Graphically presenting associations of related but distinct phenomena:

moving beyond p-values

Maia P. Smith, PhD

St. George's University, Grenada

Maia.phillips.smith@gmail.com

Background: Increasing importance of multifactorial measures

- Exposures and/or outcomes increasingly multifactorial
  - -Omics studies: genes, proteins, metabolites
  - Nutrition: nutrients and/or foods
  - Social sciences: crimes

- Increases in computing power allow research to precede hypothesis formulation– 'fishing expeditions'

- Multiple comparisons = increased risk of random false positives.

Distinguishing false from true positives: current options

Clinical judgment

$\rightarrow$Useful only if hypotheses already exist

Adjustment of p-value for significance

- Statistical correction: Bonferroni, Benjamini-Hochberg…
- Graphical visualization: Manhattan plots

$\rightarrow$ Costs statistical power: increases false negatives

$\rightarrow$ Does not address effect size

$\rightarrow$ Does not address global null ('Is there a genetic effect?')

My method:
Graph sample size against effect size (similar to a funnel plot)

Answers two questions:

→ Is there a main effect? → "Association" – maybe not causal

  • Is the plot centered on 'no effect'?

→ Is there effect heterogeneity (subgroup effects)?

  • Is the plot spread out / asymmetrical?

  • Are extreme-valued points similar in some way?

Example: Risk of crime in LA: effects of lunar phase or victim sex
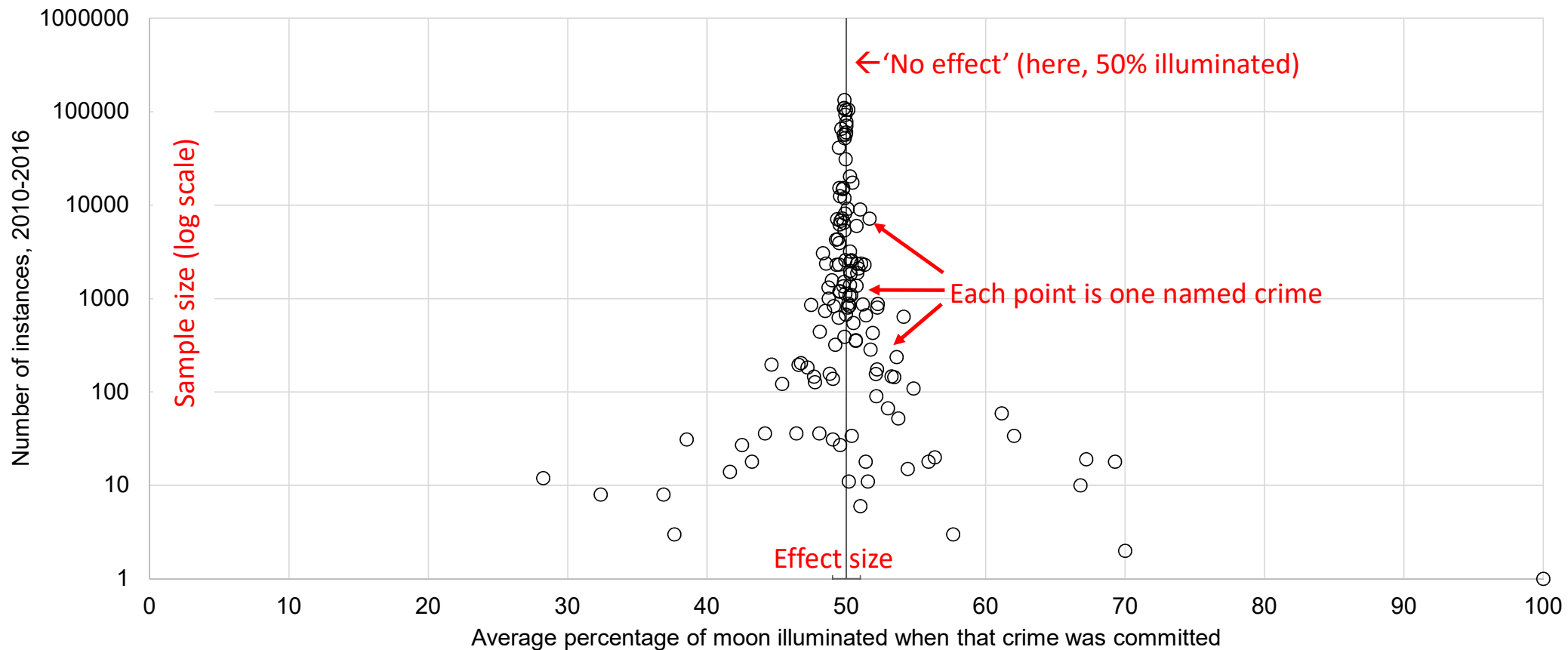
→ Is there a main effect?

