Weighting with the Redesigned National Health Interview Survey

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National Health Interview Survey (NHIS)

- **Agency:** Department of Health and Human Services (DHHS); Centers for Disease Control and Prevention (CDC); National Center for Health Statistics
- **Purpose**: To monitor the health of the US population through the collection and analysis of data on a broad range of health topics
- **Sample**: Complex sample of the civilian noninstitutionalized US population
- **Mode**: In-person interviews -- follow-up by telephone if needed
- **Data collection**: Continuous by Census field representatives
- **Target sample size**: 27,000 sample adults & 9,000 sample children
- **Content redesign start**: January 2019

2019 NHIS Questionnaire Redesign

- Goals of the redesign
  - Reduce the overall length of the interview
  - Improve the relevancy of covered health topics
  - Focus on leading causes of morbidity and mortality, targets of health promotion initiatives, and risk and protective factors
  - Harmonize overlapping content with other federal heath surveys
  - Reduce respondent burden

- Eliminated family interview; now a short household roster followed by selection of sample adult (18+) and sample child (<18)
  - Sample adult and sample child are now only people we collect detailed health information on

Time for a New Weighting Approach?

- Questionnaire redesign provided opportunity to reconsider weighting approach, especially how we adjust for nonresponse (NR)
  - Not updated in previous ~20 years
  - Declines in NHIS household response rates (~90% to ~65%)
  - Likely break some trends due to content changes
- Other developments
  - Causes of survey NR have likely changed over time
  - Statistical methods and computing power have improved
  - Increasing availability of auxiliary data

Simplified Look at *Past* Weighting Approach

Final household base weight

Household NR adjustment
(***segment-level adjustment***)

Post-stratification to population control totals
based on age, sex, race/ethnicity

Final person weight

Adult probability of selection adjustment

Adult level NR adjustment
(***segment-level adjustment***)

Interim sample adult weight

Post-stratification to population control totals
based on age, sex, race/ethnicity

Final sample adult weight

Child probability of selection adjustment

Child level NR adjustment
(***segment-level adjustment***)

Interim sample child weight

Post-stratification to population control totals
based on age, sex, race/ethnicity

Final sample child weight

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- Explored various models of survey response incorporating contextual data (county-, Census tract-level measures) and paradata related to both response and key health measures:
  - Logistic regression
  - ***Multilevel logistic regression***
  - Random forest prediction
  - Least absolute shrinkage & selection operator (LASSO) machine learning
- Explored ***raking*** versus traditional post-stratification
  - Old post stratification variables: age, sex, race/ethnicity
  - Raking: age, sex, race/ethnicity plus:
    - Education, employment status, MSA status and/or Census division

Simplified Look at *New* Weighting Approach

Final household base weight

Household NR adjustment
(***based on multi-level logistic regression***)

Adult probability of selection adjustment	Child probability of selection adjustment
Adult level NR adjustment (***based on multi-level logistic regression***)	Child level NR adjustment (***based on multi-level logistic regression***)
Interim sample adult weight	Interim sample child weight
Raking (age, sex, race/ethnicity, education, MSA status, Census Division	***Raking*** (age, sex, race/ethnicity, MSA status, Census Division
Final sample adult weight	Final sample child weight

Modeling Survey Response

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Screening Variables for Inclusion in Models of Response (1)

- Step 1: Explore associations between auxiliary variables and response
  - Response defined as response (1) vs. nonresponse (0)
  - Variables significantly associated with response ($p < .10$) move to the next step
  - This process performed for household, sample adult, and sample child response
- Step2: Explore associations between auxiliary variables (screened in from step 1) and a set of key health indicators (KHIs)
  - Variables significantly associated with KHIs ($p < .10$) in at least 3 of 5 health domains for the adult and 2 of 3 health domains for the child move to the modeling stage

Auxiliary Variables: Data Sources

- Contact History Instrument (CHI)
  - Data collected on every contact attempt
  - Variables summarized to household/respondent level
  - Example: Whether or not householder(s) expressed time constraints
- Neighborhood Observation Instrument (NOI)
  - Data collected from first observation of sample unit
  - Example: Does the sample unit have any indication that the residents are smokers?
- Census Planning Database
  - Decennial Census 2010, American Community Survey 5-year estimates (2013-17)
  - Census tract-level measures
  - Example: Percentage of ACS population that is 65 years old or over
- Area Health Resource File (AHRF)
  - Contains more than 6,000 variables related to health care access
  - County-level measures
  - Example: Number of medical doctors per 100,000 county residents

Adult Key Health Indicators

Health care service use

- ER visit, past year
- Doctor visit, past year
- Flu vaccination, past year
- Mental health counseling/therapy, past year

