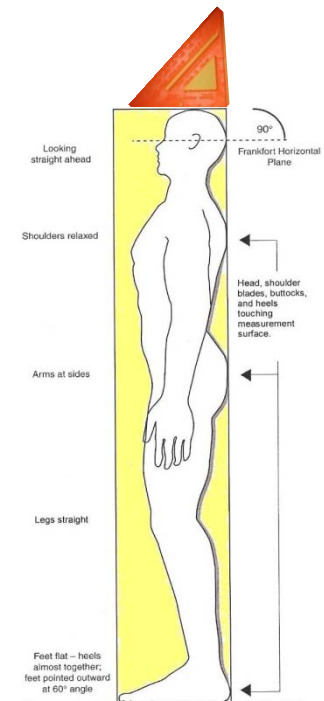
# Wave IV Biomarkers – Collection Methods

- Anthropometric Data Collection Equipment

Measure	Equipment	Pictures	Specifications
Waist	Seca 200 Circumference Tape Measure	 	200 cm maximum 2-sided cm scaling 1 mm graduations fiberglass tape plastic case automatic roll-up end-peg positioner 90 x 25 x 65 mm 50 g < \$13





# Wave IV Biomarkers – Collection Methods

- Anthropometric Data Collection Protocol
  - trained & certified staff
  - dressed & unshoed respondents
  - standing on uncarpeted floor
  - measure
    - height to nearest 0.5 cm
    - weight to nearest 0.1 kg
    - waist to nearest 0.5 cm
      - @ superior border of iliac crest
      - @ end expiration
      - horizontal to floor
    - hair/shoe height to nearest 0.5 cm, as needed



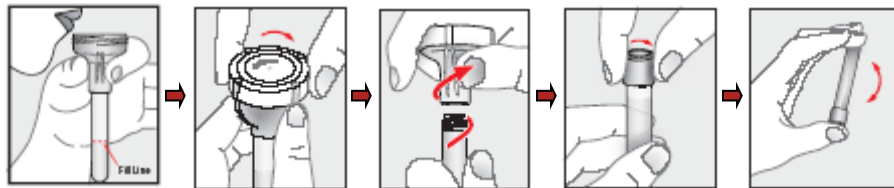
# Wave IV Biomarkers – Collection Methods

- Salivary Buccal Cell DNA Collection Equipment

Measures	Equipment	Schematic	Specifications
Genes SNP panels AIM	DNAGenotek Oragene•DNA Collection Kit	 ← Big cap  ← Funnel  ← Tube  ← Small cap	<b>collection funnel</b> <b>preservative-containing cap</b> <b>tube for storage</b> <b>small cap for shipping</b>

# Wave IV Biomarkers – Collection Methods

- Salivary Buccal Cell DNA Collection Protocol
  - trained & certified staff
  - respondents spit into funnel
  - remove funnel
  - turn big cap clockwise to add preservative
  - turn big cap counter-clockwise to remove it
  - replace big cap with small cap
  - invert 5X to mix saliva and preservative
  - package & FedEx to lab



# Wave IV Biomarkers – Central Labs

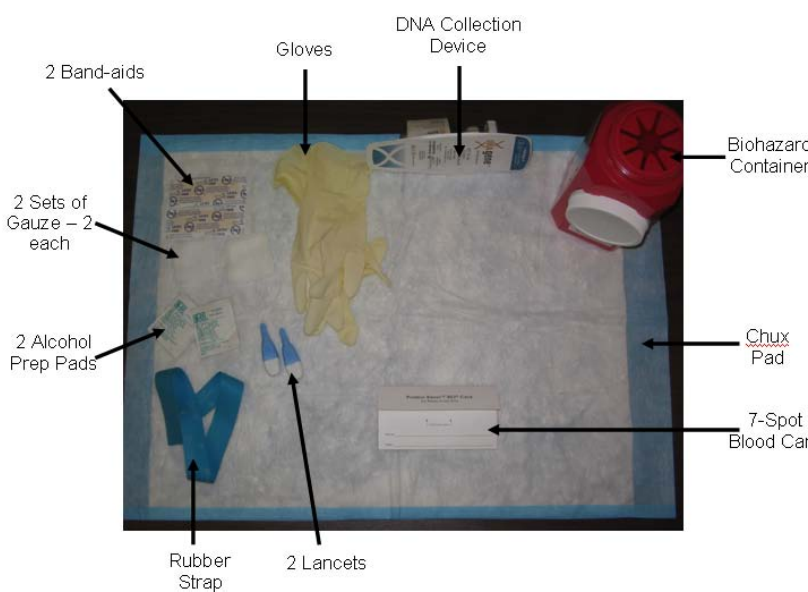
- Salivary Buccal Cell DNA
  - **Andy Smolen, Ph.D. (PI)**  
Director, Genotyping Laboratory  
Institute for Behavioral Genetics  
University of Colorado (Boulder, CO)





# Wave IV Biomarkers – Collection Methods

- Dried Whole Blood Spot Collection Equipment

Measures	Equipment	Workstation
TC	Gloves	
HDL-C	Band-aids	
TG	Gauze	
Hb <sub>A1c</sub>	Alcohol prep pads	
LDL-C*	Tourniquet	
TC:HDL-C*	Lancets	
Non-HDL-C*	7-spot cards	
Glucose*	Chux pad	
hsCRP	Biohazard container	
EBV		
<b>Hb</b>		

\*Secondary

# Wave IV Biomarkers – Collection Methods

- Dried Whole Blood Spot Collection Protocol
  - trained & certified staff
  - non-fasting respondents
  - clean middle or ring finger w/ alcohol prep pad
  - apply tourniquet to arm
  - prick finger & firmly wipe away 1<sup>st</sup> drop
  - drop up to 7 blood spots onto card
  - repeat prick X1, if necessary
  - air dry over desiccant
  - package & FedEx to lab