1. Does overall crime rate vary with lunar phase?

2. Is one sex at greater risk of victimization?

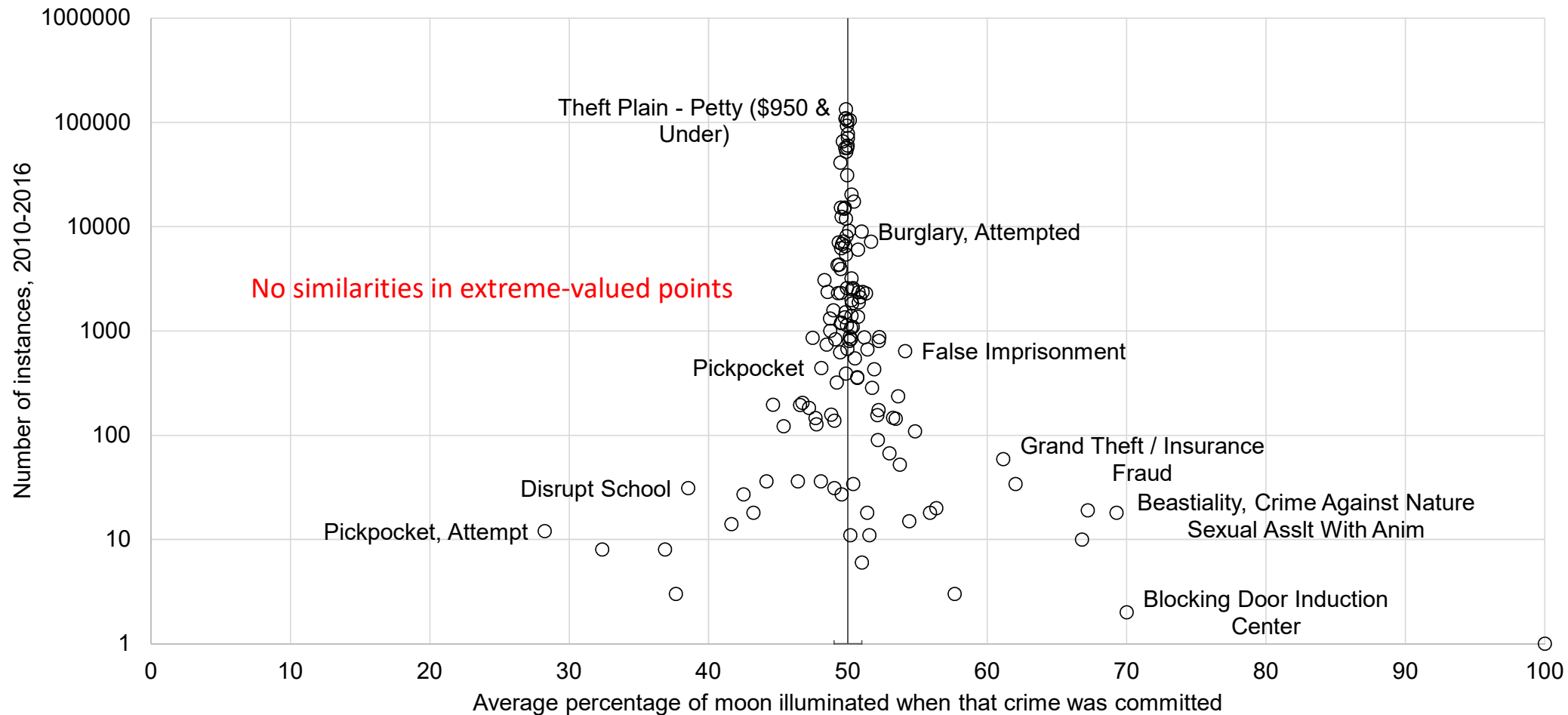→ Is there effect heterogeneity / subgroup effects?

