# Can Electronic Health Records be Used for Population Health Surveillance? Findings from the NYC Macroscope

Sharon E. Perlman, MPH
Katharine H. McVeigh, PhD, MPH
Lorna Thorpe, PhD

Innovations in Monitoring Population Health Meeting
Washington, DC
January 9, 2017

# NYC Macroscope Team


***NYC Department of Health***

*Pui Ying Chan, MPH*

*Sungwoo Lim, DrPH*

*Katharine H. McVeigh, PhD, MPH*

*Sharon Perlman, MPH*

*Jenny Smolen, MPH*

***New York University School of Medicine***

*Lorna E. Thorpe, PhD (formerly at CUNY)*



*Special thanks to Jay Bala, Amy Freeman, Ryan Grattan, Carolyn Greene, Tiffany Harris, Stephen Immerwahr, Remle Newton-Dame, Kevin Konty, Ram Koppaka, Jesica Rodriguez-Lopez, Matt Romo, Sarah Shih, Jesse Singer, Elisabeth Snell, Kathleen Tatem, Elizabeth Lurie, Katherine Bartley, Laura Jacobson, Charon Gwynn, and Lauren Schreibstein*

***This work has been made possible by the financial support of the de Beaumont Foundation, the Robert Wood Johnson Foundation, the Robin Hood Foundation, the NY State Health Foundation, the Doris Duke Charitable Foundation, and the Centers for Disease Control and Prevention.***

# Importance of high-quality data for public health

**“If we have data, let’s look at data. If all we have are opinions, let’s go with mine.”**

- ***Jim Barksdale, former Netscape CEO***

**Good data allow for:**

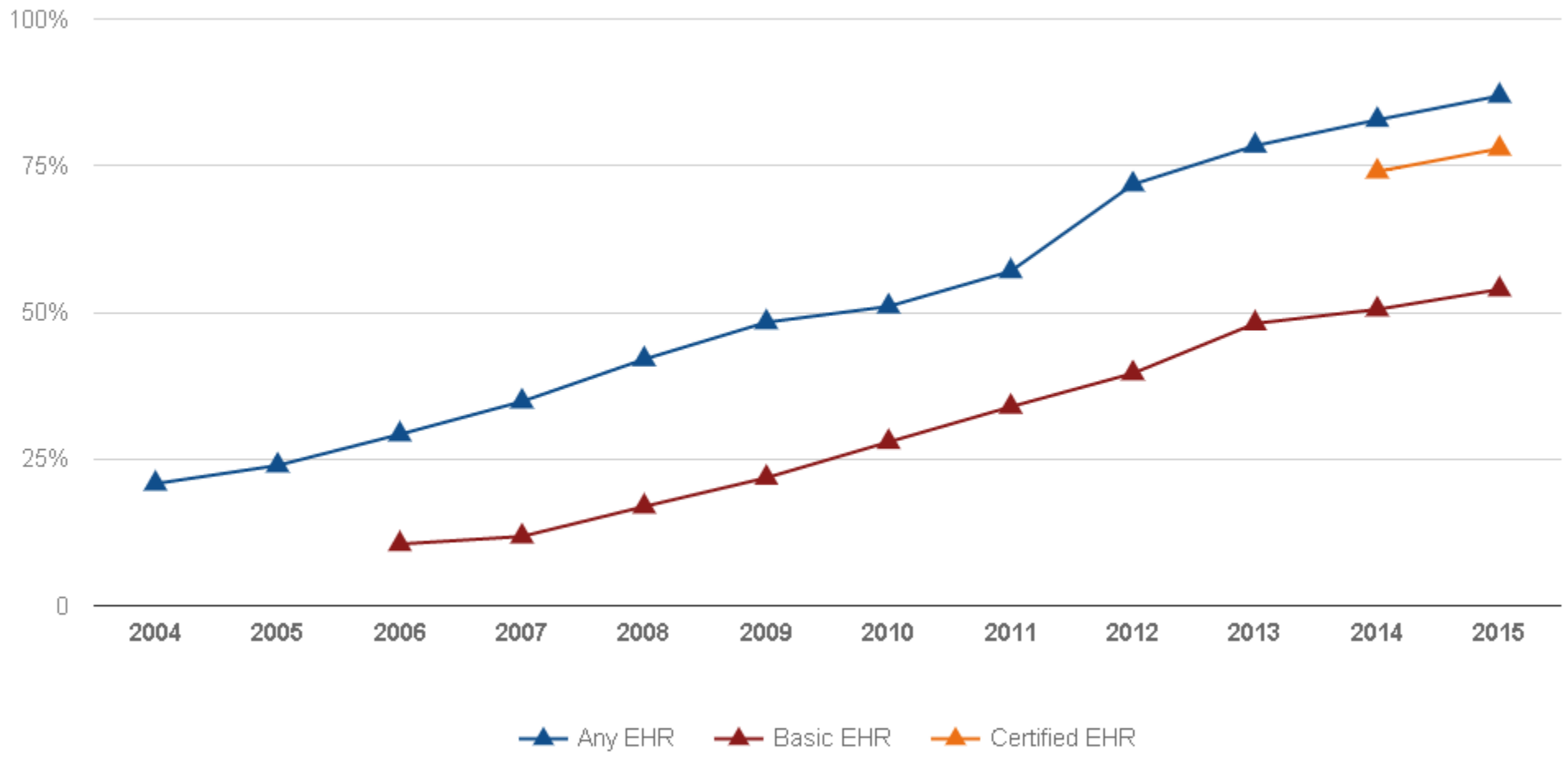
- Better policy and programmatic decisions
- Advocacy
- Evaluation/accountability
- Use resources more efficiently

# Background

**Traditional surveillance methods include**

- Birth and death certificates
- Notifiable disease reporting
- Hospitalization records
- Surveys

# Electronic Health Record Use Has Increased in the Past Decade




SOURCE: ONC https://dashboard.healthit.gov/quickstats/pages/physician-ehr-adoption-trends.php

# Potential to Use EHRs for Population Health Surveillance

Traditional surveys are very valuable, but becoming more difficult to conduct.

- Telephone survey response rates decreasing
- Examination surveys are extremely expensive, labor intensive, often have lengthy lag times between data collection and dissemination.

EHR-based surveillance can complement existing surveillance systems.

May be only source of information in jurisdictions with limited local data.

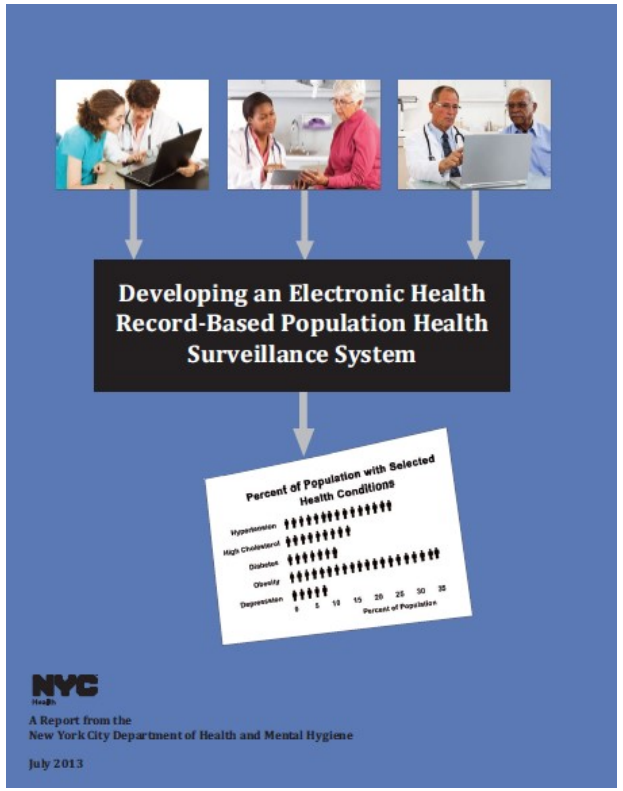
# Possible Limitations to EHR-Based Surveillance

- Only those in care
- Patients and providers in an EHR network may not be representative
- If data are aggregated, there may be duplicate records
- Data may not be collected and recorded in uniform way
- Data may be in free text or other field that is difficult to access