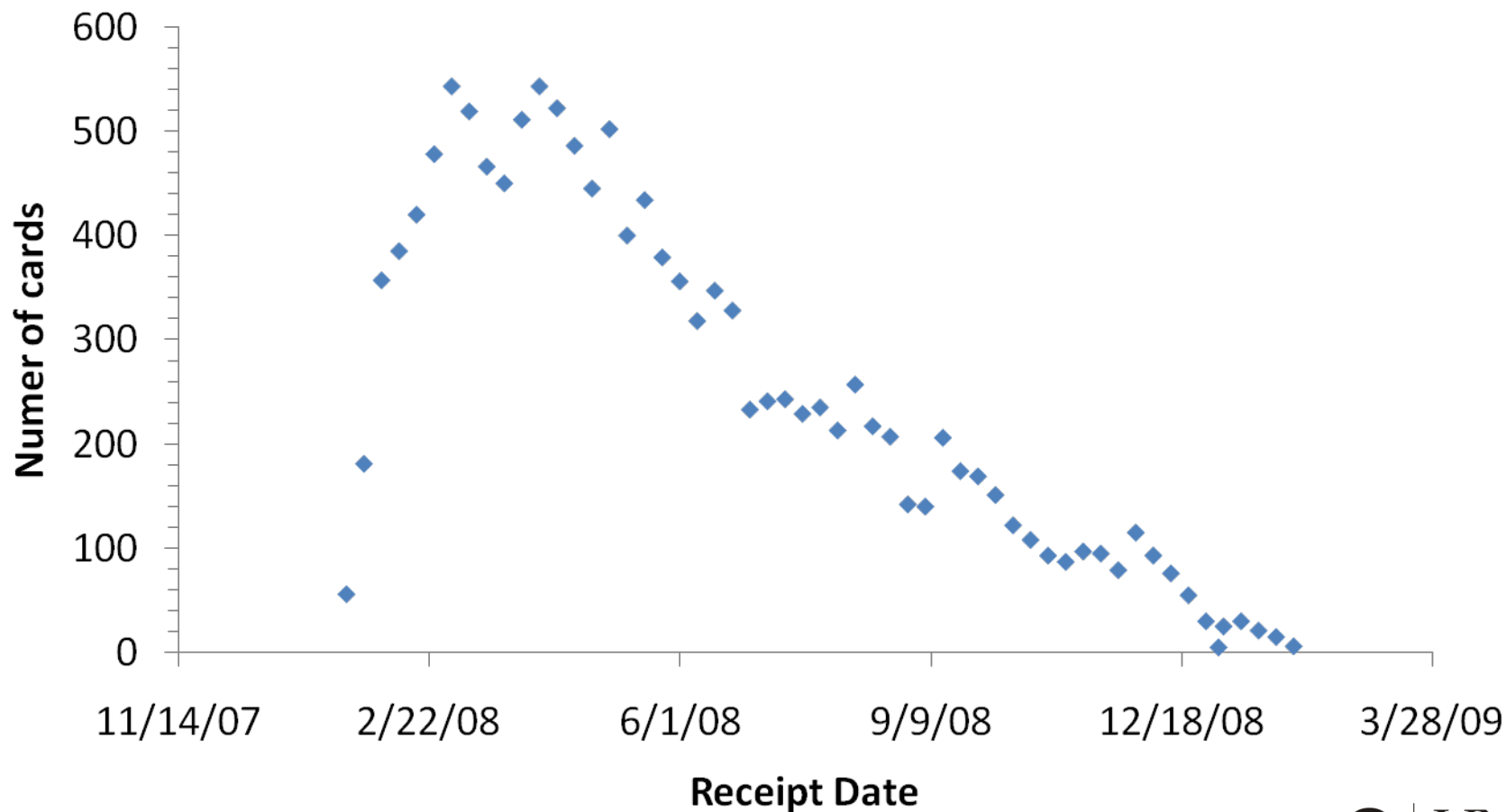


## Wave IV Biomarkers – Central Labs

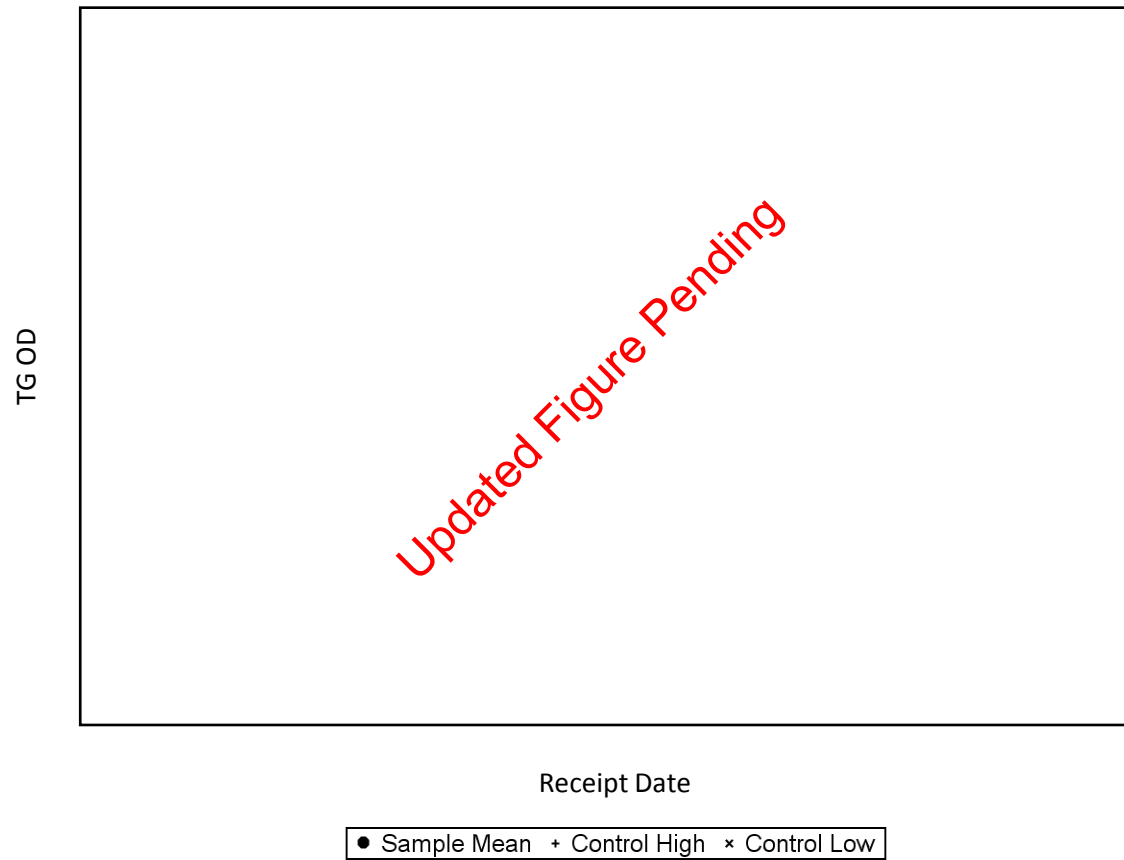
- Dried Whole Blood Spots
  - **Mark H. Wener, M.D. (PI)**  
Director, UW Medical Center Laboratories  
Department of Laboratory Medicine  
University of Washington (Seattle, WA)
  - **Robert Ray, Ph.D.**  
Director, FlexSite Diagnostics, Inc. (Palm City, FL)