1. Are certain crimes (or crime types) more or less common at a given lunar phase?

2. Are certain crimes (or crime types) more likely to victimize one sex?

Example 1: No main effect of lunar phase on crime rate: no clear heterogeneity
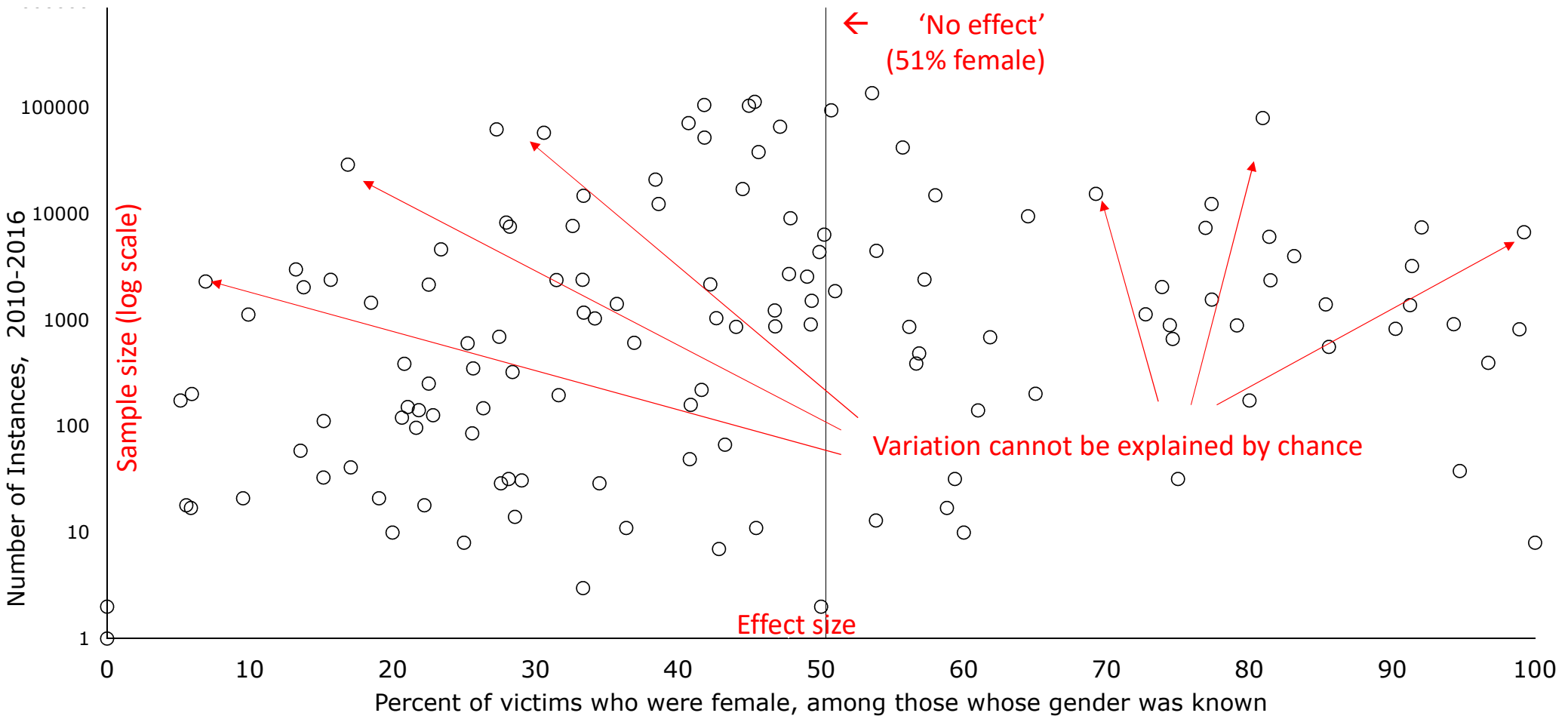