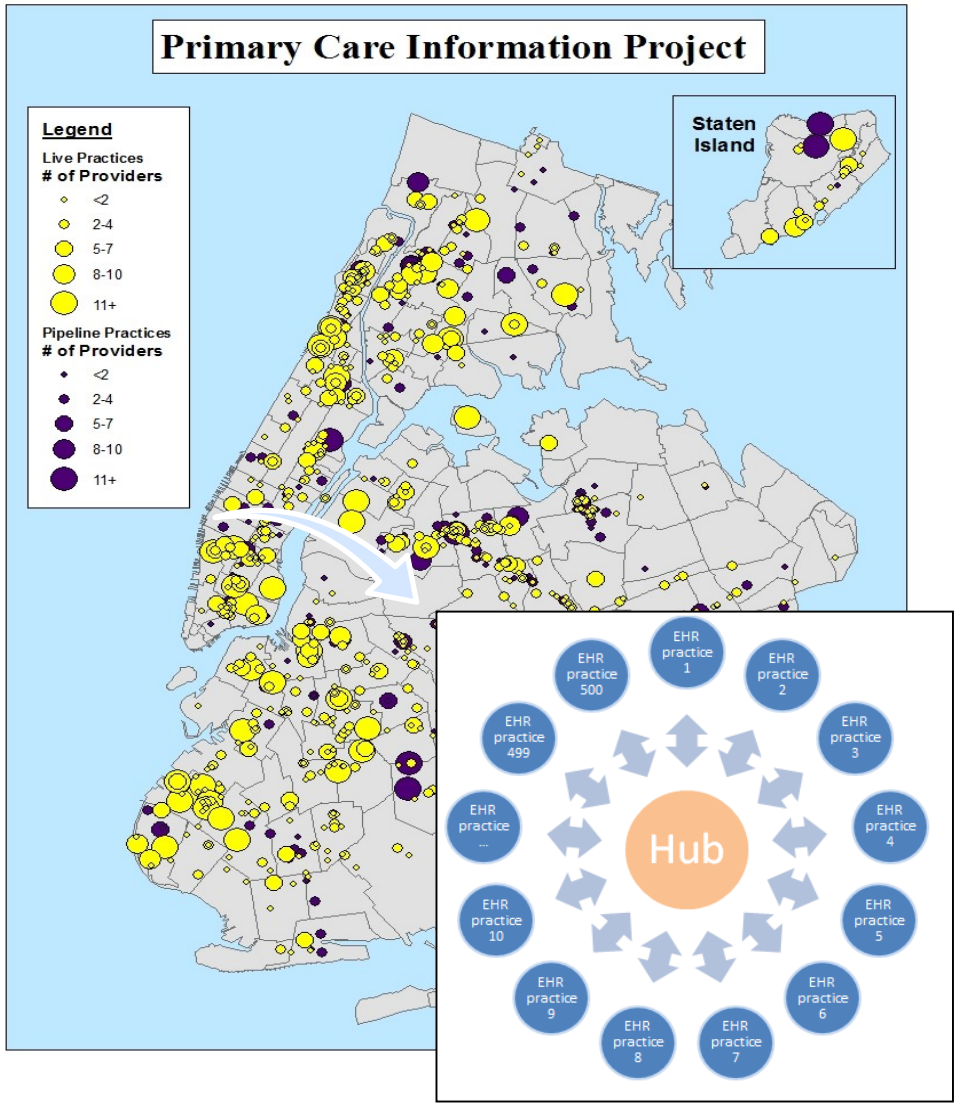
# NYC Macroscope: New York City's EHR Surveillance System

The ***NYC Macroscope*** uses primary care practice data from an EHR network to track conditions important to public health, focusing on chronic conditions.

Led by NYC Health Department, in partnership with NYUMC (formerly at CUNY)



# NYC's EHR Network: Primary Care Information Project (PCIP)




Bridges public health and healthcare

"The Hub" allows secure exchange of aggregate data with PCIP practices through a distributed model

The Hub currently covers:

- Nearly 700 practices
- 1.9 M patients in 2013

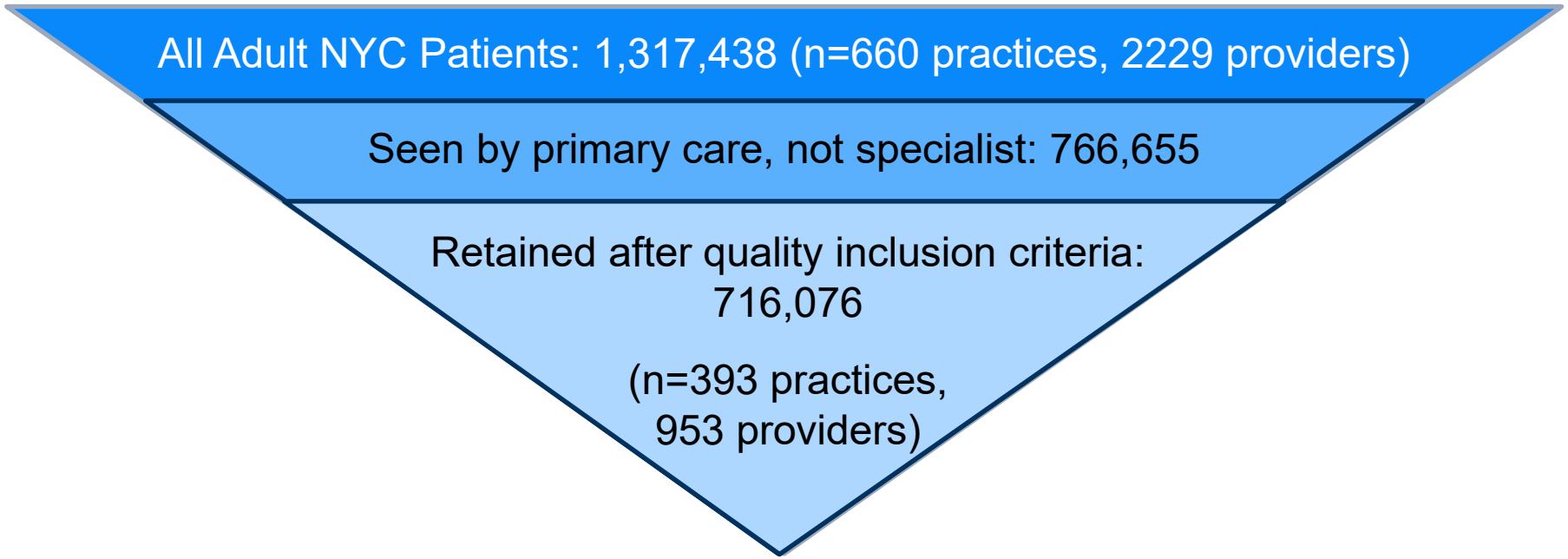
# Key Features of NYC Macroscope

- Hub Population Health System
  - eClinicalWorks EHR platform

Inclusion/exclusion criteria

- Practice – Documentation quality thresholds guided by Meaningful Use standards
- Provider – Primary care only
- Patient – Visit in 2013, ages 20-100, sex recorded as male or female, NYC Zip Code

# Macroscope Sample Size and Coverage




2013 Macroscope primary care coverage: ~17%*

*Denominator is CHS 2013 estimates of 4,137,212 NYC adults (20+) that saw provider in 2013

# Key Features of NYC Macroscope, continued

Weighted to the distribution of the NYC adult population that had seen a health provider in the past year

Validated against 2 population-based reference surveys

- 2013-14 NYC Health and Nutrition Examination Survey (NYC HANES)
  - N = 1,527; 1,135 in care
- 2013 NYC Community Health Survey (CHS)
  - N = 8,356; 6,166 in care

# NYC Macroscope Indicators

## Outcomes

### Prevalence, Treatment and Control

- Diabetes
- Hypertension
- Cholesterol

### Prevalence

- Obesity
- Smoking
- Depression

### Use of Preventive Services

- Vaccination against influenza

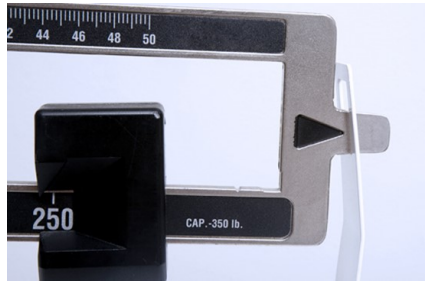
## Population Subgroups

### Sex

- Male
- Female

### Age

- 20-39
- 40-59
- 60-100




# NYC Macroscope Indicators Definitions

| Indicator | Macroscope 2013 (n=716,076) | NYC HANES 2013-14 (n=1,135 in care) | CHS 2013 (n=6,166 in care) |
|---|---|---|---|
| Obesity (BMI) | Measured height, weight | Measured height, weight | Self-reported height. weight |
| Smoking (current smoker) | Structured smoking section** | Self-reported | Self-reported |
| Hypertension, diabetes and cholesterol diagnosis | Ever diagnosed | Self-reported diagnosis | Self-reported diagnosis |
| Diabetes Augmented | Ever diagnosed** or A1c≥6.5** or Medication prescribed | Self-reported diagnosis or A1c≥6.5 | n/a |
| Hypertension Augmented | Ever diagnosed* or Systolic≥140, diastolic≥90* or Prescribed meds* | Self-reported diagnosis or Systolic≥140, diastolic≥90 | n/a |
| Cholesterol Augmented | Ever diagnosed or Total cholesterol≥ 240** or Medication prescribed | Self-reported diagnosis or Total cholesterol≥ 240 | n/a |
| Depression | PHQ-9≥10 or ever dx | PHQ-9≥10 or ever dx | n/a |
| Influenza Vaccination | CVX, CPT or ICD-9 code* | Self-report* | Self-report* |

* In the past calendar year.
** In the past 2 calendar years.

