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PHO Rounds
How to develop a surveillance system for disease aberrations

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Learning objectives

1. Use a grid to determine the frequency of surveillance for their chosen health event
2. Explain why a simpler to more complex statistical surveillance system is optimal given their event of interest
3. As part of a team design and implement an appropriate surveillance system for their health event
4. Explain to an audience why further investigation is required when an observed count exceeds that which is expected.

Outline

1. Background, goals and definitions
2. Hypothesis testing and statistics behind surveillance
3. Selecting a type of surveillance system
4. Progression from simple daily and weekly to complex surveillance systems & output reports
5. Conclusions

Surveillance is important

Public health inspectors conduct inspections and receive complaints

Call from a golf club about reports of gastrointestinal symptoms among members

18

22

25

Surveillance is important (2)

Public health inspectors conduct inspections and receive complaints

Call from a golf club about reports of gastrointestinal symptoms among members

Epidemiologists conduct weekly surveillance

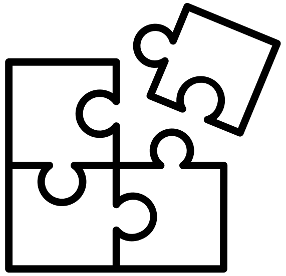
Aberration algorithm detects a cluster of giardiasis, in older males of similar ethnicity

Public health nurses follow up with giardiasis cases

Case mentions local golf club

Another case mentions the same golf club

October 17 18 22 25



Outbreak is declared

Goal of surveillance

To detect case counts in real time which are unexpectedly high

- Or low

Why? To investigate source

Definition

Reporting and *"Surveillance is the ongoing systematic*

- collection
- analysis
- interpretation of health data essential to the
    - planning
    - implementation, and
    - evaluation of public health practice, as well as the
- **Timely** dissemination to those who need to know"

Statistical reasoning; what is the normal number of cases?

Current counts are the total of all cases for current period; day, week, month

H_0 Are the current case counts statistically similar to historic comparison counts?

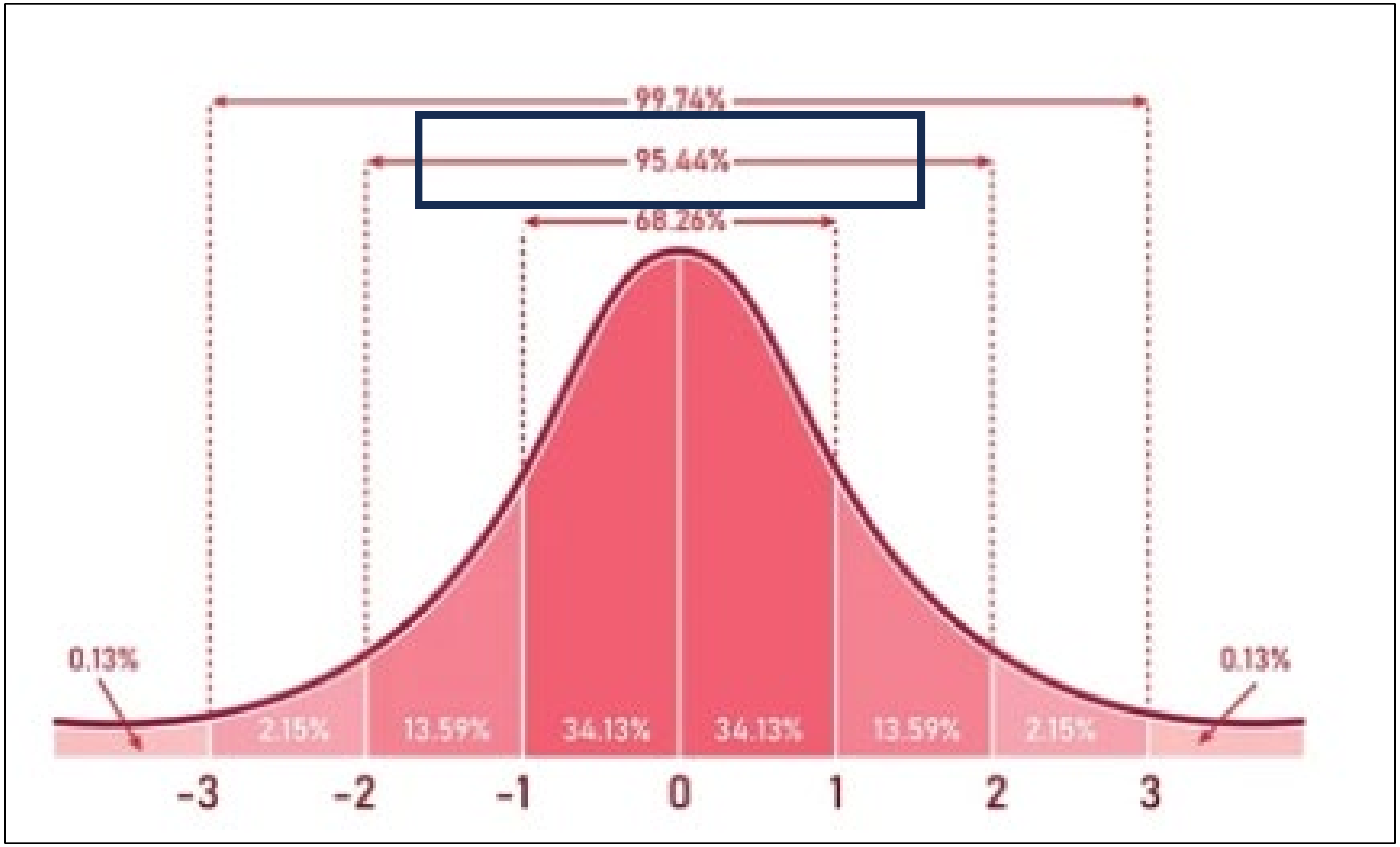
- i.e. Are this week's counts **normal,** and fall into the range of those **expected?**