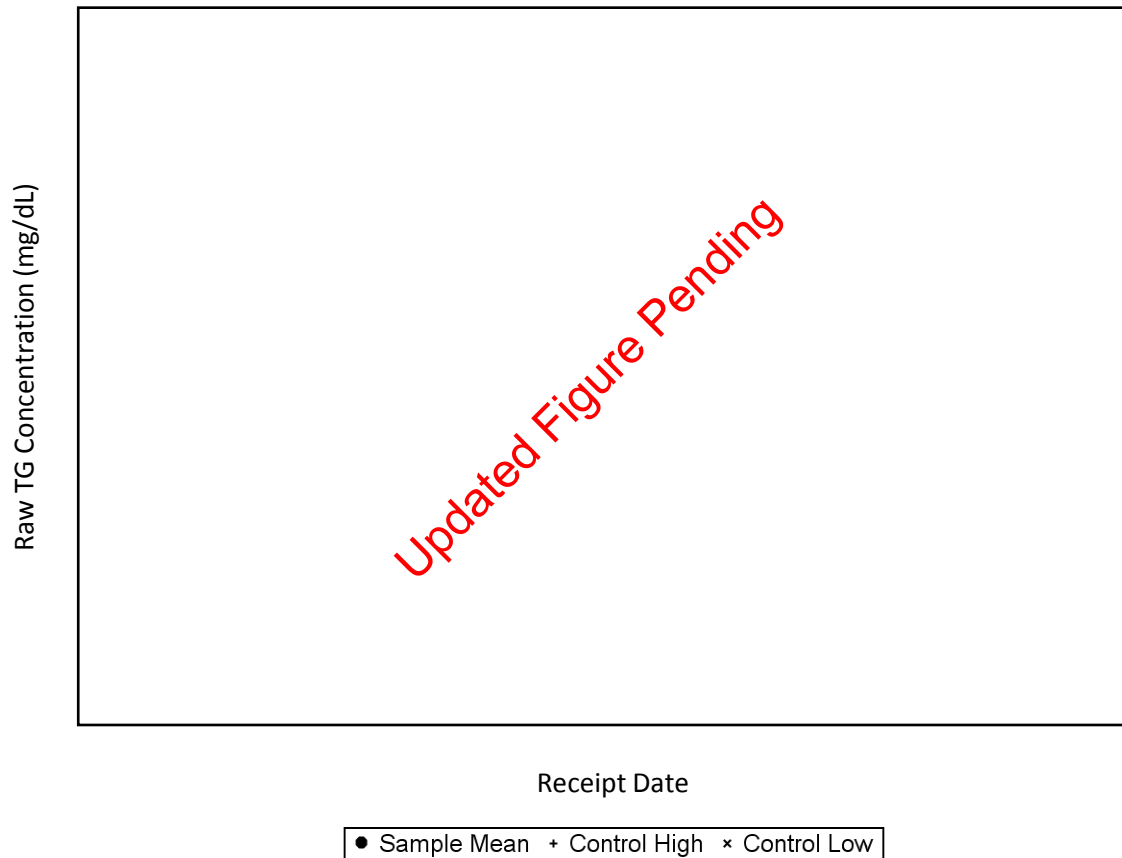
# Cards Received Per Week



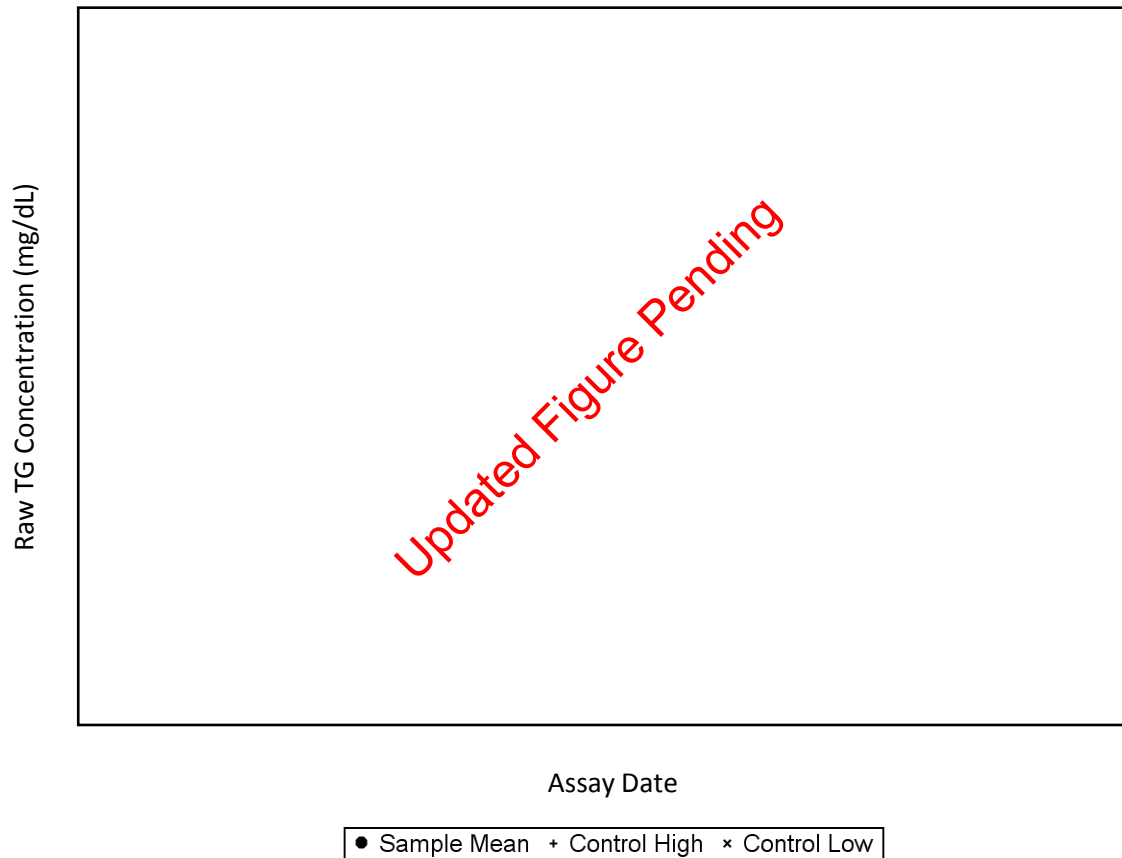
# Weekly Mean TG Optical Density



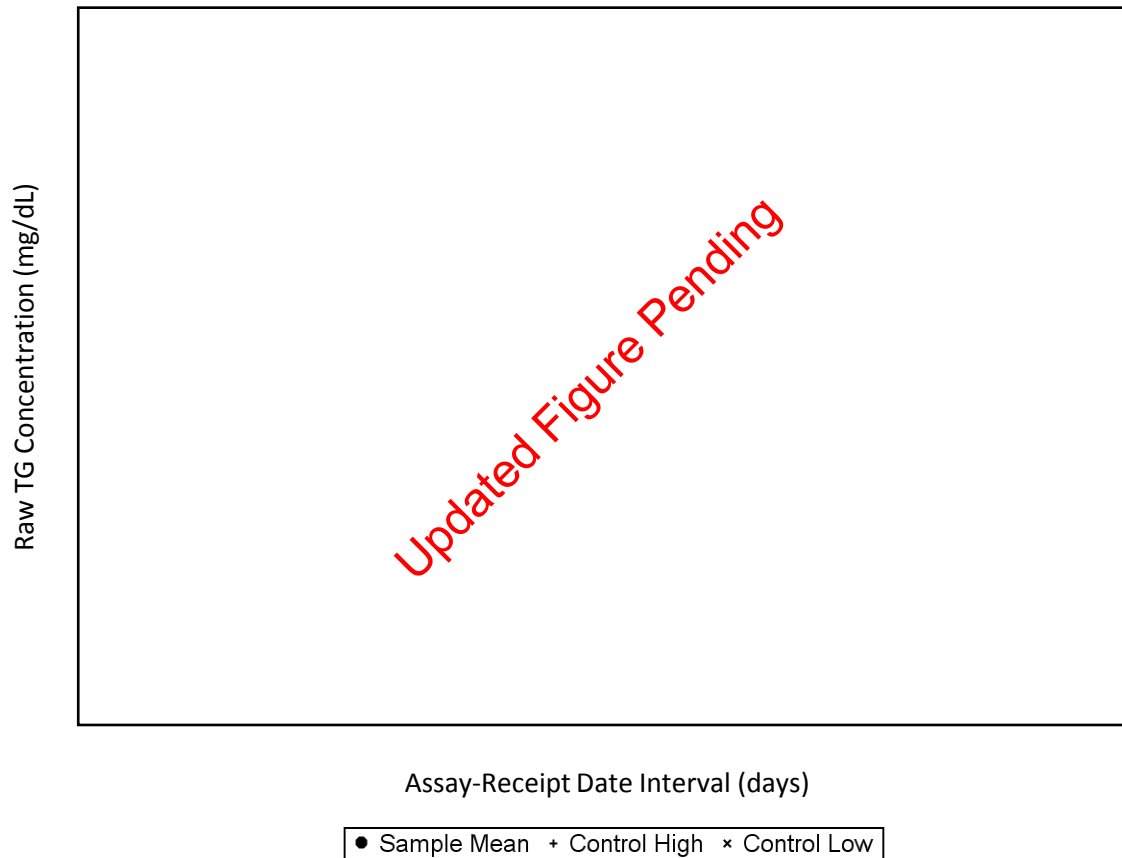
# Weekly Mean Raw TG Concentration



# Weekly Mean Raw TG Concentration

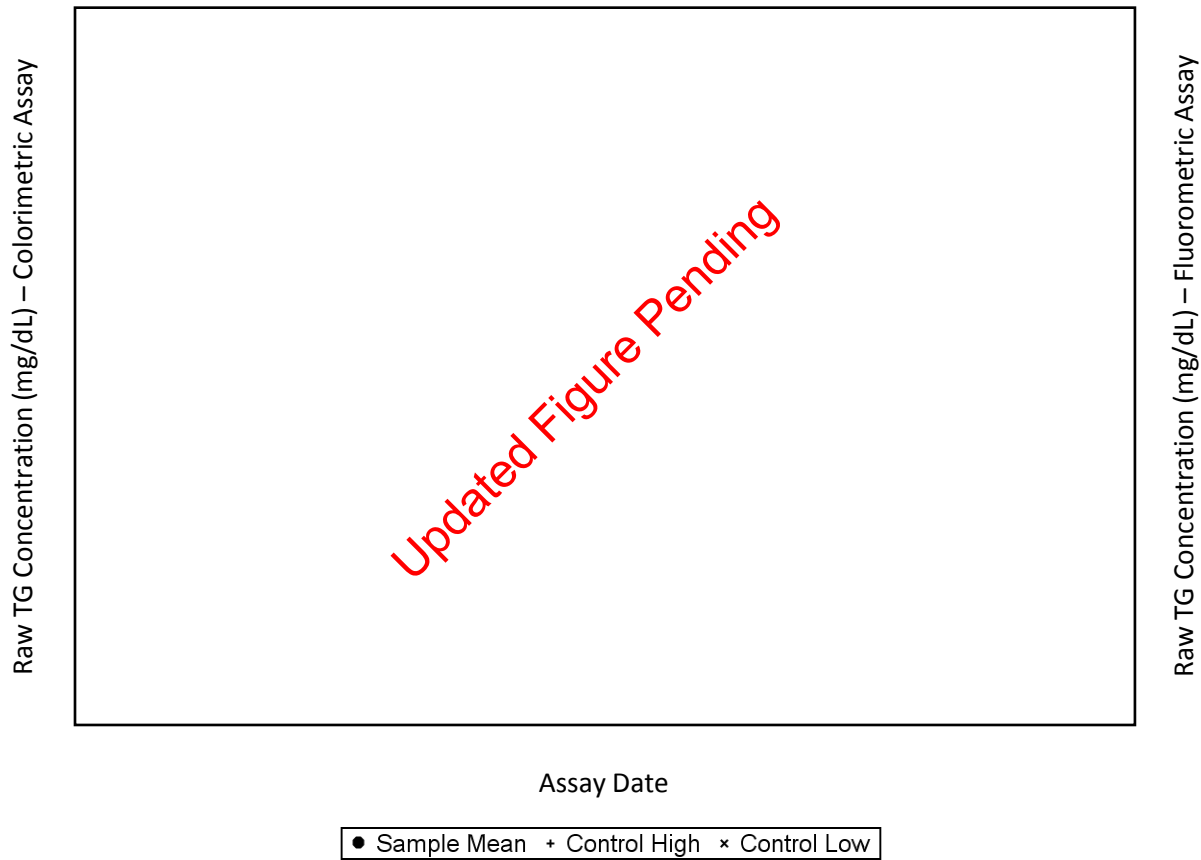


# Weekly Mean Raw TG Concentration





# Weekly Mean Raw TG Concentration



## Wave IV Biomarkers – QA/QC

- Issues
  - Conversion of Concentrations
    - OD → Raw → Plasma Equivalent
    - Colorimetric → Fluorometric
  - Trends in Concentrations Over
    - Receipt Dates
    - Assay Dates
    - Assay-Receipt Date Intervals
- Other Issues
  - Assay validity (colorimetric vs. criterion standard)
  - Intra-individual variation (visit 1 vs. 2)
  - Intra-sample variation (split sample 1 vs. 2)



