Public Health Surveillance

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Objectives of Lecture

- Key concepts of surveillance
  - Definition
  - Uses
  - Methods
- Public health surveillance systems
- Use and evaluation of surveillance systems
- Influenza surveillance

What comes to mind when you hear ‘surveillance’?

- Law enforcement agencies
- CIA
- Routine data collection
- Statistics
- Trends

Definition of Surveillance

- The ongoing systematic collection, analysis, and interpretation of outcome-specific data for use in the planning, implementation, and evaluation of public health practice.
- Includes data collection, analysis, and dissemination to those responsible for prevention and control.

What Surveillance Is

- Systematic, ongoing…
  - Collection
  - Analysis
  - Interpretation
  - Dissemination
- …of health outcome data
- Health action
  - investigation
  - control
  - prevention
Surveillance History in U.S.

- 1741 – Rhode Island passed an act requiring tavern keepers to report contagious disease
- 1850 – Mortality statistics first published by the federal government for the U.S.
- 1874 – Massachusetts instituted weekly reporting of diseases by physicians
- 1878 – Public Health Service (PHS)-type organization created to collect morbidity data for use in quarantine for cholera, smallpox, plague, yellow fever.
- 1901 – All states required disease reporting.
- 1925 – All states began participating in national morbidity reporting
- 1935 – First national health survey
- 1951 – Council of State and Territorial Epidemiologists (CSTE) authorized to determine diseases to be reported to PHS

Legal Authority for Surveillance

- Legal authority for mandatory public health surveillance resides with states
- Virginia Code
  - 32.1-35 – BOH shall promulgate a list of diseases required to be reported.
  - 32.1-36 – Physicians and laboratories shall report.
  - 32.1-37 – Medical care facilities, schools and summer camps shall report.

Purpose of Surveillance

- To assess public health status, to define public health priorities, to evaluate programs, and to stimulate research.
  - Tells us where the problems are, who is affected, and where the programmatic and prevention activities should be directed.

Virginia Code, continued

- 32.1-38 – Anyone making a report is immune from liability
- 32.1-39 – BOH shall provide for surveillance & investigation.
- 32.1-40 – Commissioner or designee can examine medical records
- 32.1-41 – Anyone examining records must preserve anonymity of the patient and the practitioner

How can surveillance data be used?

- Estimates of a health problem
- Natural history of disease
- Detection of epidemics
- Distribution and spread of a health event
- Hypothesis testing
- Evaluating control and prevention measures
- Monitoring change
- Detecting changes in health practice
- Facilitate planning
Uses of Surveillance Data

Estimates of a Health Problem

- Quantitative estimates of the magnitude of a health problem – including sudden or long-term changes in trends, patterns

Natural History of Disease

- Portrayal of the natural history of disease (clinical spectrum, epidemiology)

Detection of Epidemics

SALMONELLOSIS Incidence,* by year United States, 1973-2003

Distribution & Spread of a Health Event

- West Nile Virus in the US, 2000-2003

Hypothesis Testing

- Facilitation of epidemiologic and laboratory research – Hypothesis testing

Evaluating control & prevention measures

Effectiveness of vaccine introduction
Uses of Surveillance Data

Monitoring changes

- Monitoring changes in infectious agents and host factors

Detecting Changes in Health Practice

Facilitate Planning

- Identify target populations in need of health services
  - Refugee populations
  - Morbidity surveillance in emergency shelters
- Identify health topics to be addressed by educational programs and media

Outcomes

- Surveillance is outcome oriented
- Can measure frequency of an illness or injury, severity of the condition, and impact of the condition.
- Number of cases, incidence, prevalence; case fatality, hospitalization rate, mortality, disability; cost.
- Orient data by person, place, and time.

Planning a Surveillance System

- Establish objectives
- Develop case definitions
- Determine data source or data collection mechanism
- Field test methods
- Develop and test analytic approach
- Develop dissemination mechanism
- Assure use of analysis and interpretation

What Should be Under Surveillance?