H_1 Are the current case counts significantly different from historic comparison counts?

- Are this week's counts **abnormal** and fall into the range of unexpectedly higher numbers of cases ($p<0.05$)

Now we have the current cases, we need to compare with historic counts

Normal distribution, mean + 2*STDEV = 95% confidence limits



Defining "normal" or expected number of cases

Simple threshold

= average or mean case counts + 2*STDEV from historic time, days, weeks, months

This threshold is the 95th percentile of the normal distribution

- The 5% of counts above that is classified as "abnormally" or significantly higher than the others below 95%

We suppress all historic counts over the 95th percentile threshold

- Statistically you should not combine statistically different weekly counts
- If you include the abnormally high counts, you will get lower threshold and more false positives

Outbreak?

Outbreak definition

.”..the occurrence of cases of disease in excess of what would **normally be expected** in a defined community, geographical area or season.”

Outbreak steps

1. Confirm existing cases
2. Verify that outbreak exists
3. Describe outbreak in terms of person, place and time
4. Hypothesize source, agent
5. Identify populations at risk
6. Test hypothesis (case control study)
7. Disseminate analysis, and prevent

Selecting a surveillance system features

Counts from previous time period, how far back?

- Depends on when infection became notifiable

Comparable with current year so consider

- Change of test methods, societal conditions, pandemics

Adjusted for time of year?

- Or detect start of respiratory season?

Sufficient counts to be statistically stable?

- 3 months of data = 12 weeks or data points, likely sufficient

Frequency of analysis? Daily, weekly, monthly

- Consider range of incubation periods

All disease classifications? (Confirmed, suspect, PUI)

- What classification do they have when reported to PHU?

Duplicates?

- Remove or not?

Creating simple daily thresholds for COVID-19 sporadic, community cases

7-day lead in period.