## Wave IV Biomarkers – QA/QC

- Routine components
  - automated range checks
  - duplicate entry requirements
  - post-encounter verification interviews
- **External validation studies**
  - to assess digit preference
  - to assess accuracy
    - cardiovascular: BP monitor calibration
    - anthropometric: weight scale calibration
    - metabolic: lipid calibration
- **Inter-assay variation study**
  - to inform Colorimetric → Fluorometric conversion
- **Intra-individual variation study**
  - to assess short-term reliability



# Digit Preference

## DIGIT PREFERENCE IN ANTHROPOMETRIC VARIABLES ADD HEALTH WAVE IV, MAIN STUDY (2008-2009)

Variable	k	n	ChiSq	p	DPS
WEIGHT (kg)	10	15204	608.4	0.000	6.7
HEIGHT (cm)	10	15373	63.4	0.000	2.1
WAIST (cm)	10	15357	26.3	0.002	1.4

Sorted from high to low DPS. DPS = Hense (1991) digit preference score =  $100 * (\text{ChiSq} / (n * (k - 1)))^{0.5}$ . Range = 0-100. ChiSq = goodness of fit test stat, where  $n_i$  = observed cell freq &  $\sum(n_i/k)$  = expected cell freq in cell i. k = number of possible terminal digits, 0-9 by 1 for weight. k = number of possible penultimate digits, 0-9 by 1 for height and waist. p = p value.



# Digit Preference

Distribution of terminal digits,  
Add Health Wave IV, Main Study (2008-2009)

Weight	n	%
x.0	2369	(15.6)
x.1	1338	(8.8)
x.2	1426	(9.4)
x.3	1358	(8.9)
x.4	1331	(8.8)
x.5	1717	(11.3)
x.6	1482	(9.8)
x.7	1366	(9.0)
x.8	1484	(9.8)
x.9	1333	(8.8)



# Digit Preference

DIGIT PREFERENCE IN CARDIOVASCULAR VARIABLES  
ADD HEALTH WAVE IV, MAIN STUDY (2008-2009)

Variable	k	n	ChiSq	p	DPS
SBP2 (mm Hg)	10	15298	19.3	0.023	1.2
SBP1 (mm Hg)	10	15347	12.5	0.187	1.0
SBP3 (mm Hg)	10	15222	11.7	0.230	0.9
DBP1 (mm Hg)	10	15347	67.9	0.000	2.2
DBP3 (mm Hg)	10	15222	61.8	0.000	2.1
DBP2 (mm Hg)	10	15298	45.0	0.000	1.8
PR1 (beat/min)	10	15262	18.7	0.028	1.2
PR3 (beat/min)	10	15137	10.4	0.319	0.9
PR2 (beat/min)	10	15210	10.0	0.349	0.9

Sorted from high to low DPS. DPS = Hense (1991) digit preference score =  $100 * (\text{Chisq} / (n * (k - 1)))^{0.5}$ . Range = 0-100. Chisq = goodness of fit test stat, where  $n_i$  = observed cell freq &  $\sum(n_i/k)$  = expected cell freq in cell i. k = number of possible terminal digits, 0-9 by 1 for weight. p = p value.



# Digit Preference

Terminal Digit Preference of Blood Pressure, Add Health Wave IV

Terminal Digit	SBP Measure			DBP Measure		
	1	2	3	1	2	3
	n (%) <sup>b</sup>	n (%) <sup>b</sup>	n (%) <sup>b</sup>	n (%) <sup>b</sup>	n (%) <sup>b</sup>	n (%) <sup>b</sup>
0	1606 (10.5)	1630 (10.7)	1626 (10.7)	1591 (10.4)	1637 (10.7)	1599 (10.5)
1	1545 (10.1)	1517 (9.9)	1519 (10.0)	1445 (9.4)	1442 (9.4)	1411 (9.3)
2	1560 (10.2)	1500 (9.8)	1492 (9.8)	1667 (10.9)	1685 (11.0)	1700 (11.2)
3	1590 (10.4)	1554 (10.2)	1462 (9.6)	1753 (11.4)	1628 (10.6)	1682 (11.1)
4	1538 (10.0)	1598 (10.5)	1560 (10.3)	1558 (10.2)	1468 (9.6)	1490 (9.8)
5	1491 (9.7)	1453 (9.5)	1502 (9.9)	1476 (9.6)	1467 (9.6)	1476 (9.7)
6	1509 (9.8)	1533 (10.0)	1525 (10.0)	1419 (9.3)	1529 (10.0)	1508 (9.9)
7	1500 (9.8)	1445 (9.5)	1527 (10.0)	1506 (9.8)	1478 (9.7)	1445 (9.5)
8	1552 (10.1)	1533 (10.0)	1507 (9.9)	1476 (9.6)	1503 (9.8)	1442 (9.5)
9	1456 (9.5)	1535 (10.0)	1502 (9.9)	1456 (9.5)	1461 (9.6)	1469 (9.7)
Pearson $\chi^2$	12.49	19.26	11.71	67.90	44.99	61.76
<i>P</i> value	0.187	0.023	0.230	<0.001	<0.001	<.0001
DPS <sup>a</sup>	0.95	1.2	0.9	2.2	1.8	2.1

<sup>a</sup>DPS = digit preference score (see methods). <sup>b</sup>Unweighted sample size and percent.