- Establish priorities based on:
  - Frequency (incid., prev., mortality, YPLL)
  - Severity (case-fatality, hospitalization rate, disability rate)
  - Cost (direct and indirect)
  - Preventability
  - Communicability
  - Public interest
  - Will the data be useful for public health action?
**Surveillance Methods**

**Case Definition**

- Case definition
  - Important to clearly define condition
  - Ensures same criteria are used by all
  - Makes the data more comparable
  - Include person, place, time
  - May define suspected and confirmed cases
  - May include symptoms, lab values, time period, population as appropriate

**Case Definition Examples**

- Weak Definition - Measles
  - Any person with a rash and fever, runny nose, or conjunctivitis

- Better Definition - Measles
  - Any person with a fever > 101 F, runny nose, conjunctivitis, red blotchy rash for at least 3 days, and laboratory confirmation of IgM antibodies

- Clinical, Probable, Confirmed Case Definitions
- Outbreak Case Definition
  - Differs from routine surveillance
  - Epidemiologically linked

**Surveillance Methods**

**Data Collection**

- Data collection
  - Standardized instruments, field tested
- Passive Surveillance
  - Providers are responsible for reporting.
  - Health dept. waits to receive reports.
  - Problem with underreporting
- Active Surveillance
  - Providers contacted on regular basis to collect information
  - More resource intensive
  - Used for outbreaks or pilots (e.g., HUS)

**Surveillance Methods**

**Data Analysis**

- Ongoing review
- Descriptive statistics, Multivariate analyses
- Automated analyses

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuberculosis</td>
<td>20</td>
</tr>
<tr>
<td>Gonorrhea</td>
<td>320</td>
</tr>
</tbody>
</table>

**Surveillance Methods**

**Interpretation and Dissemination**

- Presentation of data in the form of tables, graphs, maps, etc.
- Disseminate data via reports, presentations, internet, etc.

**Surveillance Methods**

**Evaluation**

- Did the system generate needed answers to problems?
- Was the information timely?
- Was it useful for planners, researchers, etc?
- How was the information used?
- Was it worth the effort?
- What can be done to make it better?
- (More on evaluation later).
Cycle of Surveillance

• Data Collection
  – Pertinent, regular, frequent, timely
• Consolidation and Interpretation
  – Orderly, descriptive, evaluative, timely
• Dissemination
  – Prompt, to all who need to know (data providers and action takers)
• Action to Control and Prevent
• Evaluation

Data Sources

• Vital Statistics
• Notifiable Diseases
• Registries
• Sentinel Surveillance
• Syndromic Surveillance
• Surveys
• Administrative Data

Data Sources: Vital Statistics

• Live Births
• Deaths
• Fetal Deaths
• Marriages
• Divorces
• Induced Terminations of Pregnancy
• Infant Mortality (link birth and death data)

Virginia Birth Certificate

Virginia Death Certificate
Uses of Vital Statistics Data

- Monitoring long-term trends
- Identifying differences in health status within racial or other population subgroups
- Assessing differences by geographic area
- Monitoring deaths that are preventable
- Generating hypotheses about causation
- Monitoring progress toward improved health of the population; health-planning

Vital Records: Coding and Calculating

- ICD-9 historically, now ICD-10
- Infant mortality - need number of live births for denominator in calculating rates
- Other death rates - use total population in rate calculations.
- Crude and adjusted (standardized) rates used.

Vital Statistics Data

Data Sources: Notifiable Diseases

- States decide what is notifiable/reportable
  - Based on disease occurrence, potential for outbreaks, public perception of risk, etc.
  - CSTE recommendations
  - Different processes for generating N.D. list
- Weekly (or sometimes rapid) reporting to health departments by physicians, medical care facilities, laboratories.
  - States report to CDC

Quality of Vital Stats Depends on

- Care taken by health care providers in ascertaining cause of death and other factors
- Accuracy of coding (difficult for injuries)
- Relevance of existing codes for the condition being recorded
- Accuracy of population estimates
- Problems - don’t know onset, can’t see effect of diseases that don’t lead to death