Validation Study Results

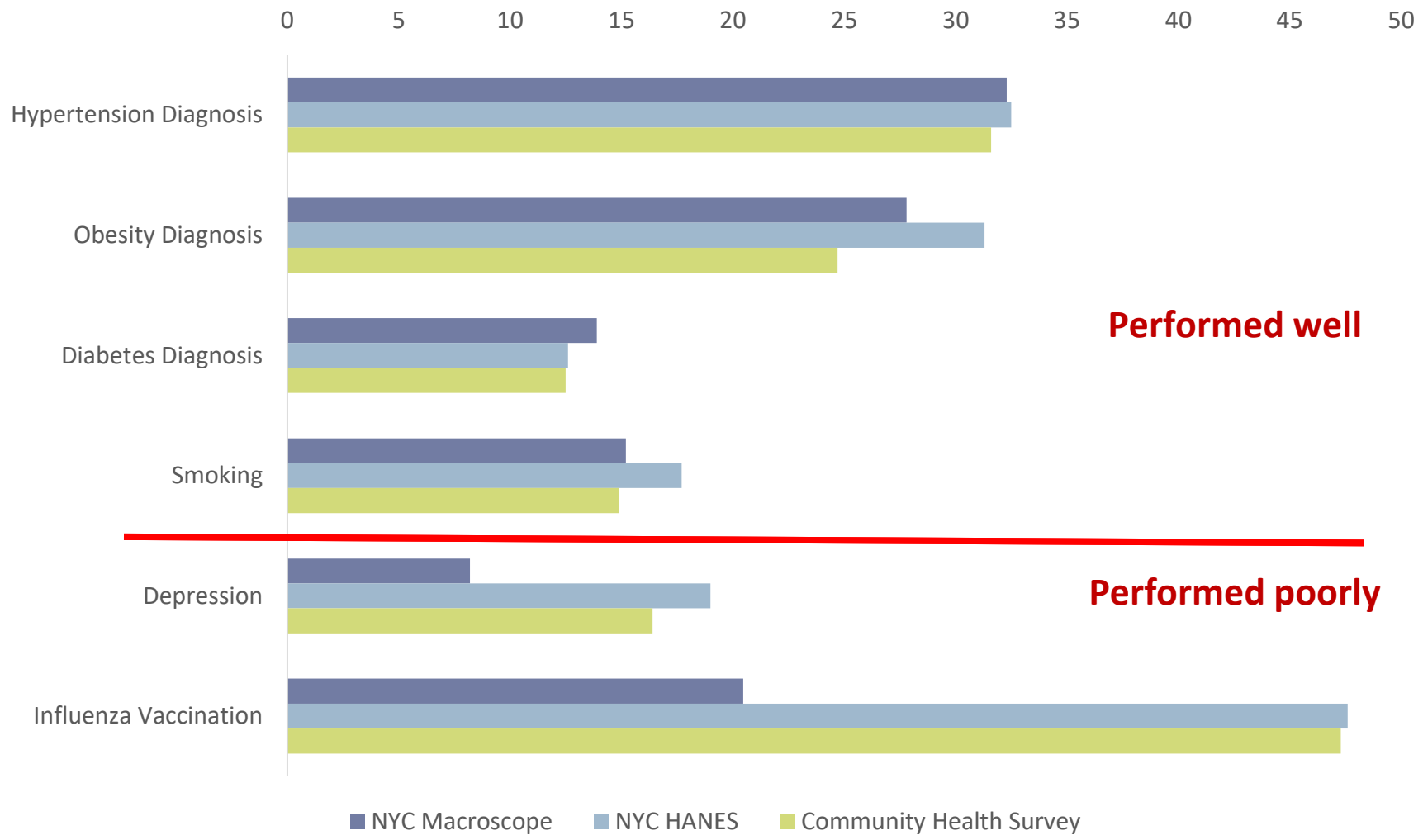
# POPULATION-BASED PREVALENCE ESTIMATE COMPARISONS

# Validating NYC Macroscope by Comparison with Existing Surveys

Used a priori criteria to determine if estimates were comparable enough to well-established surveys to consider using for population health surveillance.

| Test for Comparison | Metric | Criterion |
|---|---|---|
| Statistical Equivalence | Two One-Sided Test (TOST) | P <0.05 |
| Statistical Difference | Student's T-Test | P <0.05 |
| Relative Difference | Prevalence Ratio | 0.85-1.15 |
| Prevalence Difference | Prevalence 1 – Prevalence 2 | +- 5 points |
| Consistency across 6 strata (age x sex) | Spearman Correlation | >= 0.80 |

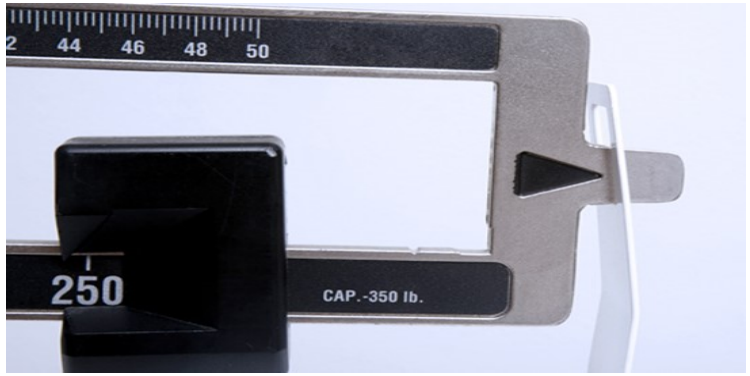
# Prevalence of Selected Indicators

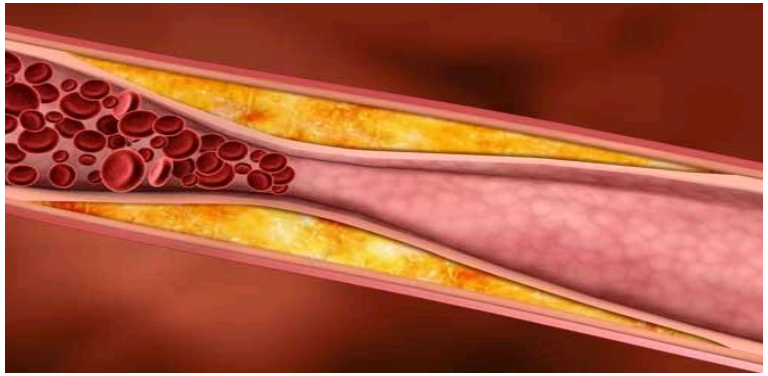


# NYC Macroscope 2013, NYC HANES 2013-14 and the 2013 Community Health Survey, New York City Adults in Care in the Past Year

| | Indicator | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Hypertension** | **Smoking** | **Diabetes** | **Obesity** | **Hypercholesterolemia** | **Depression** | **Influenza Vaccination** |
| **NYC Macroscope % (95% CI)** | 32.3 (32.2, 32.4) | 15.2 (15.1, 15.3) | 13.9 (13.8, 14.0) | 27.8 (27.7, 27.9) | 49.3 (49.1, 49.5) | 8.2 (8.1, 8.2) | 20.9 (20.8, 21.0) |
| **NYC HANES % (95% CI)** | 32.5 (29.4, 35.7) | 17.7 (15.1-20.8) | 12.6 (10.6, 14.8) | 31.3 (28.5-34.2) | 46.9 (42.6, 51.3) | 15.2 (13.0 – 17.7) | 47.6 (44.0-51.3) |
| **Community Health Survey % (95% CI)** | 31.6 (30.18, 33.0) | 14.9 (13.6-16.3) | 12.5 (11.5, 13.6) | 24.7 (23.2-26.3) | 47.9 (45.7, 50.1) | n/a | 47.3 (45.5-49.0) |
| **NYC Macroscope vs. NYC HANES** | | | | | | | |
| **Absolute Difference < 5** | ✓ (0.15) | ✓ (2.55) | ✓ (1.36) | ✓ (3.46) | ✓ (2.36) | × (10.8) | × (26.71) |
| **Prevalence Ratio of 0.85 - 1.15** | ✓ (1.00) | ✓ (0.86) | ✓ (1.11) | ✓ (0.89) | ✓ (1.05) | × (.43) | × (0.44) |
| **Test of Difference (t-test) p≥0.05** | ✓ (p=0.93) | ✓ (p=0.08) | ✓ (p=0.19) | × (p=0.02) | ✓ (p=0.29) | × (p<0.01) | × (p<0.001) |
| **Test of Equivalence (TOST) p<0.05** | ✓ (p<0.01) | ✓ (p=0.04) | ✓ (p<0.001) | × (p=0.14) | × (p=0.12) | × (p=0.99) | × (p=0.99) |
| **Spearman Correlation r≥0.80** | ✓ (1.00) | ✓ (0.83) | ✓ (1.00) | ✓ (1.00) | ✓ (0.80) | × (0.71) | ✓ (1.00) |
| **Recommendation** | **Ready for Use** | **Ready for Use** | **Ready for Use** | **Ready for Use** | **Use with caution** | **Not ready for use** | **Not ready for use** |

✓=Criterion met ×=Criterion not met




# SENSITIVITY AND SPECIFICITY OF NYC MACROSCOPE INDICATORS

# Background

NYC Macroscope prevalence estimates are similar to estimates from our gold standard surveys for measures of obesity, smoking, diabetes, hypertension, and hypercholesterolemia.

But,

- Was the similarity a reflection of good measurement properties or cross-canceling errors?

- Were these results generalizable to other EHR systems?