# Digit Preference

FI 122		
SBP3	n	%
95	1	(1)
99	1	(1)
100	2	(2)
101	1	(1)
105	1	(1)
108	3	(3)
110	9	(8)
112	4	(4)
113	1	(1)
114	2	(2)
115	3	(3)
116	5	(5)
118	15	(14)
119	2	(2)
120	36	(32)
122	5	(5)
124	6	(5)
128	6	(5)
130	5	(5)
132	1	(1)
134	2	(2)

FI 122		
DBP3	n	%
60	5	(5)
61	1	(1)
62	4	(4)
64	2	(2)
65	4	(4)
67	2	(2)
68	2	(2)
69	6	(5)
70	32	(29)
72	9	(8)
74	5	(5)
75	11	(10)
76	2	(2)
78	4	(4)
79	1	(1)
80	16	(14)
82	2	(2)
84	2	(2)
85	1	(1)





# Digit Preference

- Summary
  - affects relatively few FIs & participants
  - yet some FI / participant data
    - consistently affected
    - severely affected
  - highly suspect FI data has been deleted & flagged



# BP Monitor Calibration



# BP Monitor Calibration

- Standard protocol (Dec 2008 – Jul 2009)
  - involved two technicians
  - inspected 292 monitor/cuff pairs returned from the field
    - damage
    - missing parts
    - electronic malfunction
  - attached large adult cuff to 37 cm rigid cylinder
  - connected in tandem with
    - BP monitor (Microlife 3MC1-PC\_IB)
    - Pressure meter (Netech DigiMano, Model 2000)
  - recorded pressures over 280-40 mm Hg in 20-unit dec
  - attached adult cuff to 28.5 cm rigid cylinder
  - repeated pressure recordings



# BP Monitor Calibration

## Microlife Blood Pressure Monitor Calibration

Tech ID: \_\_\_\_\_ FI Cuff: \_\_\_\_\_ FI Monitor: \_\_\_\_\_ Test Date: \_\_\_\_\_ Cuff: ADULT or LARGE ADULT

### Visual Check

- ♦ TUBE HAS CRACKING? ..... Y   N   NO MATCHING TUBING
- ♦ TUBE HAS HOLES? ..... Y   N   NO MATCHING TUBING
- ♦ CUFF HAS WORN OUTER CLOTH OR VELCRO? ..... Y   N   NO MATCHING CUFF
- ♦ TUBE LEAKS? ..... Y   N   NO MATCHING TUBING
- ♦ CUFF HAS LEAKAGE OF CUFF BLADDER? ..... Y   N   NO MATCHING CUFF

♦ COMMENTS: \_\_\_\_\_

### Calibration Check with Pressure-Vacuum Meter

Observed pressure values on the Digimano Pressure-Vacuum Meter and the Microlife from 280 to 40 ( $\pm 2$ ) mmHg in approximate decrements of 20 ( $\pm 2$ ) mmHg.

MEASUREMENT NUMBER	DIGIMANO	MICROLIFE
1 (280).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
2 (260).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
3 (240).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
4 (220).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
5 (200).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
6 (180).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
7 (160).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
8 (140).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
9 (120).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
10 (100).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
11 (80).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
12 (60).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg
13 (40).....	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> . <input type="text"/> mmHg .....	<input type="text"/> <input type="text"/> <input type="text"/> mmHg

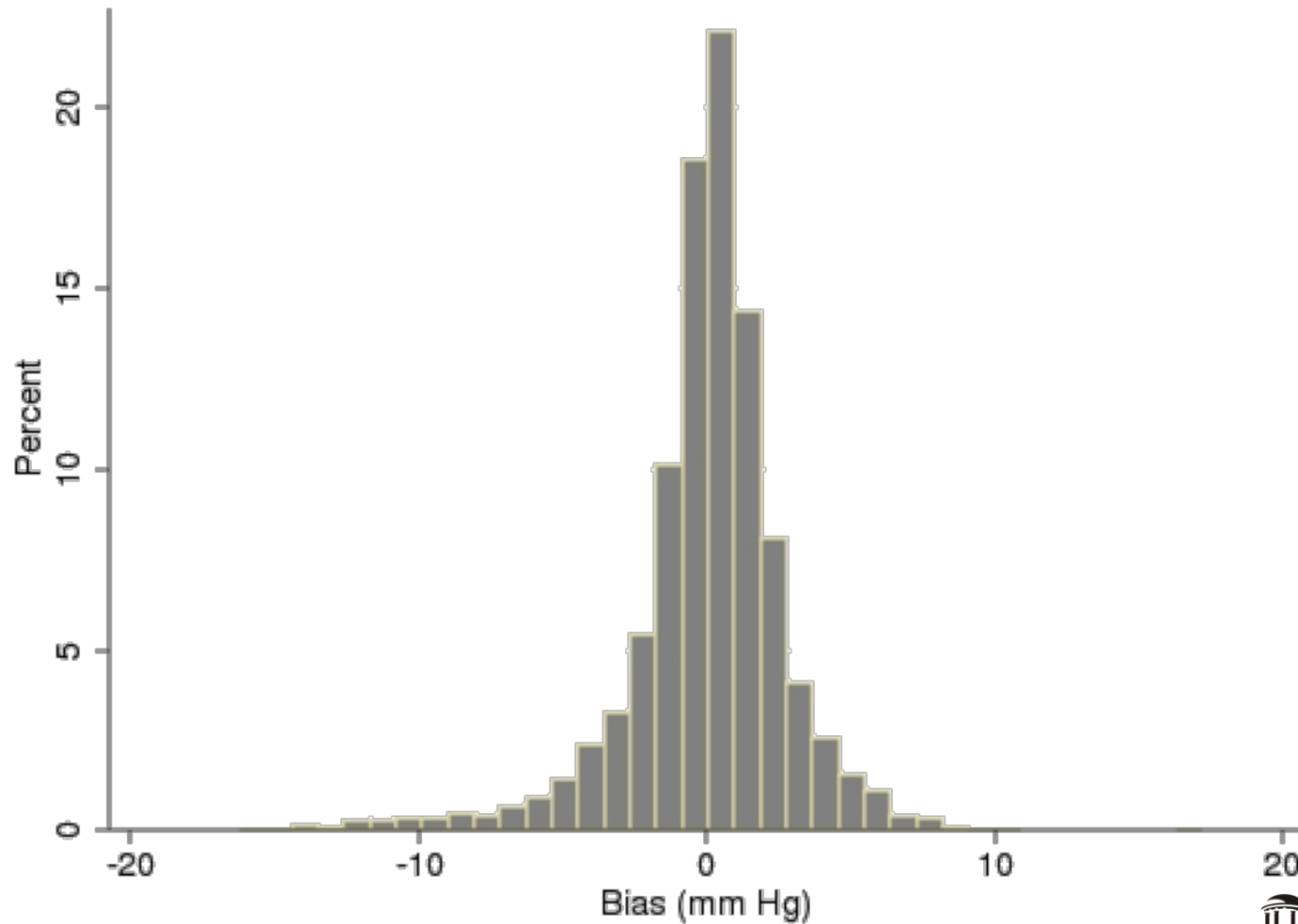


## BP Monitor Calibration

- Analysis
  - bias (mm Hg) = meter - monitor difference
  - relative bias (%) =  $100 \times \text{bias} / \text{meter pressure}$