Reportable Disease List

- Over 70 reportable diseases/conditions
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Epi-1 Form

Chain of Communication

Providers → Local H.D. → Regional → Central Office → Other States

Other Health Districts → CDC

Add this in 2009

Number of Virginia Children Reported with Blood Lead Levels ≥ 10 µg/dL, by Range of Elevation and Year, from 2005 to 2007

Geographic Distribution of Human Arbovirus Cases Recorded in Virginia since 1975

STD and HIV Trends
Limitations of Disease Reporting

- Underreporting
  - Reporting better for more serious diseases and those for which there is laboratory confirmation
  - Need to seek medical consultation to be diagnosed and then reported
- Lack of representativeness of reported cases
- Inconsistent case definitions

Reasons for Not Reporting

- Assume someone else reported.
- Did not know reporting was required; don’t have a copy of the reportable disease list.
- Do not know how to report; don’t have form or telephone number.
- Concern about confidentiality and doctor-patient relationship.
- No incentive to report. Time-consuming. Unaware of value.

How to Improve Reporting

- Contact physicians in the community
  - Tell them the health department is very interested in morbidity reporting
- Maintain a reasonable list of reportable diseases
- Maximize contact through presentations, mailings, newsletters, media, etc.
- Use the data

Nonetheless...

- The best system we have for communicable disease morbidity
- Information available quickly and from all jurisdictions
- Can detect outbreaks / changes in incidence
- Allows disease control measures to be implemented

Data Source: Registries

- Information from multiple sources is linked for each individual over time.
  - Diverse sources of information. E.g., hospitals (sometimes >1), pathology, death certificates.
- Used for cancer, congenital anomalies, trauma, etc.
- Most are passive but resource intensive.
- More lag in data availability due to complexity of data collection process.

Populations Covered by Registries

- Hospital-based
- Population-based
- Exposure registries
  - World Trade Center Health Registry
  - Three Mile Island
Example: Virginia Cancer Registry

- Methods prescribed by ACOS, NAACCR, Virginia regulations, CDC.
- Hospital registries are main source of data.
- Voluntary reporting, 1970-1989
- Mandatory reporting, 1990-present
- Demographic, geographic, clinical data
- Annual merge with vital records for survival information.

Registry Data

Electronic Surveillance

- National Electronic Disease Surveillance System (NEDSS)
  - A set of criteria developed by CDC that all public health surveillance systems must meet
  - Virginia adopted CDC’s NEDSS Base System
  - Supported by EP&R funds

NEDSS

- Shared secure web-based disease surveillance database for Virginia
  - Eliminates delays in reporting
  - Improves communication about cases
  - Assists in earlier detection of events
  - Provides more data in electronic form for analysis
- All Virginia health departments connected by the end of 2006
- Includes electronic reporting from laboratories

EARS

- Early Aberration Reporting System
- Daily automated analysis of surveillance data

Data Source: Sentinel Systems

- To gather timely public health information in a relatively inexpensive manner.
- Cannot derive precise estimates of prevalence or incidence in the population.
- Sentinel Health Events
- Sentinel Sites
- Sentinel Providers
Sentinel Health Events

- A condition whose occurrence serves as a warning signal.
- Particularly useful for occupational exposures.
- Silicosis, occupational asthma, pesticide poisoning, lead poisoning, carpal tunnel syndrome.
- Cases trigger intervention activities.

Sentinel Sites or Providers

- Surveillance at certain hospitals, clinics, or physician practices.
- Sentinel Sites - monitor conditions in subgroups that may be more vulnerable – E.g., drug clinic, STD clinic, MCH clinic
- Sentinel Providers - monitor activity in ambulatory care settings.
  - For diseases that are not reportable
  - For influenza

Influenza Activity Monitoring with Sentinel Surveillance

- Sentinel site surveillance for influenza
  - Conducted year-round to detect emerging threats
  - Used to track flu season - Flu activity level usually elevated Oct/Nov through April/May
  - Consider
    - chief complaints from EDs and Urgent Care Centers,
    - positive lab specimens,
    - outbreaks.