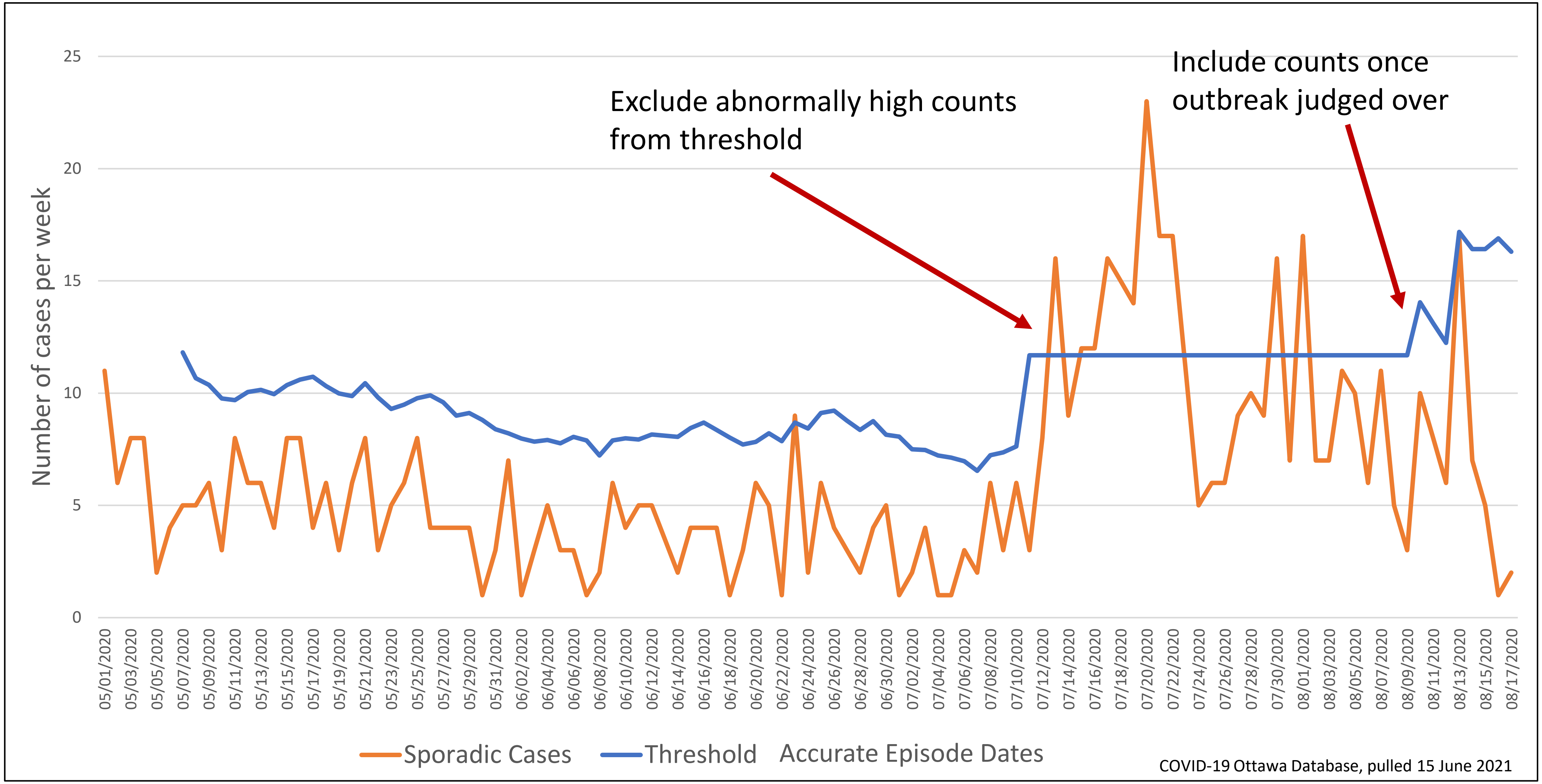
Threshold will stabilize with more observations

Check with case managers, intake staff as they identify many outbreaks or potential outbreaks are identified early.

C8 =AVERAGE(B2:B8)+(STDEV.P(B2:B8))*2

	A	B	C	D
1	CalcDate	Sporadic Cases	Threshold	
2	2020-05-01	11		
3	2020-05-02	6		
4	2020-05-03	8		
5	2020-05-04	8		
6	2020-05-05	2		
7	2020-05-06	4		
8	2020-05-07	5	11.81	
9	2020-05-08	5	10.67	
10	2020-05-09	6	10.37	
11	2020-05-10	3	9.76	