# BP Monitor Calibration



**Accuracy of Monitor Pressure, by Meter Pressure (mm Hg),  
Add Health Wave IV (2008-2009)**

Meter Pressure (mm Hg)	Bias (mm Hg) <sup>a</sup>			Relative Bias (%) <sup>b</sup>		
	Median	Mean	SD	Median	Mean	SD
280	1.70	1.79	1.78	-0.60%	0.64%	0.64%
260	1.30	1.34	1.89	0.50%	0.51%	0.73%
240	1.10	1.20	1.89	0.46%	0.50%	0.79%
220	1.10	1.26	2.15	0.50%	0.57%	0.98%
200	1.10	1.38	2.16	0.55%	0.69%	1.08%
180	0.70	0.57	2.66	0.39%	0.31%	1.48%
160	0.30	0.06	2.69	0.19%	0.03%	1.68%
140	0.00	-0.28	2.65	0.00%	-0.20%	1.89%
120	-0.40	-0.71	2.59	-0.33%	-0.60%	2.16%
100	-0.60	-1.30	3.27	-0.59%	-1.30%	3.27%
80	-0.75	-1.23	2.74	-0.95%	-1.53%	3.42%
60	-0.70	-1.30	2.73	-1.16%	-2.17%	4.53%
40	-0.90	-1.55	2.53	-2.24%	-3.86%	6.28%

<sup>a</sup>Bias = meter pressure - monitor pressure. <sup>b</sup>Relative bias = 100 × (bias ÷ meter pressure). SD = standard deviation.

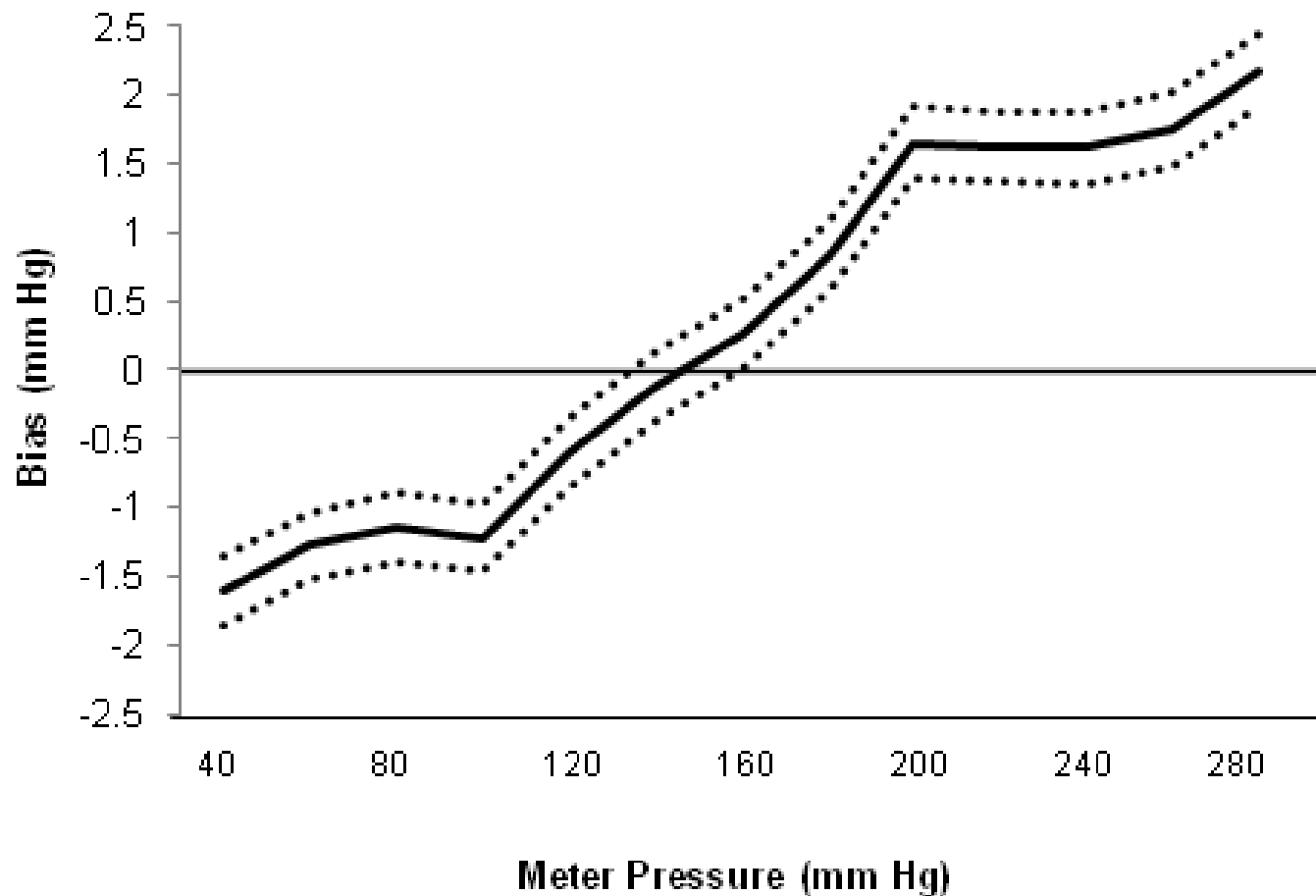


# BP Monitor Calibration

- Model: multi-level, random-intercept
  - $Y_{ijk} = \beta_0 + \beta_1 P_{ijk} + \beta_2 C_{ijk} + \gamma_{1k} + \gamma_{2j(k)} + \varepsilon_{ijk}$
  - where
    - $i$  =  $i^{\text{th}}$  cuff pressure (level 1)
    - $j$  =  $j^{\text{th}}$  cuff (level 2)
    - $k$  =  $k^{\text{th}}$  monitor (level 3)
  - and
    - $Y_{ijk}$  = bias (mm Hg)
    - $\beta_0$  = intercept
    - $P_{ijk}$  = vector of meter pressure categories (1-13)
    - $C_{ijk}$  = vector of covariates, e.g. technician ID
    - $\gamma_{1k} + \gamma_{2j(k)}$  = random intercepts @ levels 3 & 2
    - $\varepsilon_{ijk}$  = random error @ level 1



# BP Monitor Calibration



# BP Monitor Calibration

- Summary
  - bias:  $< 2$  mm Hg
  - relative bias:  $< 4\%$
  - both:  $> 0$  @ BP  $< 140$   
@ BP  $> 140$  mm Hg