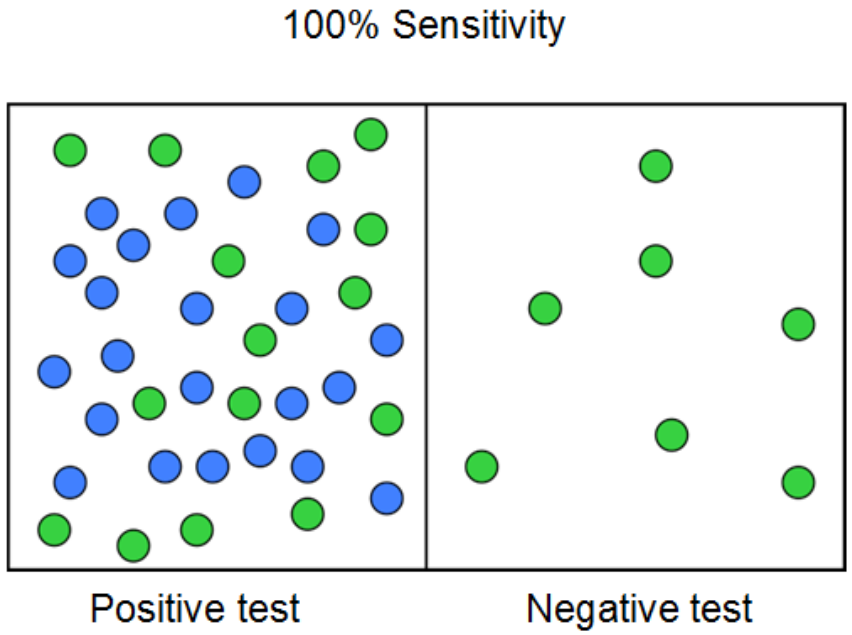
# NYC Macroscope Chart Review Study Methods

To answer these questions, we

- Recruited NYC HANES participants who had visited a doctor in the past year (consent/HIPAA)
- Obtained **printed** copies of EHR records by secure FAX
- Abstracted data from medical records of NYC HANES participants
- Used NYC Macroscope indicator algorithms to classify patient outcomes
- **For each individual,** linked NYC Macroscope and NYC HANES outcome classifications and assessed whether those classifications were similar or different
- **Across individuals**, computed sensitivity and specificity to summarize the agreement between NYC Macroscope and NYC HANES classifications

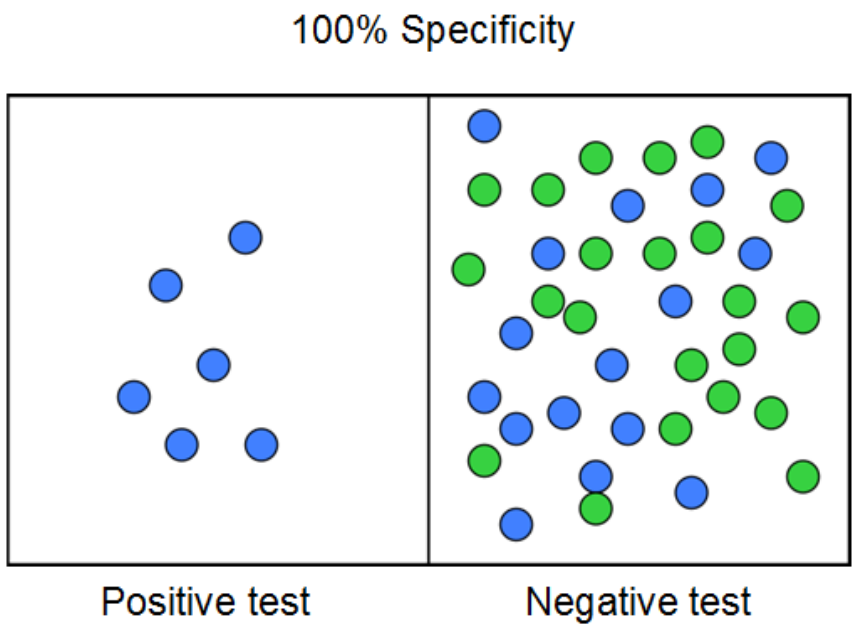
# Sensitivity and Specificity

## Sensitivity




Blue = has the condition
Green = does not have the condition

## Specificity




Blue = has the condition
Green = does not have the condition

# Measures

Outcomes limited to those that had performed well in population level analysis

- Smoking,
- Obesity,
- Hypertension (2),
- Diabetes (2)
- Hypercholesterolemia (2)

# Statistical Analysis

Sensitivity and specificity of NYC Macroscope indicator definitions

- In data from providers who contribute to the NYC Macroscope
- In data from practices that do not contribute to the NYC Macroscope

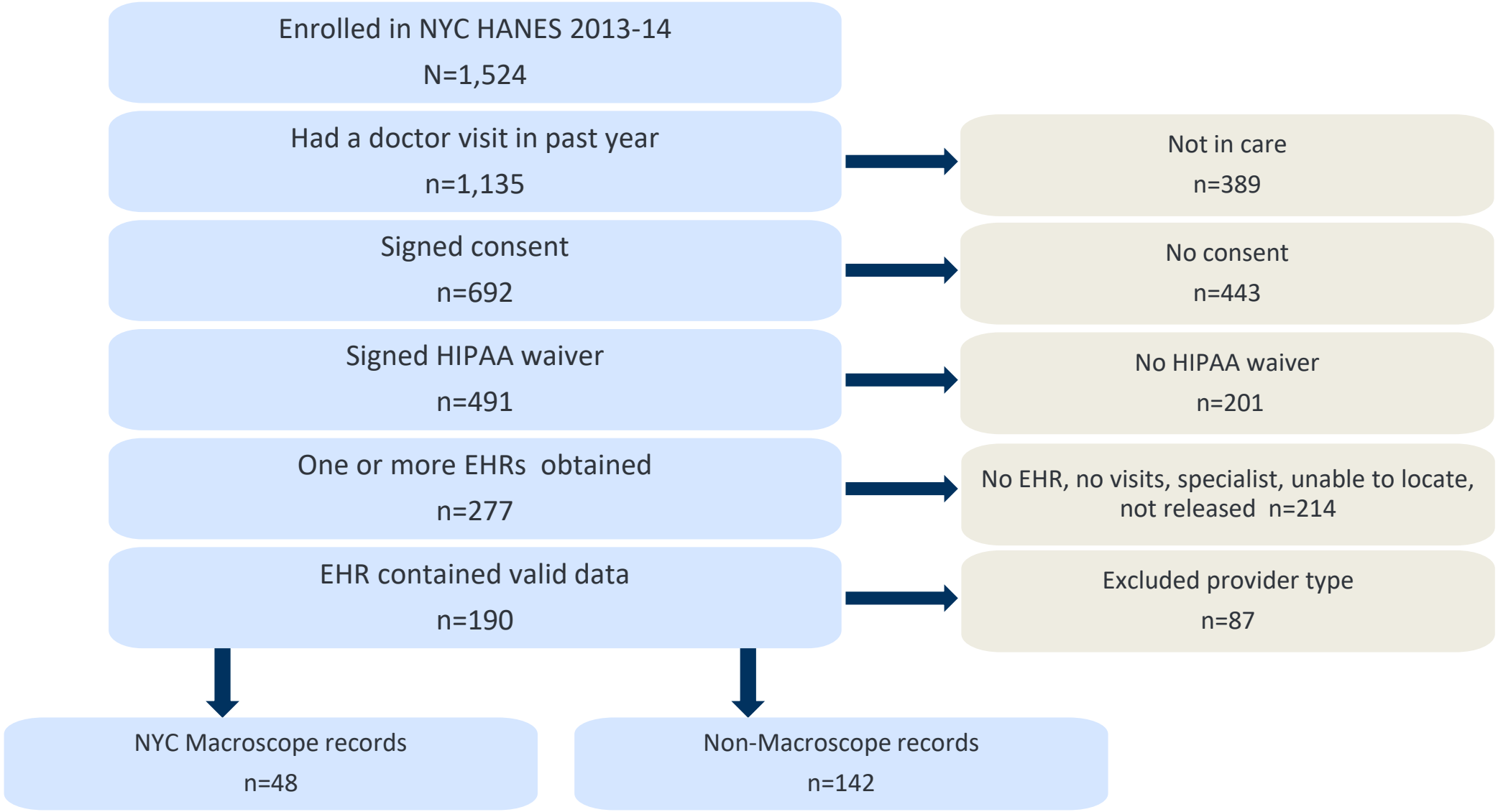
Validity threshold: Sensitivity ≥ 0.70 AND Specificity ≥ 0.80

