Epidemiology and Surveillance 101 – J Ferguson May 2019[1]

Epidemiology is the "study of distribution and determinants of health-related states among specified populations and the application of that study to the control of health problems." *A Dictionary of Epidemiology*

Public health aims: Discover the agent, host, and environmental factors that affect health • Determine the relative importance of causes of illness, disability, and death • Identify those segments of the population that have the greatest risk from specific causes of ill health • Evaluate the effectiveness of interventions (health programs and services) in improving population health

Host, agent, and environment: a model for infectious disease and spread - the microbe that causes the disease, the organism that harbors the disease, and the external factors that cause or allow disease transmission.

Epidemic or outbreak: disease occurrence among a population that is in excess of what is expected in a given time and place (because it was introduced from outside). **Endemic**, belonging or native to a particular people or country, indigenous. (Use "to" with a place and "in" with a population) **Pandemic**: a disease or condition that spreads across regions. Rate: number of cases occurring during a specific period within a population at risk;

Incidence: the rate of newly diagnosed cases of the disease. Generally reported as the number of new cases occurring within a period of time (per month or per year) against the population at risk of developing the disease (e.g. per 100,000 population). Also termed 'incident density'. Can be further categorized according to different subsets of the population – e.g., by gender, by racial origin, by age group or by diagnostic category. https://www.advancedrenaleducation.com/content/incidence-and-prevalence

Prevalence: actual number of cases alive, with the disease either during a period of time (period prevalence) or at a particular date in time (point prevalence). Period prevalence provides the better measure of the disease load since it includes all new cases and all deaths between two dates, whereas point prevalence only counts those alive on a particular date. Prevalence is most meaningfully reported as the number of cases as a fraction of the total population at risk, often categorized according to different subsets of the population.

Incidence to Prevalence: The relationship between incidence and prevalence depends greatly on the natural history of the disease state being reported. In the case of an influenza epidemic, the incidence may be high but not contribute to much growth of prevalence because of the high, spontaneous rate of disease resolution. In the case of a disease that has a low (or zero) cure rate, but where maintenance treatment permits sustained survival, then incidence contributes to continuous growth of prevalence.

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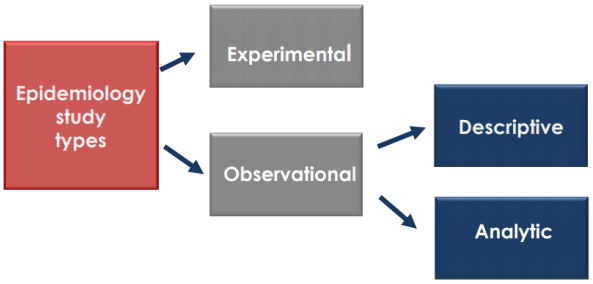
[1] https://wwwnc.cdc.gov/eid/page/preferred-usage - excellent advice on key terminology to use and things to avoid! e.g. **die of, die from -** Patients die of, not from, specific diseases or disorders.

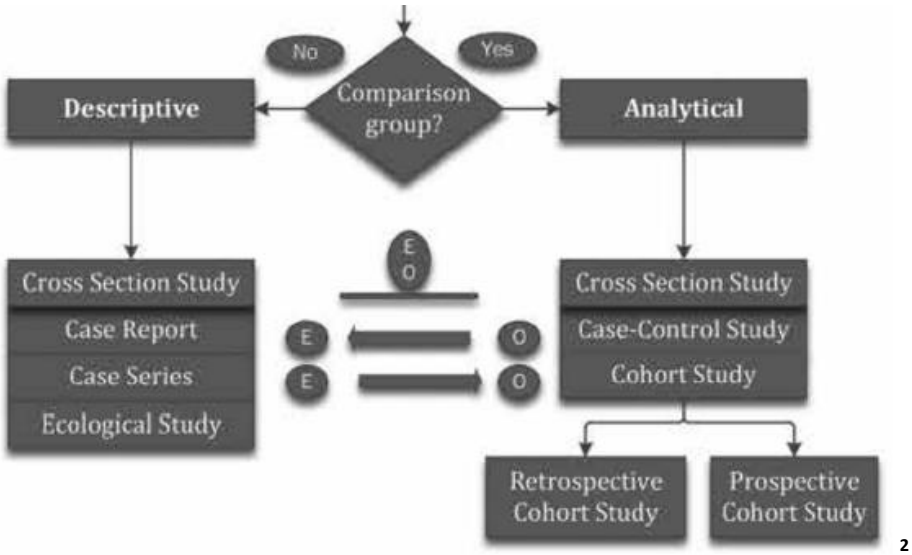
Rate, ratio: Rate is the incidence of a disease (or number of deaths) in a specified population in a specific time period. If no time period is specified, ratio is preferred e.g. the overall case-fatality ratio for SARS is ≈12%. The rate of West Nile virus infection in Canada is ≈300 per 100,000 population per year.