Lunar phase and crime incidence

← 'No effect' (here, 50% illuminated)

Each point is one named crime

Effect size

Sample size (log scale)

Number of instances, 2010-2016

Average percentage of moon illuminated when that crime was committed

Example 1: Examination of extreme-valued points: no subgroup effects

Number of instances, 2010-2016

1000000

100000 — Theft Plain - Petty ($950 & Under)

No similarities in extreme-valued points

10000 — Burglary, Attempted

1000 — False Imprisonment

Pickpocket

100 — Grand Theft / Insurance Fraud

Disrupt School — Beastiality, Crime Against Nature Sexual Asslt With Anim

10 — Pickpocket, Attempt

Blocking Door Induction Center

1

Average percentage of moon illuminated when that crime was committed

Example 2: No main effect of sex on crime risk: however significant heterogeneity

← 'No effect' (51% female)

Sample size (log scale)

Number of Instances, 2010-2016

Variation cannot be explained by chance

Effect size

Percent of victims who were female, among those whose gender was known

Example 2: Examination of extreme-valued points: obvious subgroup effects

Y-axis: Number of Instances, 2010-2016 (log scale: 1, 10, 100, 1000, 10000, 100000, 1000000)

X-axis: Percent of victims who were female, among those whose sex was known (0 to 100)

Labels on plot:
- Battery With Sexual Contact
- Rape, Forcible
- Sex, Unlawful
- Sexual Penetration With A Foreign Object
- Purse Snatching
- Rape, Attempted
- Pimping
- Peeping Tom
- Resisting Arrest
- Assault With Deadly Weapon On Police Officer
- Battery On A Firefighter
- Failure To Yield
- Failure To Disperse
- Drunk Roll
- Lynching - Attempted
- Purse Snatching - Attempt

Mostly male victims: attacks on emergency personnel

Mostly female victims: sex offenses (and purse snatching)

Conclusion: Association of rate of crime(s) with lunar phase or victim gender

→ Is there a main effect?