# Sensitivity Analyses

Meaningful Use

Unstructured Data

# Participant Inclusion/Exclusion Flow Chart

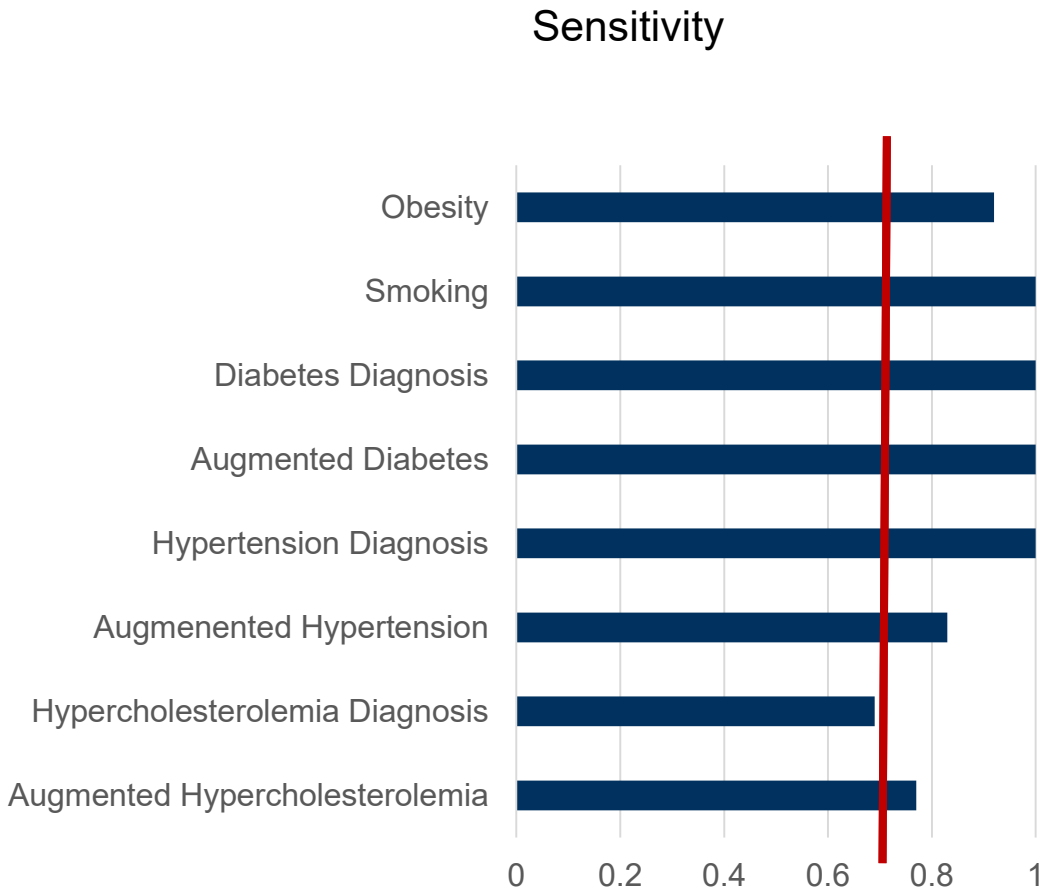


# Samples

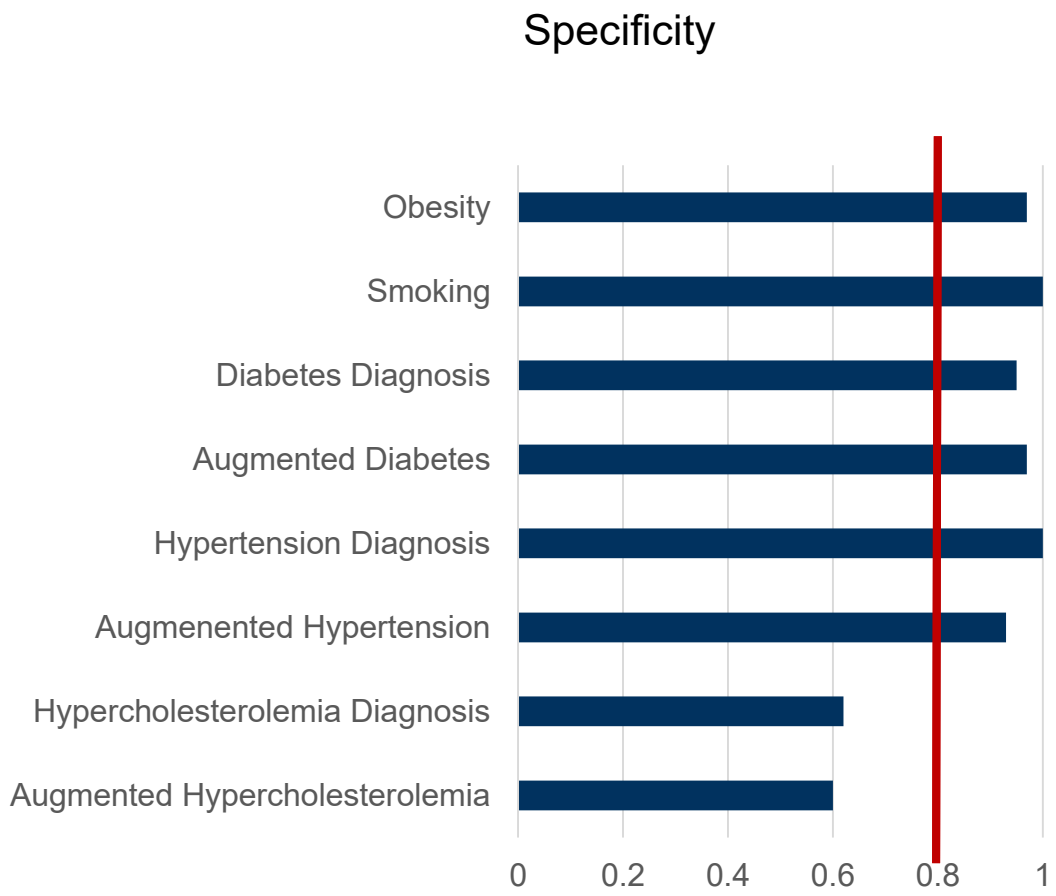
| Number | NYC Macroscope | Non-Macroscope Records | |
|---|---|---|---|
| | | All Records | MU1 Subsample |
| **Records/Patients** | 48 | 142 | 86 |
| **Providers** | 39 | 133 | 79 |
| **Practices** | 34 | 89 | 49 |
| **EHR Vendor Platforms** | 1 | >20 | > 15 |