Syndromic Surveillance

- Uses pre-diagnostic indicators to identify emerging health problems

Automating Syndromic Surveillance

- Began as manual activity just after 9/11/01
- Automated in 2004 with ESSENCE
  - Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Johns Hopkins University, Applied Physics Laboratory)
- Access limited to approved VDH staff
- Collaborate with District of Columbia and Maryland to monitor national capital region

ESSENCE

- Hospital emergency departments and urgent care centers electronically transmit chief complaints to secure VDH server every day
- System also includes:
  - Over the counter drug sales
  - Military claims
  - HMO claims
  - School attendance (being added)
**Syndromes**

- Complaints tallied into syndrome categories
  - Death
  - Sepsis (serious infection)
  - Rash
  - Respiratory (e.g., cough)
  - Gastrointestinal (e.g., diarrhea)
  - Unspecified Infection (fever)
  - Neurological (e.g., dizziness)
  - Other

**ESSENCE**

- Automated analyses identify unusual patterns and increases are investigated

**Exposure Detection**

- U.S. Postal Services’ BioHazard Detection System
  - Tests for anthrax in mail sorting area every hour
  - Selected Post Offices in Virginia
  - Response is collaborative
- Homeland Security/DOD BioWatch System
  - DC area, including northern Virginia
  - Central Virginia around Richmond
  - Eastern Virginia around military bases
  - Monitors for biologic agents atop buildings

**Data Source: Surveys**

- If done continually or periodically, can monitor risk factors and changes in prevalence over time
- Can also assess knowledge, attitudes
- People usually queried only once and not monitored on an individual basis after that
- From questionnaires, interviews (in person or telephone), or record review

**National Surveys – www.cdc.gov/nchs**

- National Health Interview Survey
  - Random selection of households
  - In home interview gathering information on all in the household
  - Self-reported illnesses, chronic conditions, injuries, impairments, use of health services
  - Civilian, non-institutionalized population

**National Surveys, continued**

- National Health and Nutrition Examination Survey (NHANES)
  - Prevalence of chronic conditions, distribution of physiologic and anthropomorphic measures, and nutritional status for representative samples of the U.S. population
- National Health Care Survey, includes
  - National Hospital Discharge Survey
  - National Ambulatory Medical Care Survey
**BRFSS**
- Behavioral Risk Factor Surveillance System
  - Random digit telephone surveys on non-institutionalized adults’ health behavior and use of prevention services
  - Height, weight, physical activity, smoking, alcohol use, seatbelt use, cholesterol screening, mammography, etc.
  - Done in most states
  - CDC program

**Other Survey Examples**
- Exit interviews at health facilities
- Special studies
  - Risk-behavior
- Cluster surveys
  - Rapid surveillance after emergencies

**Data Source Administrative Data**
- Routinely collected for other reasons.
- E.g., hospital discharge data collected for billing purposes, Medicaid and Medicare data, emergency department data, data collected in managed care organizations.
- Virginia Health Information (VHI) – our hospital discharge database

**Usefulness of Administrative Data**
- Depends on:
  - What information is computerized
  - Standardization of codes for diagnoses, symptoms, procedures, reasons for the visit
  - Time between occurrence of health event and availability of data
  - Ability to link with other data systems
  - Whether supplementary information can be obtained
Data Sources We Covered

• Vital Statistics
• Notifiable Diseases
• Registries
• Sentinel Surveillance
• Syndromic Surveillance
• Surveys
• Administrative Data

Other Important Surveillance Systems

• Injury
• Diabetes
• Child/Adolescent Hospitalizations
• Special temporary systems
• Drug safety
• Food Safety
• Etc. – Public health collects a lot of information on the health of our communities!