Health care access

- Usual source of care
- Skipped doses of prescription meds to save money

Health behaviors

- Current smoker
- Obese

Health insurance coverage

- Public coverage
- Private Coverage
- Uninsured

Health status

- Functional disability
- Asthma episode, past year
- Hypertension
- Excellent/very good health

Child Key Health Indicators

Health care service use

ER visit, past year

Doctor visit, past year

Flu vaccination, past year

Mental health counseling/therapy, past year

Health care access

Usual source of care

Public coverage

Private Coverage

Uninsured

Health status

Disability

Asthma episode, past year

Excellent/very good health

Current ADD/ADHD

Stressful life events indicator

Screening Variables for Inclusion in Models of Response (2)

- Step 1: Explore associations between auxiliary variables and response
  - Response defined as response (1) vs. nonresponse (0)
  - Variables significantly associated with response ($p < .10$) move to the next step
  - This process performed for household, sample adult, and sample child response
- Step2: Explore associations between auxiliary variables (screened in from step 1) and a set of key health indicators (KHIs)
  - Variables significantly associated with KHIs ($p < .10$) in at least 3 of 5 health domains for the adult and 2 of 3 health domains for the child move to the modeling stage
- ~60 of the 213 variables explored made it to the modeling stage
  - Household (n=48)
  - Adult (n=48)
  - Child (n=26)

Modeling Survey Response

- Step 1: Estimate a standard binomial logistic regression of response (response vs. nonresponse)
  - Includes variables retained from prior screening steps
  - Backward elimination ($p < .10$)
    - Variables retained in this procedure are carried forward to a multi-level logistic regression of response
- Step 2: Estimate a multi-level logistic regression of response (response vs. nonresponse)
  - Random effects for Census tract
  - Fixed effects for variables retained from Step 1
  - Output predicted probabilities (response propensities)

Forming and Applying Nonresponse Adjustments

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Household Nonresponse Adjustment

- Step 1: Order the response propensities from low to high and group them into quintiles
- Step 2: Form the NR adjustment factor by taking the inverse of the median response propensity within each propensity quintile: 1 / median RP
- Step 3: Multiply the final household base weight by the NR adjustment factor

Nonresponse Adjustment Factors: Household, 2019

Response Propensity Quintiles				
1 (low)	**2**	**3**	**4**	**5 (high)**
3.44	1.92	1.40	1.23	1.11

Nonresponse adjustment factor formed by taking the inverse of the median response propensity within each quintile.

Sample Adult and Sample Child Nonresponse Adjustments

- The NR-adjusted household weight is the starting point for the sample adult and sample child weight
- Step 1: Multiply the NR-adjusted household weight by inverse of adult (child) probability of selection
  - This becomes the adult (child) base weight
- Step 2: Group response propensities from the final adult (child) response model into quintiles
- Step 3: Form the NR adjustment factor by taking the inverse of the median response propensity within each propensity quintile: 1 / median RP
- Step 4: Multiply the adult (child) base weight by the NR adjustment factor

Nonresponse Adjustment Factors: Sample Adult and Sample Child, 2019

	Response Propensity Quintiles				
	1 (low)	**2**	**3**	**4**	**5 (high)**
Sample adult	1.25	1.12	1.07	1.05	1.03
Sample child	1.24	1.12	1.09	1.05	1.04

Nonresponse adjustment factor formed by taking the inverse of the median response propensity within each quintile.

Raking

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Raking (1)

- Adjusting sample weights so that marginal totals of the adjusted weights on specified characteristics (e.g., age, sex, race/ethnicity) agree with corresponding totals for the population

- Most often used to reduce biases from nonresponse and noncoverage

- Iterative process by which all variables are considered in turn. For each variable, weights are adjusted to align the survey marginals with population marginals

Raking (2)

- More flexible than post-stratification (PS)
  - PS requires control totals for ALL cells of a cross-classification
    - PS can spread the sample too thinly over large number of adjustment cells
- Thus, raking can typically handle more variables than PS

Raking Variables

- Various combinations of the following variables were explored: age, sex, race/ethnicity, employment status (adult only), education (adult only), MSA status, and Census division
  - Final sample adult raking dimensions:
    - Age by sex (18 cells)
    - Age by race and ethnicity (26 cells)
    - Education (4 cells)
    - MSA status by Census division (23 cells)
  - Final sample child raking dimensions:
    - Age by sex (10 cells)
    - Age by race and ethnicity (15 cells)
    - MSA status (3 cells)
    - Census division (9 cells)