# Lipid Calibration

- Standard Protocol (Apr 2008 - Jul 2008)
  - procured 3 CDC LSP plasma pools, together representing
    - low
    - medium
    - high
  - mixed each pool with washed RBCs
  - spotted 20 cards with each plasma-RBC mixture
    - pool 1
    - pool 2
    - pool 3
  - sent 1 card/pool to the lab, 2x/wk x 10 wk
  - masked lab & technicians to origin of card
  - processed the spots per Add Health protocol



# Lipid Calibration

- Analysis
  - lab | CDC correlations (Pearson; Spearman)
  - bias (mg/dL) = lab - CDC difference
  - relative bias (%) =  $100 \times \text{bias} / \text{CDC}$
  - coefficient of variation =  $\text{sd}(\text{lab}) / \text{mean}(\text{lab})$



# Lipid Calibration

Correlation of lipid concentrations, lab vs. CDC

Variable		Pearson*	Spearman*
Primary	TC	Updated table pending	
	HDL-C		
	TG		
Secondary	LDL-C		
	NON-HDL-C		

LDL-C = TC - HDL-C - TG ÷ 5 when TG < 400 (Friedwald).

NON-HDL-C = TC - HDL-C. \*P values < 0.0001 for all

tests of  $H_0: r = 0.0$ .



# Lipid Calibration

Difference in lipid concentrations (mg/dL), lab vs. CDC

		Mean (SD)		Relative		
Variable		Lab	CDC	Bias	Bias	CV
Primary	TC	Updated table pending		Updated table pending		Updated table pending
	HDL-C					
	TG					
Secondary	LDL-C	Updated table pending		Updated table pending		Updated table pending
	NON-HDL-C					

LDL-C = TC - HDL-C - TG ÷ 5 when TG < 400 (Friedwald). Bias = lab - CDC. Relative bias = (100 \* bias) / CDC. NON-HDL-C = TC - HDL-C. P = p value for student's t test of H<sub>0</sub>: Bias = 0.



# Lipid Calibration

- Summary
  - pending completion of trend & conversion analyses



# Inter-Assay Variation Study

- Standard Protocol
  - identified a race/ethnicity-, gender- & TG-stratified random sample of 96 Main Study participants
    - four race/ethnic groups: NHW, NHB, Hispanic & other
    - three TG concentrations: low, medium & high
    - two genders: male & female
    - $4 \times 3 \times 2 = 24$  groups
    - 4 participants / group
  - resubmitted calorimetrically assayed cards for fluorometric assay
  - masked labs & technicians to participant identity
  - processed the lipids





# Inter-Assay Variation Study

- Summary
  - pending completion of trend analysis

# Intra-Individual Variation Study

- Standard Protocol (2007 - 2009)
  - computed n needed to estimate the reliability assuming
    - measures are interval-scale
    - reliability estimated as an ICC
    - underlying ICC = 0.7 & precise, 95%CI = 0.2
  - identified a race/ethnicity- & gender-stratified random sample
    - ~ 50 participants in Pre-Test & ~ 50 in Main Study
  - excluded siblings and pregnant women
  - examined participants 2x, 1-2 wk apart
    - visit 1: full interview + biomarkers
    - visit 2: abbreviated interview + biomarkers
  - masked labs & technicians to respondent identity
  - processed the biomarkers



# Intra-Individual Variation Study

Characteristics of the IIV population\*

Characteristic		Mean (sd) or n (%)	
		Visit 1	Visit 2
Age (y)		28.5	(1.9)
Female		50	(50%)
Race/Ethnicity	Non-Hispanic White	64	(64%)
	Non-Hispanic Black	16	(16%)
	Hispanic	12	(12%)
	Other	8	(8%)
Pre-Test Participant		42	(42%)
Time of Day		x:xx pm	x:xx pm
Fasting duration (hr)		x.x (x.x)	x.x (x.x)
Fasting $\geq$ 8 hr		xx	(xx%)
V1-V2 Interval (d)		8.6	(3.0)
Same Field Interviewer Both Visits		84	(84%)

\*Based on a final sample of 100 IIV participants.

# Intra-Individual Variation Study

- Analysis
  - Nested, random-effects model partitioning biomarker variance into its components:
  - $Y_{ijk} = \mu + P_i + V_j(P_i) + \varepsilon_{ijk}$
  - where:
    - $Y_{ijk}$  = value @  $j^{\text{th}}$  visit of  $i^{\text{th}}$  participant
    - $\mu$  = intercept
    - $P_i$  =  $i^{\text{th}}$  participant
    - $V_j(P_i)$  =  $j^{\text{th}}$  visit nested within  $i^{\text{th}}$  participant
    - $\varepsilon_{ijk}$  = random error
  - assuming:
    - $P_i$ ,  $V_j(P_i)$  and  $\varepsilon_{ijk}$  are independent and  $\sim N(0, \sigma^2)$
  - under this assumption:
    - $\sigma_T^2 = \sigma_{BP}^2 + \sigma_{BV}^2 + \sigma_{WV}^2$  and  $\text{ICC} = \sigma_{BP}^2 / \sigma_T^2$

# Intra-Individual Variation Study

Reliability of available biomarkers  
Add Health, Wave IV (2007-2009)

Type	Measure	ICC (95% CI) *
Anthropometric	Weight	1.00 (1.00-1.00)
	Height	0.98 (0.98-0.99)
	BMI	0.99 (0.99-1.00)
	Waist	0.98 (0.97-0.99)
Cardiovascular	SBP	0.81 (0.74-0.88)
	DBP	0.68 (0.57-0.79)
	PR	0.47 (0.31-0.63)
Metabolic	HbA1C	
	Non-HDL-C	
	LDL-C	
	HDL-C	
	TC	
	Glucose	
Inflammatory	TG	
	hsCRP	
Immune	EBV	
Hematologic	Hb	

Updated table pending

\*ICC (95% CI) = intra-class correlation coefficient, 95% confidence interval.



# Intra-Individual Variation Study

- Summary of reliability
  - anthropometric measures
    - excellent, near unity
  - cardiovascular measures
    - SBP / DBP acceptable
    - PR marginal
  - other measures
    - pending completion of trend & conversion analyses



## To Learn More

- Resources
  - General
    - <http://www.cpc.unc.edu/projects/addhealth>
  - User Guides
    - <http://www.cpc.unc.edu/projects/addhealth/data/guides>
      - cardiovascular & anthropometric measures
      - BP monitor calibration form & protocol
      - FI verification script
  - Wave IV Data
    - <http://www.icpsr.umich.edu/icpsrweb/DSDR/access/add-health.jsp>



# Wave IV Biomarkers – Discussion