- Is crime more common at full or new moon? **Not really**
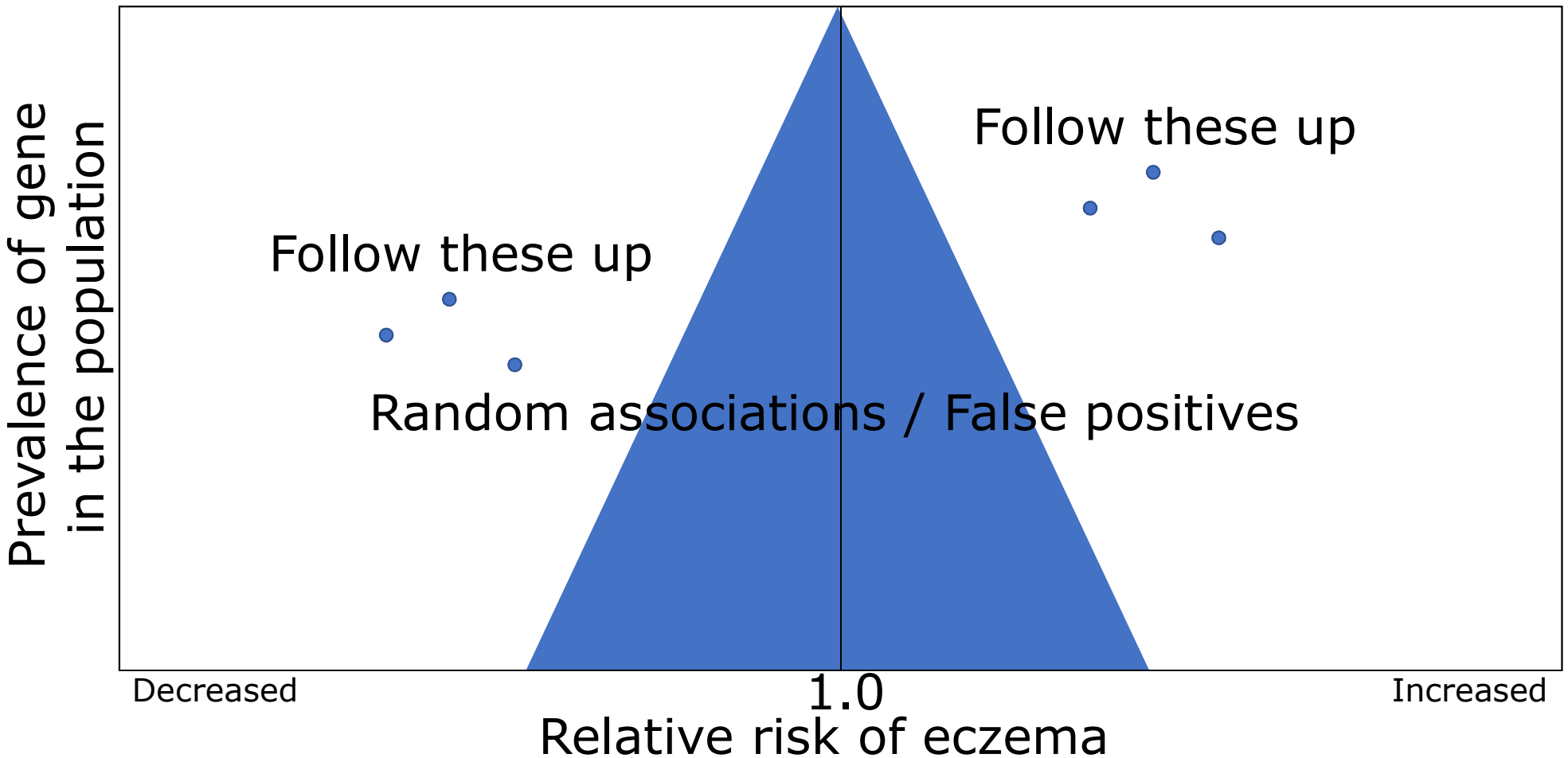- Is one sex at greater risk of victimization? **Not really**

→ Is there effect heterogeneity?