No significant differences in patient characteristics across samples

# 48 NYC Macroscope Records

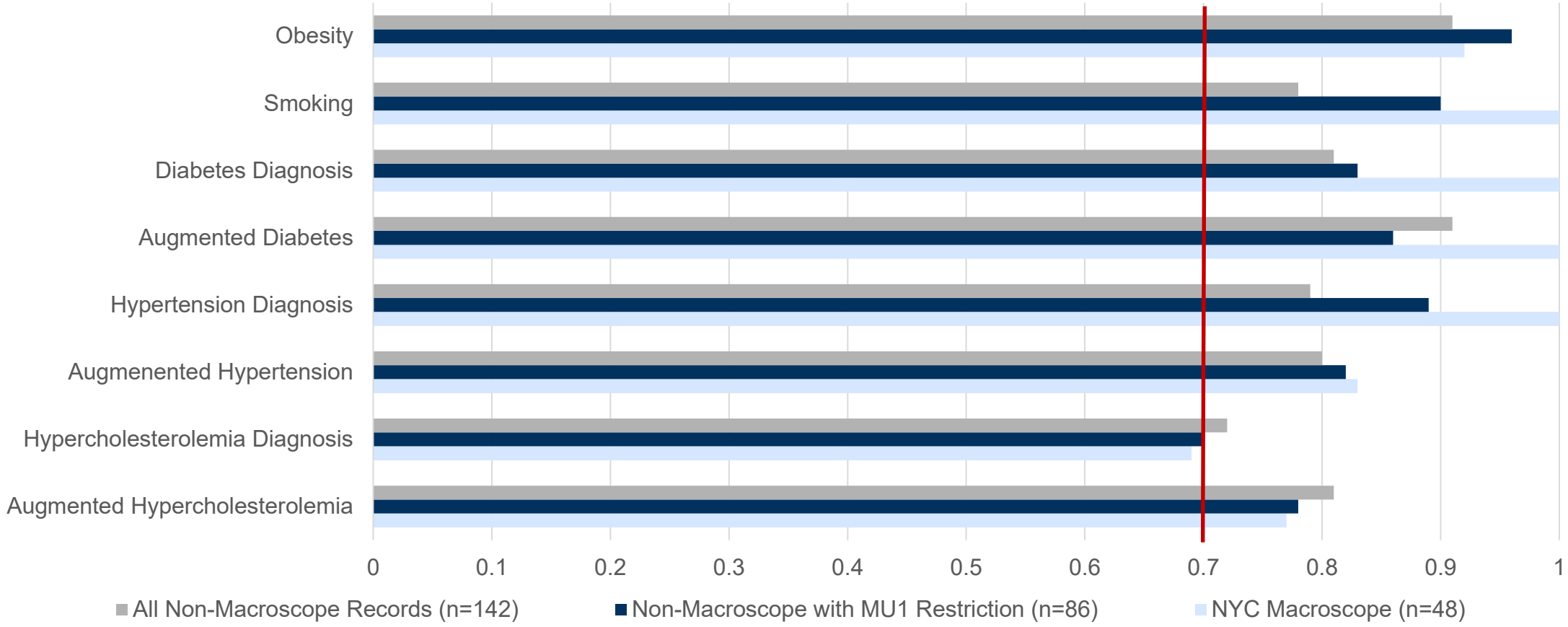



**Validity threshold ≥ 0.70**



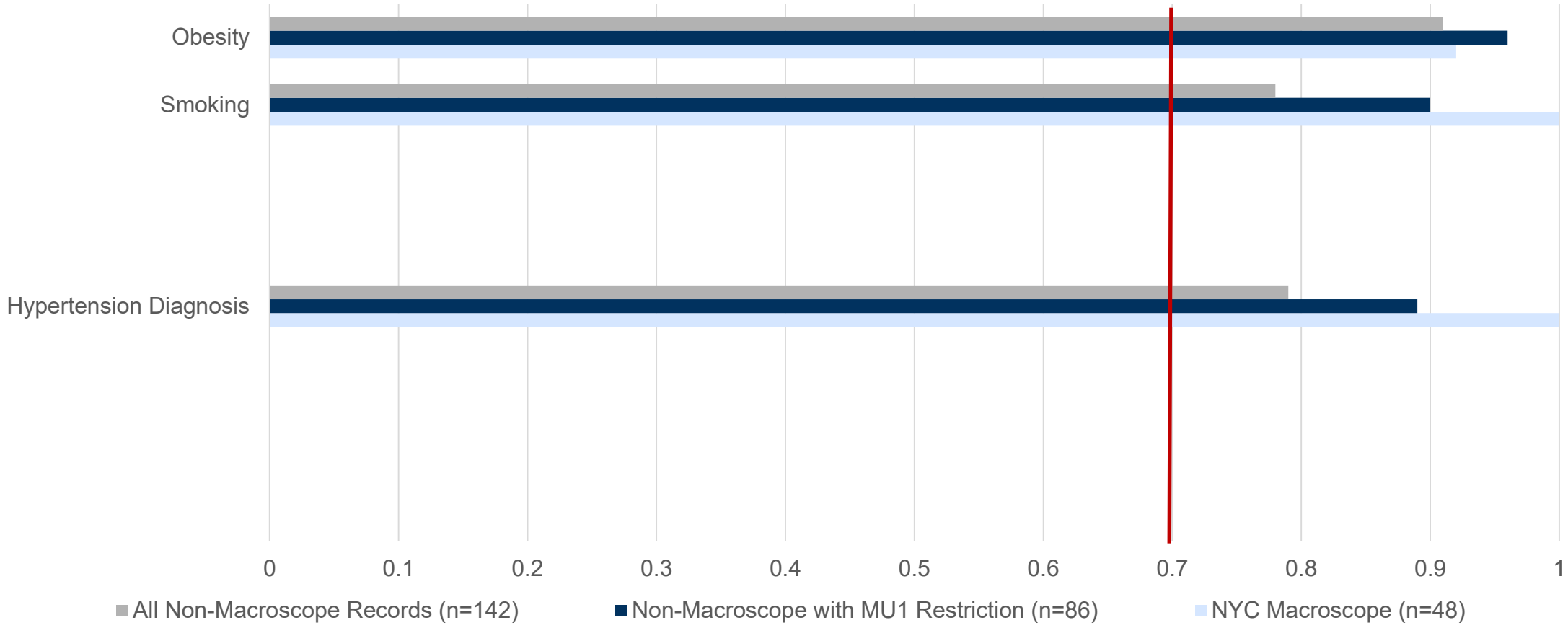

**Validity threshold ≥ 0.80**

# Sensitivity



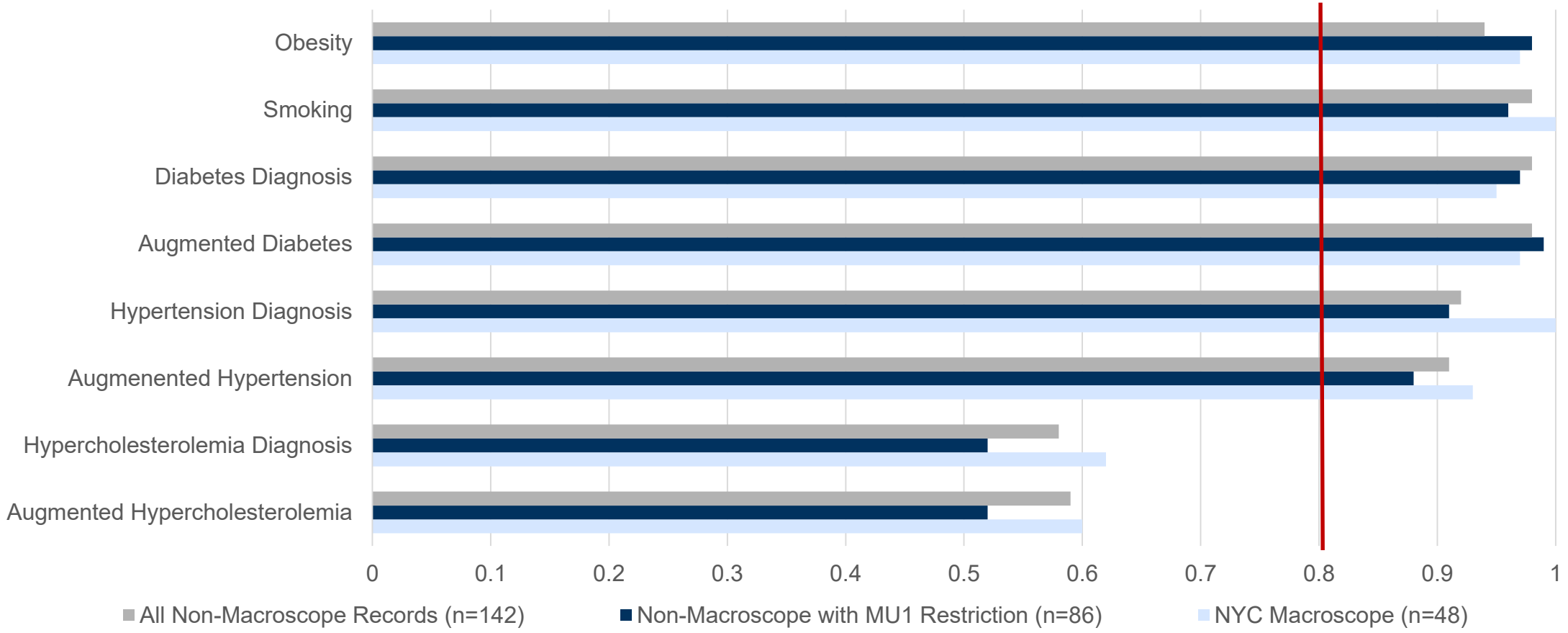

**Validity threshold ≥ 0.70**

# Sensitivity




**Validity threshold ≥ 0.70**

# Specificity




**Validity threshold ≥ 0.80**

# Summary

Both indicators of hypercholesterolemia performed poorly

All other measures performed well

The above conclusions are consistent across NYC Macroscope and Non-Macroscope records

Restricting records to those from providers who have attested to stage 1 Meaningful Use improved the sensitivity of the obesity, smoking and hypertension diagnosis indicators

# Strengths and Limitations

Strengths

- Heterogeneity of providers (N = 172) and EHR vendor platforms (N > 20)
- Innovative sample and gold standard criterion

Limitations

- Small sample size/large confidence intervals

# Conclusions

NYC Macroscope indicators of obesity, smoking, diabetes and hypertension prevalence are ready for use by NYC Macroscope

NYC Macroscope indicator definitions of obesity, smoking, diabetes and hypertension are generalizable to EHR data from other sources

Further work is required to develop valid indicators of hypercholesterolemia

Incorporating meaningful use criteria into EHR surveillance system design may improve validity, especially for obesity, smoking and hypertension diagnosis indicators


## The New York City Macroscope

### Using Data from Electronic Health Records for Population Health Surveillance

# WHAT HAVE WE LEARNED?

# What are our aspirations for population health surveillance using EHRs?

- **Improved ability to monitor burden of key health conditions *(timeliness, completeness, smaller areas, smaller populations)***

# What are our aspirations for population health surveillance using EHRs?

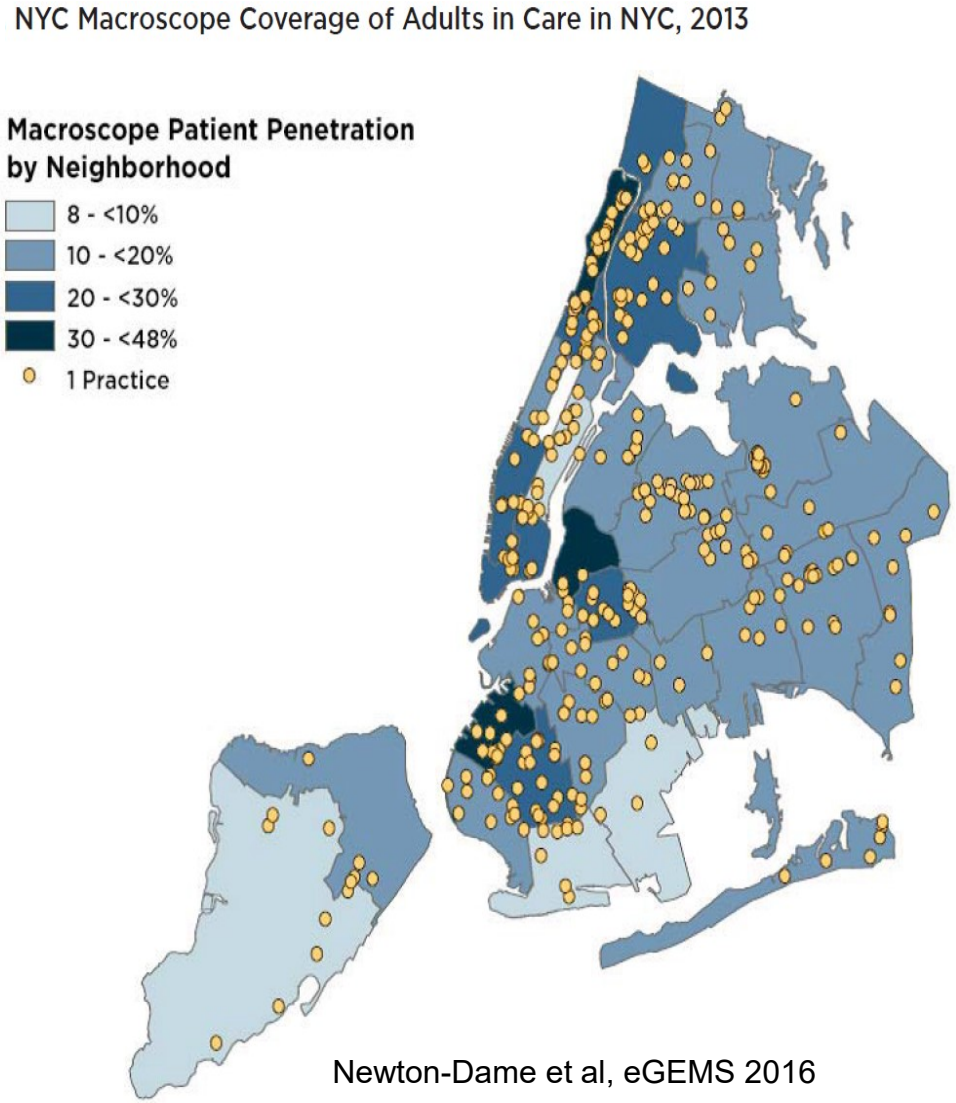
- **Improved ability to monitor burden of key health conditions *(timeliness, completeness, smaller areas, smaller populations)***
  - IMPORTANT CONTEXT: Meaningful Use (MU) criteria have incentivized hospitals and practices to record and exchange structured data on patients
    - Focus has been on improving syndromic surveillance, immunization, and electronic laboratory reporting
    - Hospital MU reporting is rapidly improving. Primary care practices (PCP) are adopting EHRs, but face larger challenges achieving MU or other incentivized criteria
    - ***Still….***EHR expansion among PCPs extends surveillance opportunities to chronic disease prevalence, behavioral risk factors and clinical preventive services