Analysis of Surveillance Data

• Descriptive epidemiology
  – Person, place, time
• Incidence and Prevalence
  – Rates -- crude, specific, standardized
• Trends and seasonality
• Geographic clustering (maps)

Graphics used to describe data

Interpretation of Surveillance Data

• Limitations
  – Under-reporting
  – Biased reporting
  – Inconsistent case definitions
• Consider context
  – Seasonality
  – Recent policy changes

Interpretative Uses of Surveillance Data

• Identifying epidemics
• Identifying new syndromes or risk groups
• Monitoring trends
• Evaluating public policy
• Projecting future needs
Data Dissemination

• What should be said? To whom? Through what communication medium? How should the message be stated? What effect did the message create?
• Determine answers based on the purpose of the system.
• SOCO - single overriding communication objective. [What is new? Who is affected? What works best?]

Evaluating Surveillance Systems

• System objectives and usefulness
  – Actions taken as a result of the data.
  – Does the system do what it’s supposed to do?
• Operation of the system
  – who is reporting? to whom? what information is collected? how is information stored? who analyzes the data? what are the findings? how often are reports disseminated? to whom? etc.
• Cost

Evaluation - System Attributes

• Sensitivity
  – Proportion of cases detected by the system. Completeness of reporting. Detect epidemics? Increased awareness, new diagnostic test, change in surveillance method may impact.
• Predictive Value Positive
  – Proportion of persons identified as having the disease who actually have it.

Sensitivity/Specificity and Predictive Value +/-

<table>
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<th>Condition</th>
<th>Present</th>
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<th>No</th>
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<tbody>
<tr>
<td>Detected by Surveill</td>
<td>True positive (A)</td>
<td>False positive (B)</td>
<td>A+B</td>
</tr>
<tr>
<td></td>
<td>False negative (C)</td>
<td>True negative (D)</td>
<td>C+D</td>
</tr>
<tr>
<td></td>
<td>A+C</td>
<td>B+D</td>
<td></td>
</tr>
</tbody>
</table>

Sensit. = A/A+C
Specif. = D/B+D

PVP= A/A+B
PVN= D/C+D
Evaluation - System Attributes

• Representativeness
  – Do the characteristics of reported events compare favorably with those in the population.
  – Is there case ascertainment bias?
  – Bias in descriptive information about a reported case?

• Timeliness
  – Any delay between the steps? (onset, diagnosis, report to public health, disease control actions)

Ethical and Legal Issues Relating to Surveillance

• Professional obligations
• Protecting confidentiality and privacy
• Informed consent
  – Mandated activity vs. Research
• Maintaining public trust
• Right of Access

ILI Surveillance

• 57 emergency departments and 24 urgent care facilities currently provide chief complaint data that are used to identify visits for influenza-like illness.

![ILI Surveillance Chart]

Hospitalizations

• Of the EDs providing chief complaint data, 40 provide data that identify hospital admissions from the ED.

![Hospitalizations Chart]

Deaths

• Death certificates that mention flu or pneumonia are tracked by week, locality, age group
• Pediatric flu-associated deaths – each case reported and information collected

• Insufficient data available to graph

• Usually have 2-3 per flu season in Virginia

Outbreaks

• Report to public health
  – More illness than expected in a group setting
• Investigation includes assessment of the situation, recommendations to limit disease spread, and/or laboratory confirmation
• Track by area, type of setting, etc.
Passive Reporting

- Based on regulatory requirement
- Physicians report number of cases of flu diagnosed each week, by type (A or B), if available
- Labs report cases confirmed by PCR, culture, or DFA
  - Not rapid tests

School Absenteeism

- Schools working with health department to send data
- Daily enrollment and absences in students and teachers/staff

School Closures

- Decisions to close are made in consultation with the health department
- Schools have been instructed to enter closures into CDC web site
- CDC web site sends message to CDC and VDH

Sentinel Lab Surveillance

- Sentinel physicians – one per district (35), test one patient per month
- Sentinel EDs – one per district, test one patient per month
- Sentinel hospitals – one per region (5), test five inpatients per month
- Purpose is surveillance for circulating strains

Weekly Flu Activity Level

- None
- Sporadic
- Local
- Regional
- Widespread
Contact Information

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