- Are certain types of crime more common at a given lunar phase? **No**
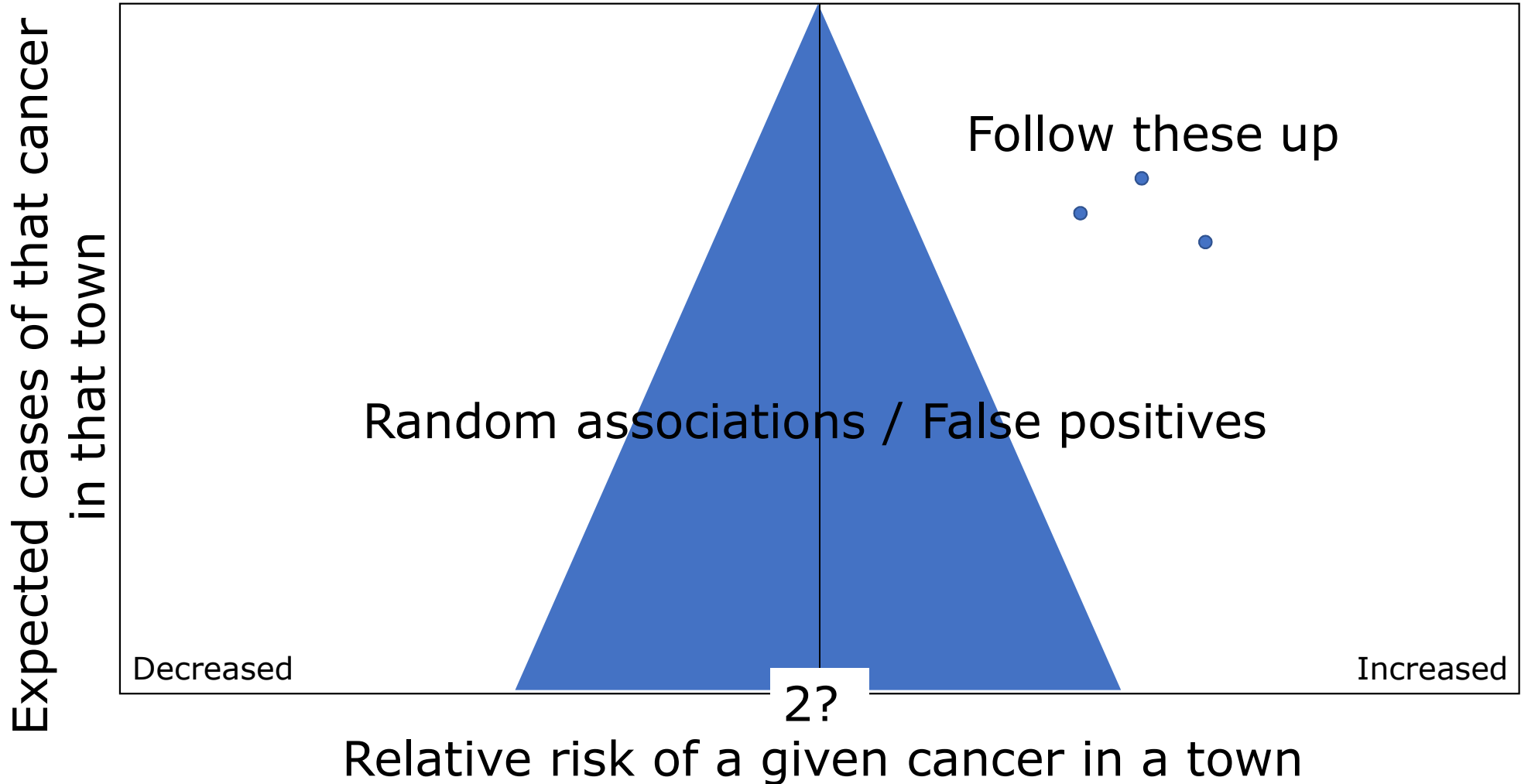- Are certain types of crime more likely to victimize one gender? **Yes**

Conclusions:

- Effects of lunar phase on crime are <mark>consistent with artifact</mark> and can be ignored, **regardless of individual p-value**

- Effects of sex on crime victimization are <mark>consistent with a true effect</mark> and should not be ignored, **regardless of p-value**
  →Base rate of victimization does not vary much by sex: no main effect
  →Large within-outcome heterogeneity: 'crime' is not a single outcome
  　　　　→Studies of sex and crime should consider the clusterings we found (e.g. treat sex offenses as one cluster, and crimes against emergency personnel as another).