# What are our aspirations for population health surveillance using EHRs?

- **Improved ability to monitor burden of key health conditions *(timeliness, completeness, smaller areas, smaller populations)***
  - IMPORTANT CONTEXT: Meaningful Use (MU) criteria have incentivized hospitals and practices to record and exchange structured data on patients
    - Focus has been on improving syndromic surveillance, immunization, and electronic laboratory reporting
    - Hospital MU reporting is rapidly improving. Primary care practices (PCP) are adopting EHRs, but face larger challenges achieving MU or other incentivized criteria
    - ***Still….***EHR expansion among PCPs extends surveillance opportunities to chronic disease prevalence, behavioral risk factors and clinical preventive services

- **Improved ability to monitor quality of clinical care (disease management)**
  - Unique aspiration of EHR-based surveillance, beyond what telephone surveys or claims data can provide

# What Impact Does Coverage and Representativeness of NYC Macroscope Sample Have?

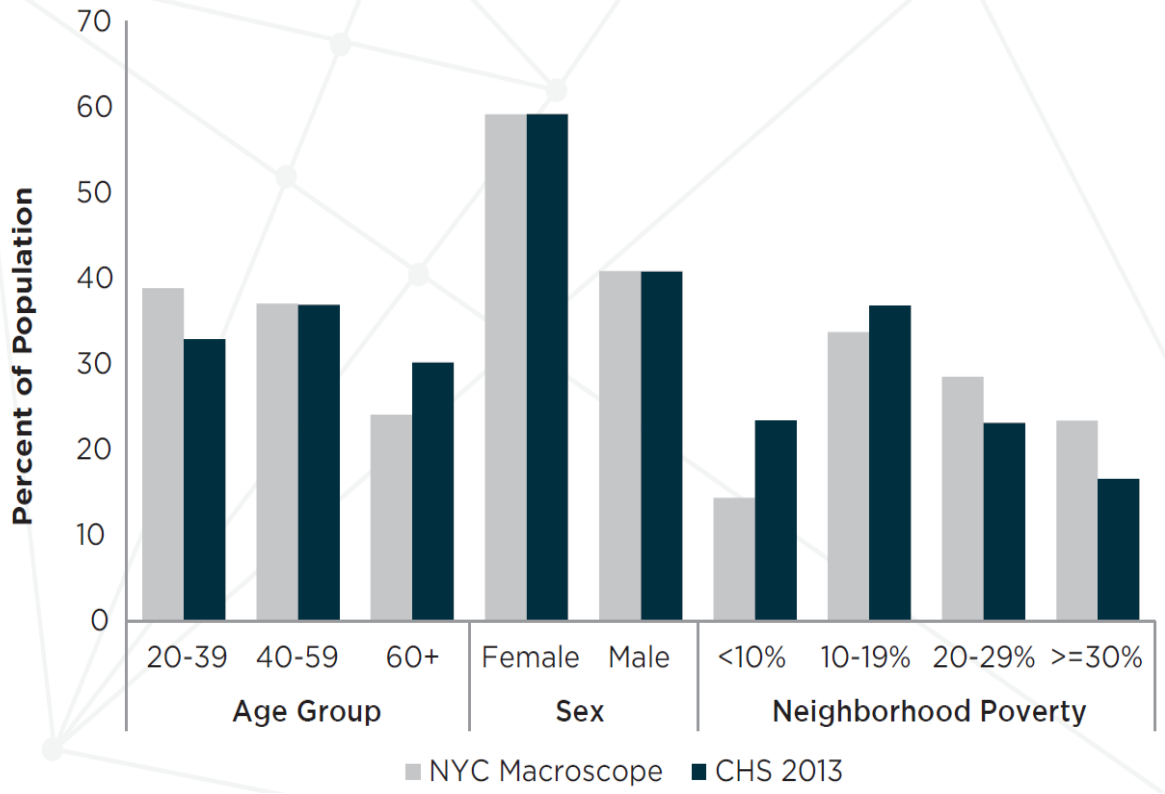



Newton-Dame et al, eGEMS 2016

- NYC Macroscope sample represented 17% of the 4.1 million adult New Yorkers in care in 2013
- Approximately 10% of all primary care providers in NYC
- Population coverage ranged from 8%-47% across neighborhoods
- Lower penetrance in more affluent areas of the city

# Representativeness of the NYC Macroscope Sample

Figure 3. Distribution of NYC Macroscope (Unweighted) Versus CHS Estimations of the Population in Care, 2013




- Before weighting, patients in NYC Macroscope were younger and more likely to be living in high poverty neighborhoods than NYC adults in care overall

- By statistically weighting to as many factors as available in both EHR and 'gold standard' data sources, we sought to reduce selection bias

- *For most indicators with low measurement error, prevalence estimates were comparable to 'gold standard' survey, suggesting minimal selection bias*

Newton-Dame et al, eGEMS 2016

# Who Can We Generalize To? ….Estimate to the "In Care" vs Total Population

- Approximately 75% of the NYC adult population is "in care" (seen provider in past year)

  In-care population more likely to be: Older, female, non-Hispanic and insured

  …more likely to have: Diabetes, hyperlipidemia, and hypertension

- Changing proportions of the population that is uninsured/underinsured over time can influence surveillance validity (uncertain future of ACA)

⇨ *Currently may be inappropriate to generalize findings from primary care EHR systems in the United States to the total population (including persons not in care)*

Romo et al, Preventing Chronic Disease 2016

# How does Missing Data Influence Prevalence and Control Estimates?

- **NYC Macroscope missing data <u>at the patient level</u> varied by indicator**
  - Very low for BMI and blood pressure
    - <2% missing for BP among patients with hypertension
    - <8% missing for BMI
  - High for smoking and labs for diabetes and cholesterol
    - 23% of patients with hyperlipidemia missing cholesterol lab results
    - 27% of patients with diabetes missing A1C lab results
    - 32% missing smoking status
    - 66% missing depression screening
- **Patient-level missingness was clustered within clinical practices**
    - ~15% of practices were missing labs on >50% of their patients

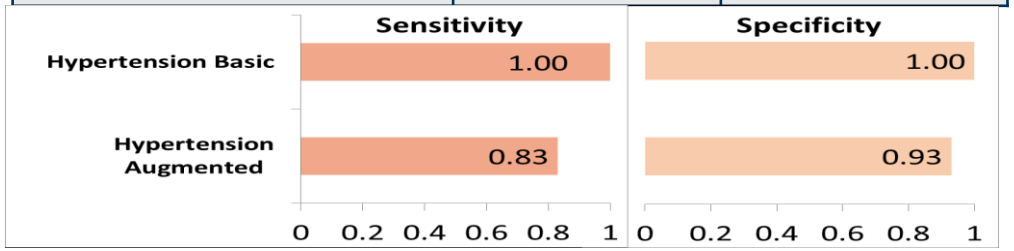
⇨ *Reflects that some practices still lack lab interfaces, and some providers are not ordering labs or screening as recommended, some information stored in wrong fields.* ***MU attainment improves these statistics.***

| CONSTRUCT | OVERALL % COMPLETE |
|---|---|
| Depression screening | 33.9 |
| Smoking screening | 67.9 |
| BMI measured | 92.2 |
| Blood pressure in hypertension | 98.1 |
| A1c test in diabetes | 73.4 |
| Total cholesterol in hyperlipidemia | 76.7 |

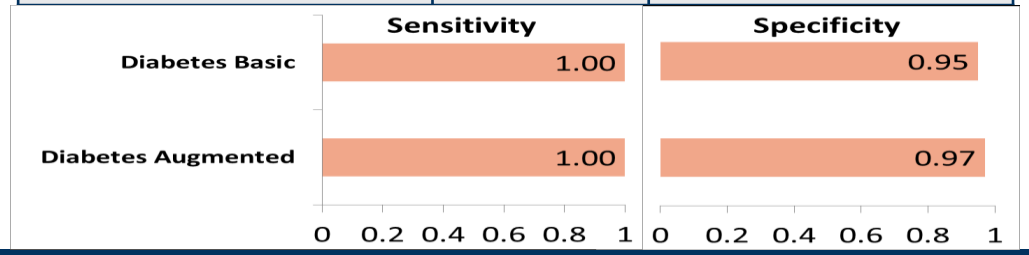
# NYC Macroscope Findings -- Consistency with Other Studies