Daily thresholds, mean + 2*STDEV, COVID- 19, Ottawa, May - Aug 2020

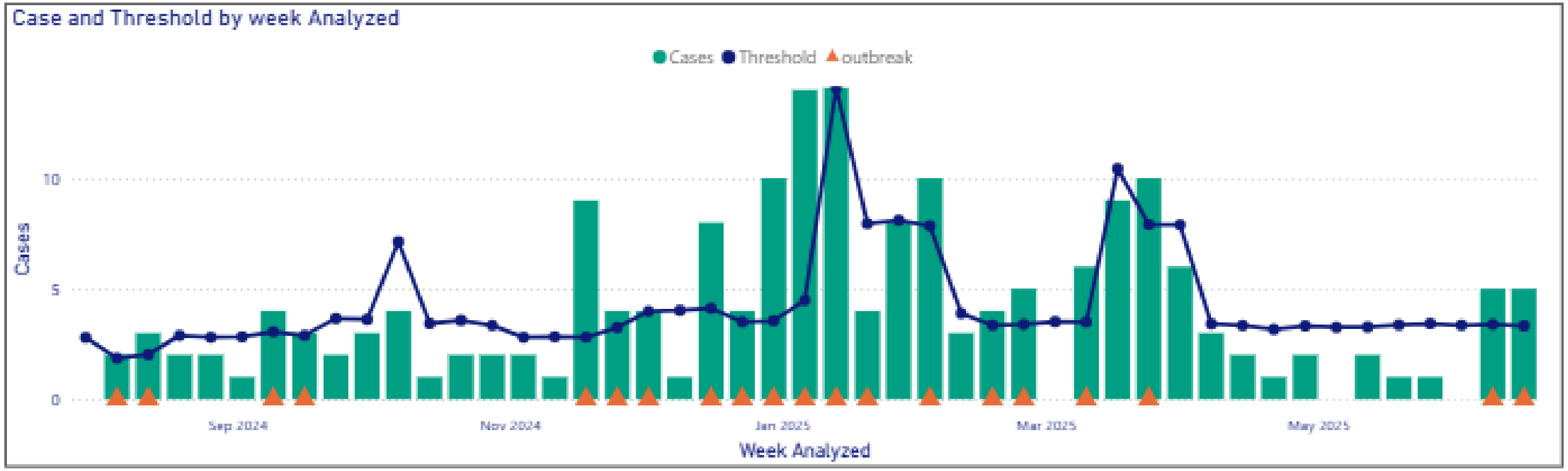


Weekly simple surveillance of all DPHS with STATA

- Compares moving average and STDEV of the current week with 3 previous and 3 subsequent weeks
- STDEV cumulative for last 10 years
- Accounts for low counts during pandemic
- Accounts for time of year
- Excludes counts which are above the threshold

Issues

- Based on 95th percentile of a normal, not a Poisson distribution, so inaccurate for low numbers of cases e.g., anaplasmosis, babesiosis
- Cannot easily deal with week 53 or transition to new year week 52 to week 1



Farrington Method

Adjusts for time of year

Uses a Poisson distribution to analyze case counts

- works for common and rare diseases with weekly counts below and above 10
- Most sensitive algorithm, with fewest false positives
- Adjustable parameters
  - How far back to go in time?
  - Transformations, (Poisson, normal and other)
  - Low number suppression, **Caution**
  - Weights most recent data more heavily