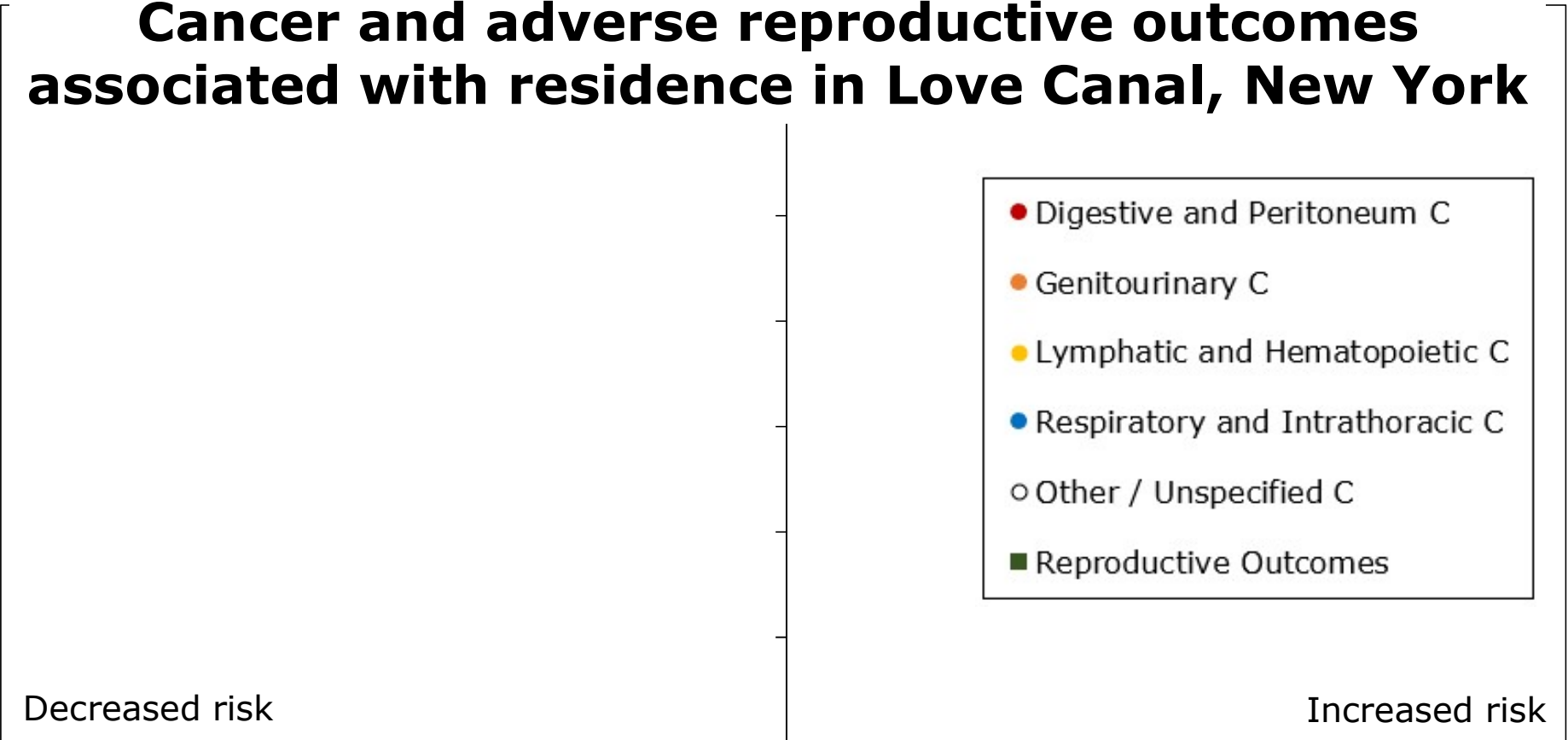# Application: Genome-wide association studies (GWAS)

Further application: Environmental health

Expected cases of that cancer in that town (y-axis)

Relative risk of a given cancer in a town (x-axis)

Follow these up

Random associations / False positives

Decreased

Increased

2?