- Findings on **hypertension**, **diabetes**, **obesity, and smoking** highly robust and consistent with other studies

| Prevalence Estimate | Hypertension | |
|---|---|---|
| | Basic | Augmented |
| NYC Macroscope | 32.3% | 39.2% |
| NYC HANES | 32.5% | 40.3% |




| Prevalence Estimate | Diabetes | |
|---|---|---|
| | Basic | Augmented |
| NYC Macroscope | 13.9% | 15.3% |
| NYC HANES | 12.6% | 17.8% |




## HYPERTENSION AND DIABETES PREVALENCE

- Consistent with findings from 4 other countries using primary care EHR data
- Sensitivity same or slightly higher than other individual-level validation studies in Canada and Sweden
- Augmented definition – using meds & lab information in EHRs
  - Performs well at identifying 'undiagnosed' hypertension
  - Diabetes prevalence is higher in NYC HANES than Macroscope (reflecting risk-based A1c screening in clinical practices vs universal screening in survey)

# NYC Macroscope Findings -- Consistency with Other Studies

- Findings on **hypertension**, **diabetes**, **obesity, and smoking** highly robust and consistent with other studies

| Prevalence Estimate | Obesity |
|---|---|
| NYC Macroscope | 27.9% |
| NYC HANES | 31.3% |
| NYC CHS | 24.7% |
| Sensitivity | 0.92 |
| Specificity | 0.97 |

| Prevalence | Smoking |
|---|---|
| NYC Macroscope | 15.2% |
| NYC HANES | 17.7% |
| NYC CHS | 14.9% |
| Sensitivity | 1.0 |
| Specificity | 1.0 |

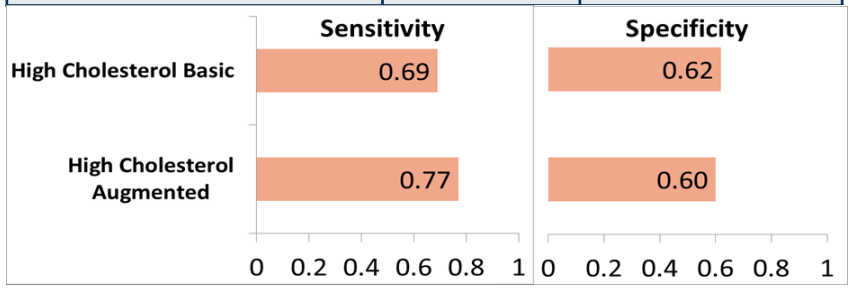
## OBESITY AND SMOKING PREVALENCE

- NYC Macroscope estimates are lower than NYC HANES, yet estimates are closer to directly-measured NYC HANES than widely used telephone survey estimate
- Sensitivity and specificity indicate little measurement error, consistent with other published chart reviews
- Obesity has minimal missing data, smoking has substantial missing data, but appears to be non-differential (by age group, sex and neighborhood poverty)

# Areas still in need of improvement: Hyperlipidemia Prevalence

- Validation of **hyperlipidemia** estimates less successful – similar to experiences elsewhere

| Prevalence Estimate | High Cholesterol | |
|---|---|---|
| | Basic | Augmented |
| NYC Macroscope | 49.3% | 54.5% |
| NYC HANES | 46.9% | 56.8% |




## HYPERLIPIDEMIA PREVALENCE

- Consistent with 3 other countries, our validation **did not** identify that EHR estimates were statistically equivalent to survey measures
- Sensitivity and specificity were below thresholds in all samples
- Longer screening interval, shifting definitions, and diagnosis/treatment dependence on other factors may contribute to poor estimation

# Areas still in need of improvement: Treatment and Control Measures

- Few studies have examined ability of EHR records to estimate treatment and control of chronic diseases
- Our study found treatment and control of hypertension, diabetes and hyperlipidemia performed poorly
  - Definitions more complex than prevalence (requiring long med lists, lab results, and nested queries)
  - Statistical power for comparisons limited by small sample sizes of diagnosed adults in NYC HANES

Table 3b. Control of Diagnosed Cardiovascular/Metabolic Conditions among New York City Adults in Care, Past Year (2013)

| OUTCOME | 2013 NYC MACROSCOPE[a] | 2013 NYC HANES | STATISTICALLY EQUIVALENT | STATISTICALLY DIFFERENT |
|---|---|---|---|---|
| | % (95% CI) | % (95% CI) | (TOST[c]) | (*T* TEST) |
| Hypertension | 65.7 (65.3–66.0) | 58.5 (51.1–65.6) | 0.72 | 0.05 |
| Hyperlipidemia | 87.1 (86.9–87.3) | 79.3 (73.2–84.3) | 0.84 | 0.006 |
| Diabetes | 80.4 (79.9–80.9) | 82.6[d] (68.2–91.3) | 0.31 | 0.71 |

**Needs Improving:**

- **EHR coverage**
- **Provider representation**
- **Patient-level documentation**
- **Proper disease management**

# Next Steps

- Analyzing trend data (2012-2015)
  - Validate trends against the NYC Community Health Survey
  - Examine data by race and health disparities
- Constructing and validating small geographic area estimates
- Developing and testing additional indicators (e.g. childhood obesity)

# Thank you!

Sharon Perlman: sperlma1@health.nyc.gov
Tina McVeigh: tmcveigh@health.nyc.gov
Lorna Thorpe: lorna.thorpe@nyumc.org

We can also be reached at nycmacroscope@health.nyc.gov, or search for “NYC Macroscope”.

# Indicator Definitions

Table 1: Indicator Definitions in NYC Macroscope 2013, NYC HANES 2013-14 and CHS 2013

| Indicator | Type | NYC HANES (n=1,135) | CHS (n=6,166) | NYC Macroscope (n=716,076) |
|---|---|---|---|---|
| Smoking | Prevalence | Smoked 100 cigarettes in lifetime and currently smoke every day or some days | Smoked 100 cigarettes in lifetime and currently smoke every day or some days | Current smoker recorded in structured smoking section** |
| Obesity | Prevalence | BMI≥30 from measured height and weight | BMI≥30 from self-reported height and weight | BMI≥30 from most recent height and weight* in vitals |
| Depression | Prevalence | Ever told had depression or PHQ-9 score of 10-27 | | Ever diagnosis of depression or ever PHQ-9 score of 10-27 |
| Influenza vaccination | Prevalence | Self-reported receipt of influenza vaccination* | Self-reported receipt of influenza vaccination* | CVX, CPT or ICD-9 code indicating receipt of influenza vaccination* |

# Indicator Definitions

| Indicator | Type | NYC HANES (n=1,135) | CHS (n=6,166) | NYC Macroscope (n=716,076) |
|---|---|---|---|---|
| Hypertension (HTN) | | | | |
| | Prevalence of History/Diagnosis | Ever told had HTN | Ever told had HTN | Ever diagnosis of HTN |
| | Total prevalence: HANES gold standard | BP systolic≥140 or diastolic≥90 or ever told had HTN and currently taking medication | | Most recent blood pressure (BP)* systolic≥140 or diastolic≥90 or ever diagnosed HTN with medication prescribed* |
| | Total prevalence: Augmented | BP≥140/90 or ever told had HTN | | Most recent blood pressure (BP)* systolic≥140 or diastolic≥90 or ever diagnosed HTN or medication prescribed* |
| | Treatment | Medication prescribed* among ever told had HTN | | Medication prescribed* among ever diagnosed HTN |
| | Control | BP<140/90 among ever told had HTN | | Most recent BP <140/90* among ever diagnosed HTN |

# Indicator Definitions

| Indicator | Type | NYC HANES (n=1,135) | CHS (n=6,166) | NYC Macroscope (n=716,076) |
|---|---|---|---|---|
| High cholesterol | | | | |
| | Prevalence of History/Diagnosis | Ever told had high cholesterol | Ever told had high cholesterol | Ever diagnosis of high cholesterol |
| | Total prevalence: HANES gold standard | Total cholesterol ≥240 or ever told had high cholesterol and currently taking medication | | Most recent total cholesterol ≥240** or ever diagnosis of high cholesterol with medication prescribed* |
| | Total prevalence: Augmented | Total cholesterol ≥240 or ever told had high cholesterol | | Most recent total cholesterol ≥240** or ever diagnosis of high cholesterol or medication prescribed* |
| | Treatment | Medication prescribed* among ever told had high cholesterol | | Medication prescribed* among ever diagnosed high cholesterol |
| | Control | Total cholesterol <240 among ever told had high cholesterol | | Most recent total cholesterol <240** among ever diagnosed with high cholesterol |

# Indicator Definitions

| Indicator | Type | NYC HANES (n=1,135) | CHS (n=6,166) | NYC Macroscope (n=716,076) |
|---|---|---|---|---|
| | Prevalence of History/Diagnosis | Ever told had DM | Ever told had DM | Ever diagnosis of DM |
| | Total prevalence: Augmented | A1c>=6.5 or ever told had DM | | Most recent A1c>=6.5** or ever diagnosis of DM or medication prescribed* |
| | Treatment | Currently taking medication among ever told had DM | | Medication prescribed* among ever diagnosed DM |
| | Poor control | A1C > 9 among ever told had DM | | Most recent A1C >9** among ever diagnosed DM |

* In past calendar year

** In past 2 calendar years

*** For full list of treatment medication queried for hypertension, diabetes and cholesterol, see Appendix A