- Package available in R
  - More recent adaptation with enhanced sensitivity

Weekly simple surveillance with STATA

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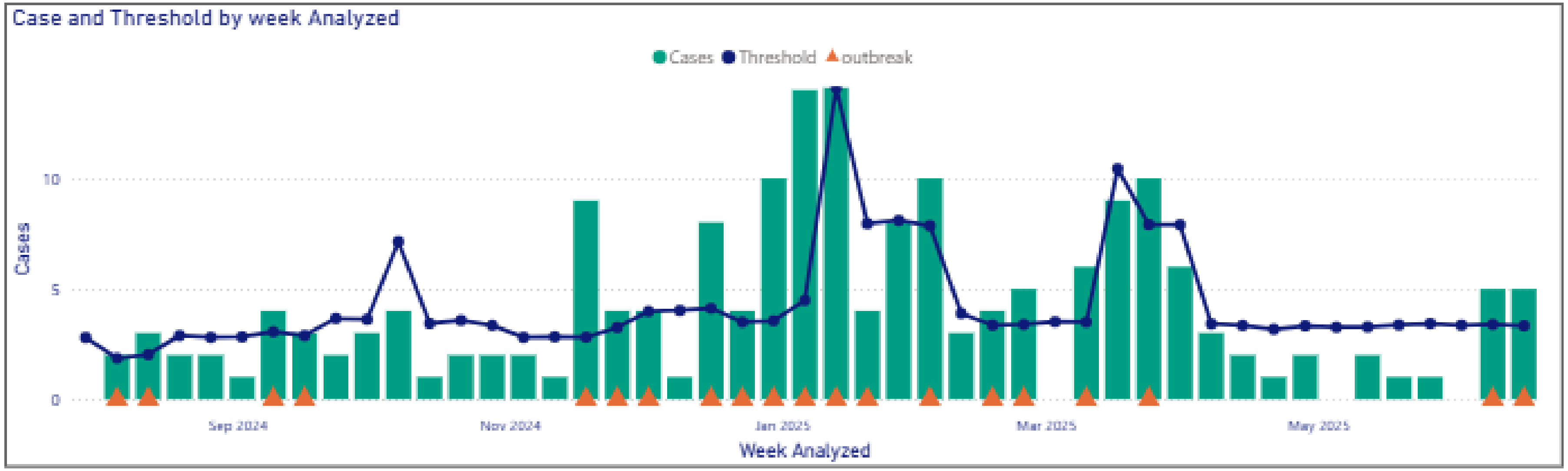
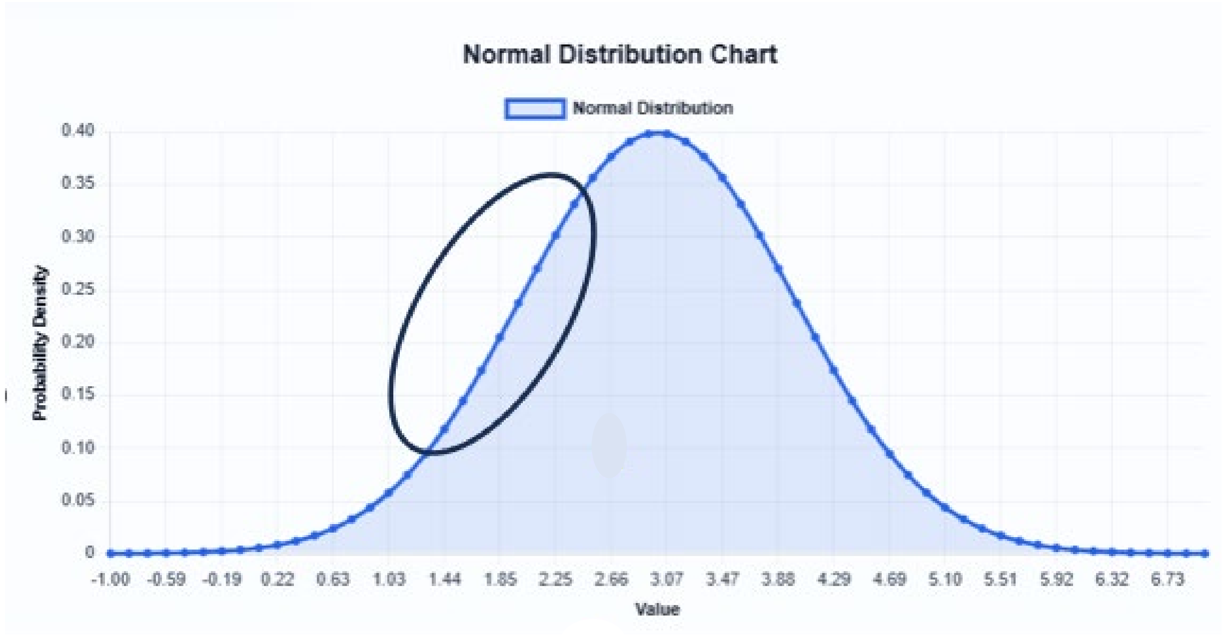
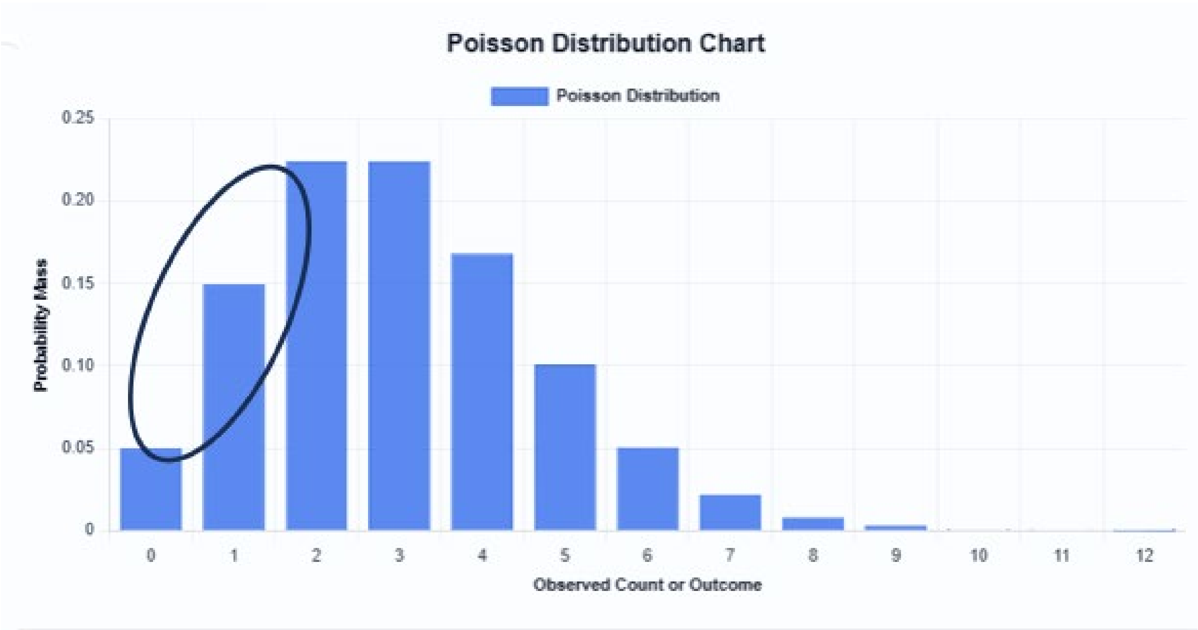


Normal and Poisson distributions





The normal distribution is continuous and symmetric; it is used to measure continuous intervals like temperature. The mean of this graph is 3 and it extends from - 1 to about 6.7.