Final Weights

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Sample Adult Weight: 2019

	N	Min.	1st Quartile	Median	Mean	3rd Quartile	Max.	CV (%)	DEFF
Old approach	31,997	644	4,214	6,634	7,842	9,815	121,990	68	1.46
New approach	31,997	629	3,958	6,254	7,842	9,351	154,456	80	1.64

CV = coefficient of variation
DEFF = design effect

Capping the Household Nonresponse Adjustment

- To constrain variance, we explored capping the household NR adjustment at:
  - 3.0
  - 2.5
  - 2.0
- Trade-off: While capping will reduce the variance of the weights, it will likely result in an increase in NR bias

Capping Nonresponse Adjustment Factors: Household, 2019

	Response Propensity Quintiles				
	1 (low)	**2**	**3**	**4**	**5 (high)**
Uncapped	3.44	1.92	1.40	1.23	1.11
Cap at 3.0	3.00	1.92	1.40	1.23	1.11
Cap at 2.5	2.50	1.92	1.40	1.23	1.11
Cap at 2.0	2.00	1.92	1.40	1.23	1.11

Nonresponse adjustment factor formed by taking the inverse of the median response propensity within each quintile.

Sample Adult Weight: 2019

	N	Min.	1st Quartile	Median	Mean	3rd Quartile	Max.	CV (%)	DEFF
Past approach	31,997	644	4,214	6,634	7,842	9,815	121,990	68	1.46
New approach (uncapped)	31,997	629	3,958	6,254	7,842	9,351	154,456	80	1.64
New, cap 3.0	31,997	640	4,027	6,357	7,842	9,455	139,764	76	1.58
New, cap 2.5*	31,997	652	4,107	6,460	7,842	9,551	121,705	73	1.53
New, cap 2.0	31,997	665	4,189	6,527	7,842	9,657	102,032	70	1.49

CV = coefficient of variation

DEFF = design effect

*Weight included on 2019 sample adult datafile

How Did We Decide?

- Relative to the uncapped weight, looked at mean squared error (MSE) for 15 adult KHIs (and 13 child KHIs) across the different capping levels

- For all 3 cap levels we saw a reduction in MSE relative to the uncapped weight
  - Any increases in bias were outpaced by reductions in variance

- Overall, capping at 2.5 provided the best bias-variance tradeoff relative to the uncapped weight

Impact on Estimates

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Comparison of Select Adult Estimates Using the Old and New Sample Adult Weight: 2019

	Base Weight	Old Weight		New Weight		
Outcome	**%**	**%**	**SE**	**%**	**SE**	**|New – Old|**
Uninsured	8.6	10.2	0.24	11.0	0.27	0.8
Doctor visit, past year	86.7	85.3	0.26	84.9	0.27	0.4
Flu vaccination	50.6	47.7	0.38	46.8	0.39	0.9
Functional disability	10.5	8.7	0.19	9.0	0.21	0.4
Excellent/very good health	56.3	58.9	0.39	57.4	0.40	1.5
Obese	32.2	31.6	0.34	32.0	0.36	0.4
Current smoker	13.8	13.3	0.24	14.0	0.26	0.7

Comparison of Select Child Estimates Using the Old and New Sample Child Weight: 2019

	Base Weight	Old Weight		New Weight		
Outcome	**%**	**%**	**SE**	**%**	**SE**	**|New – Old|**
Uninsured	4.2	4.3	0.30	4.3	0.30	0.1
ER visit, past year	17.9	18.2	0.52	18.0	0.53	0.2
Flu vaccination, past year	51.9	52.1	0.67	51.7	0.68	0.4
Asthma episode, past year	3.3	3.3	0.23	3.3	0.24	0.0
Excellent/very good health	87.8	87.6	0.45	87.5	0.46	0.1
Stressful life event, ever	17.2	16.6	0.49	16.0	0.47	0.6
Current ADD/ADHD	8.1	7.3	0.33	7.1	0.32	0.2

Summary

- Moved from geography-based NR adjustments to adjustments within response propensity classes based on response models using rich auxiliary data
  - Old approach was static and could not adjust for changing patterns of nonresponse over time
  - New approach will update response models annually, ensuring NR adjustments continue to perform well
- Moved from weight calibration via post-stratification to raking
  - Raking is more flexible and allows additional dimensions (e.g., education, MSA status, Census division)

Thank you!

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- Coming to the NHIS website in late September:

  Bramlett MD, Dahlhamer JM, Bose J, Blumberg SJ. 2020. New procedures for nonresponse adjustment to the 2019 National Health Interview Survey Sampling Weights. National Center for Health Statistics, Division of Health Interview Statistics.