Final example: Environmental health

Cancer and adverse reproductive outcomes associated with residence in Love Canal, New York

Expected number of cases based on population

Decreased risk

Increased risk

- Digestive and Peritoneum C
- Genitourinary C
- Lymphatic and Hematopoietic C
- Respiratory and Intrathoracic C
- Other / Unspecified C
- Reproductive Outcomes

1.0

Standardized incidence ratio, vs. a reference population

Final example: Environmental health

Cancer ('C') and adverse reproductive outcomes associated with residence in Love Canal, New York
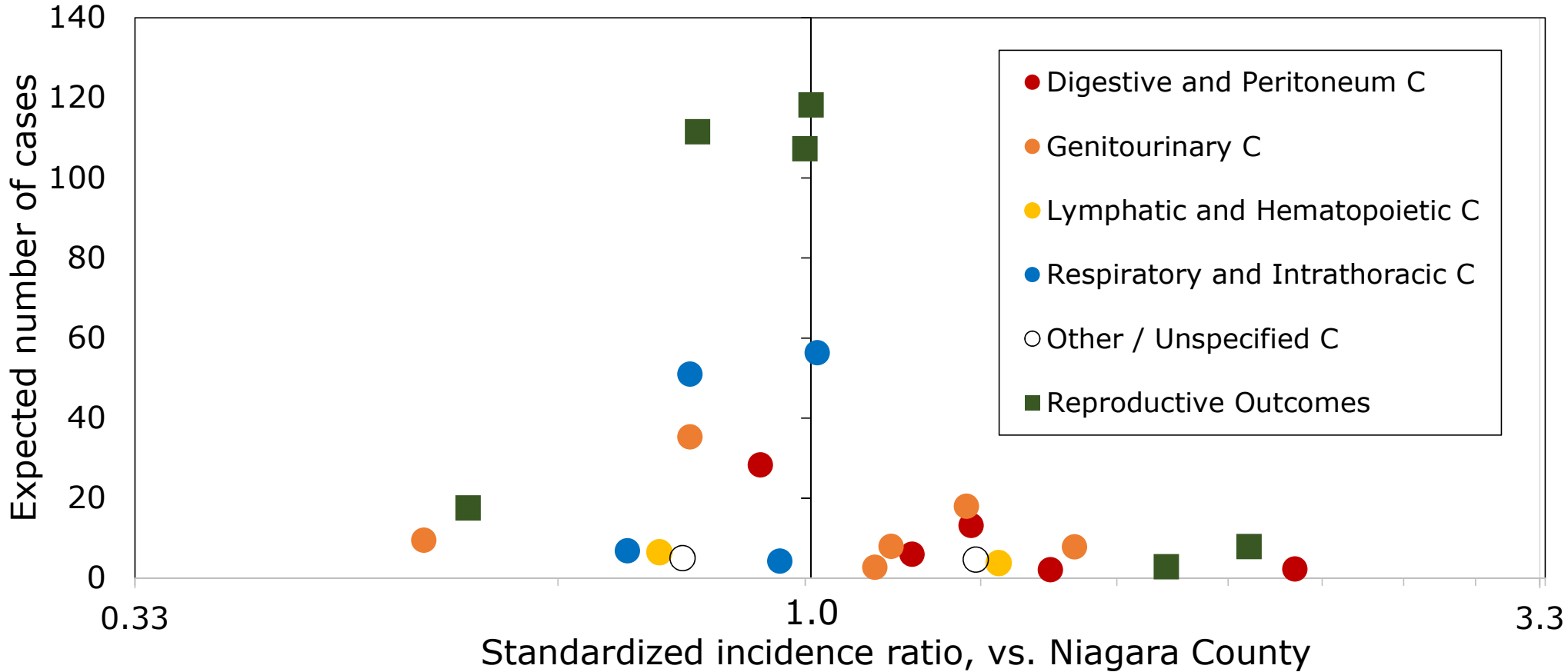
Data from Tables 10 and 17 in Love Canal Follow-up Health Study, New York State Health Department; available at health.ny.gov/environmental/investigations/love_canal/docs/report_public_comment_final.pdf.

Thanks for listening!
Questions? Comments?