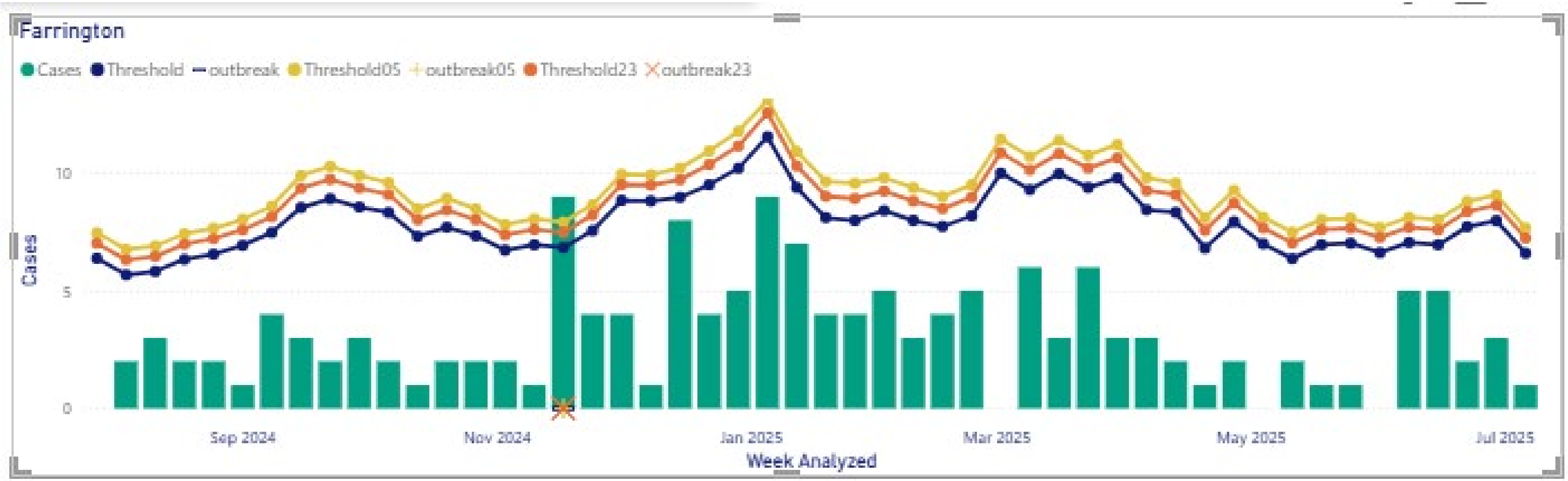
The Poisson distribution is tall and asymmetric; it is used to measure the number of times (probability) that each count occurs during a set period. The mean of this graph is 3 and it extends from 0 to 7

https://toolsir.net/math/probability-distribution-visualizer/

Weekly surveillance with Farrington method

Below are the case counts and thresholds for the Farrington Method in R displayed on PowerBI

- There are 3 thresholds one of which is computed with the 2/3 power transformation for the Poisson distribution in orange



Output, weekly surveillance report, OPH

Weekly Aberration Report

Weekly Surveillance Summary for Week 31 (Week Starting July 27, 2025) as of 06Aug2025

Dear OPH colleagues, please find the weekly surveillance results below and attached. The following infections exceeded the mean and two standard deviations ("threshold" in the table) for the current week and the 3 weeks on either side for last 10 years, or are rare and noted for awareness.

As the majority of outbreaks and potential outbreaks are usually discovered by managers in the course of following up cases or complaints, we have added a new table of outbreaks and/or possible outbreaks reported to us from IPAC or IDP, should there be any.

Disease	Reports	Threshold	Interpretation
BLASTOMYCOSIS	1	0.66	1 report was received for a female in their 60s who lives in near a river. Follow-up is ongoing. The last confirmed case in Ottawa was reported in June with onset in May.
HIV/AIDS	9	8.55	Reports were received for 5 females in their 40 – 60s and 4 males in their 20s through their 50s. 2 of the males had been tested through immigration screening.

Outbreaks, notable increases or cases reported by OPH Programs

Infection	History	Source
RPEP	The high numbers of RPEP incidents continue to dog IDP. As of Wednesday, at 4:00 pm we have 42 reports for the month of August, which is half that which we reported for the whole of July. Please see the RPEP tab of the internal DPHS Dashboard for more information.	IDP

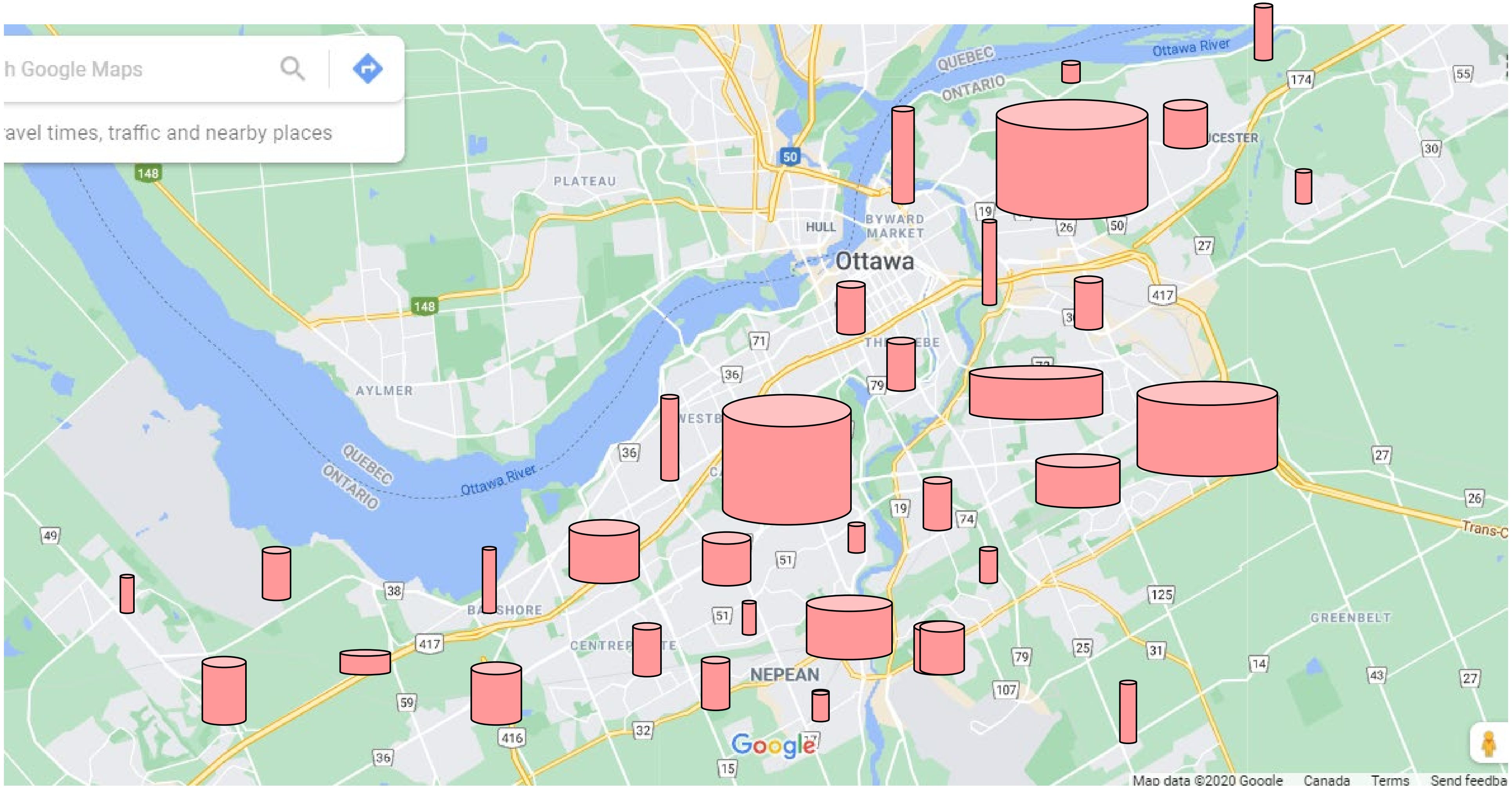
When counts exceed the threshold

- Scan line list for case similarities in
  - Place, same neighbourhood, congregate living (postal code), underhoused
  - Age group
  - Gender
  - Language, community
- Sample interpretation;
  - “2 reports of meningitis are from two females in their 50s and 90s respectively. 1 is confirmed as invasive meningococcal disease, and the other is still being investigated as to whether it meets the case definition. 1 report from a male in their 30s was caused by VZV. None of the clients resided close to each other.”

When to use spatial temporal surveillance?

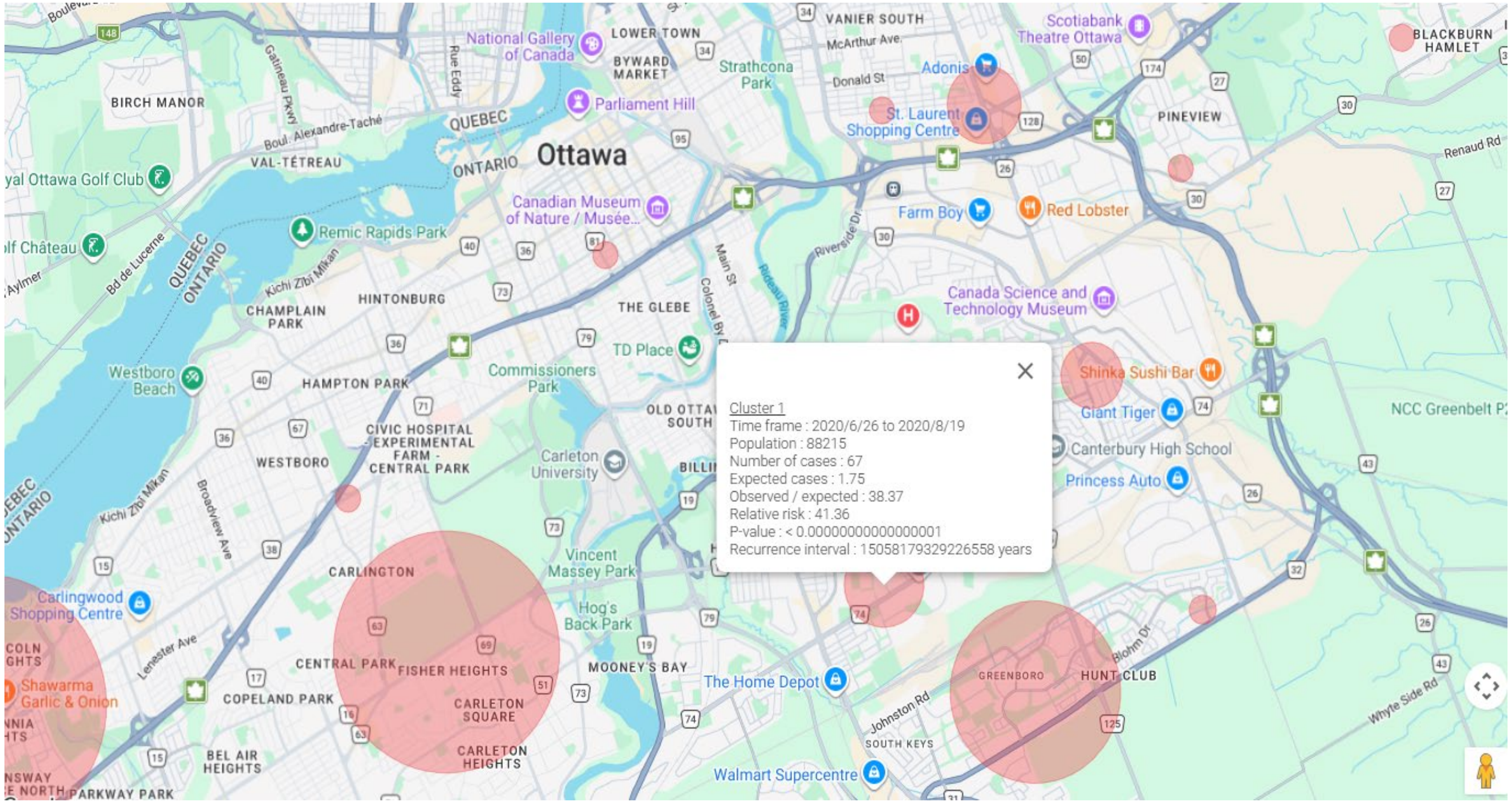
- To detect clusters in time and space
  - Not only when number are unusually high, but where and for how long (prioritization)
- Single source exposures such as cooling towers for legionella
  - We interview clients with legionella to obtain possible exposures
- Enterics to define areas where groceries may be contaminated
  - Use address of client as they likely shop close to where they live
- Lyme & arthropod borne diseases (obtain exposures)
- TB & STBBI but may indicate only areas (social networks of where folks at risk live)

Expected (Null) distribution (standardised by population density)



Observed space-time clusters of COVID-19, Ottawa, 19 Aug 2020

- Rates in Ottawa at the time; 1.75/100,000 or 16 cases/day (7-day average)
- Rates in that cluster 41 times that;
- From 26 June – 19 Aug 2020



Conclusion

- Surveillance systems based on numeric algorithms vary in sensitivity from 25 – 67 % depending on method and infection of interest
- A large proportion of advance alerts come from public health nurses and public health inspectors investigating incidents and receiving information from the public so ask them weekly
- Selection of which method depends on;
    - Specific needs of the program
    - Distribution of the events under study
    - Frequency
    - Accessibility
    - Ease of use
    - Try to do all notifiable disease at once rather than each one individually
- Keep reports short, consistent, clear and interpretable

References

Definition of surveillance.

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Outbreak definition

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Surveillance systems and evaluations

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2. Zhou H et al, Journal of Biomedical Informatics 2017;76:34-40 http://dx.doi.org/10.1016/j.jbi.2017.10.010)
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