At risk population measures: population (community), admissions, separations (generally similar), inpatient-days (midnight census method or accrual method- patients counted only in the month when discharge occurs). Cases must be a drawn from the same population measure used for denominator.



Descriptive epidemiology	Analytic epidemiology
When was the population affected?	**How** was the population affected?
Where was the population affected?	**Why** was the population affected?
Who was affected?	

Time, Place, Person



[2]

- Cross sectional study - Subjects are selected because they are members of a certain population subset at a certain time
- Case-control study[3] - Subjects identified as having a disease or condition are compared with subjects without the same disease or condition.
- Cohort study - Subjects are categorized on the basis of their exposure to one or more risk factors. A group of individuals sharing the same experience followed up to a specified period of time
- Ecological study - Studies population or group level rather than individual level (e.g., country, state, or school) to measure prevalence and incidence of a disease

Mortality: importance of age adjustment - https://www.health.ny.gov/diseases/chronic/ageadj.htm .

Epidemiology in infection control:

- characterises infectious and non-infectious diseases within healthcare (time, place, person)
- determine the exposure-disease relationship (the epidemiological triangle), modes of acquisition and transmission (direct/indirect)
- Calculate measures of association between exposure and disease – 'odds' and 'risks'
- Identify (modifiable) patient risk factors – what makes them more susceptible to getting disease?

[2] Clinical Microbiology Newsletter, Vol. 40, No. 6 March 15, 2018
[3] JAMA 2018: Case-Control Studies Using "Real-world" Evidence to Assess Association

Surveillance[4] *"The continuous and systematic process of data collection, analysis, interpretation and dissemination for monitoring health problems."* Surveillance methods are 'distinguished by their practicability, uniformity, and rapidity, rather than by complete accuracy'. There is a surveillance cycle, described as 'data collection–data analysis and interpretation–data dissemination'. Cf. QI cycle – plan-do-check-act. Surveillance data for quality improvement must be of high quality. The characteristics that qualify data as evidence for action include:

- representativeness — the data fairly represent the thing measured
- accuracy — the data reflect what is intended to be measured
- precision — the data and the target of measurement correspond closely
- authoritativeness — the data are appropriate for drawing a meaningful conclusion
- clarity — the data are presented in a form that the target audience can understand.

Outcome surveillance – healthcare-associated (HCA) blood stream infections (> 400 per annum; 72 HCA SAB – these are reportable, current target < 2 / 10000 bed days; dropping to 1 / 10000 in July 2020), post-operative surgical site infections (prosthetic joint and CABG reportable), MRO acquisition – new onset colonisation or infection (MRSA, CPE, VRE; Intensive care unit MRSA acquisition reportable), C. difficile infections

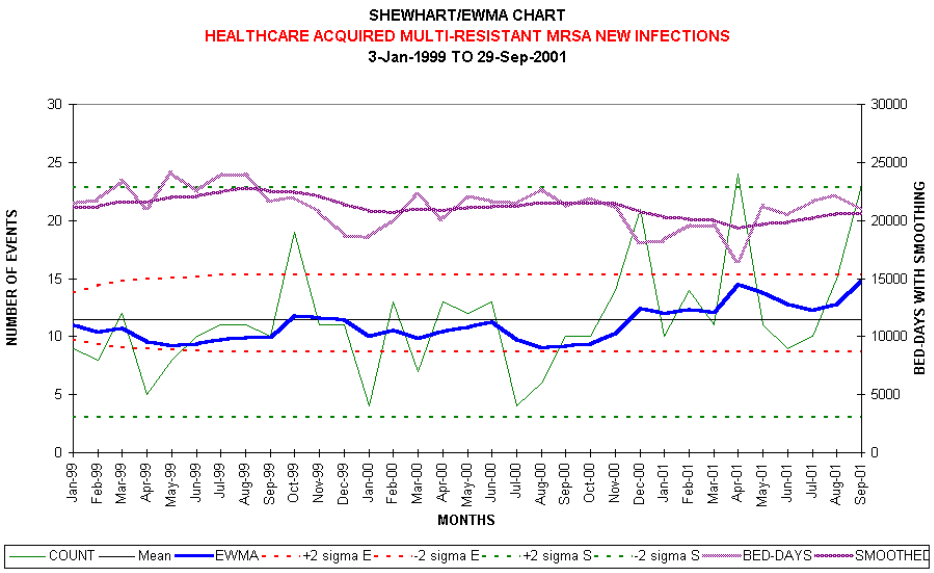
Process surveillance – audits of practice- hand hygiene compliance, aseptic technique, IV lines, environmental audits, urinary catheter use, surgical prophylaxis practice. Required across all sites. Chose measures that are linked by data to outcomes – e.g. hand hygiene and MRSA transmission / infection in hospitals

Purposes of HAI surveillance:

- Establishing endemic rates to inform infection prevention strategy over time
- Outbreak identification
- Identify and quantify emerging risks
- Evaluate control measures
- Reporting and comparison purposes (including public reporting)

Surveillance data is expressed as time-series of counts or proportions (rates), incidence over time or point prevalence. As most HAI surveillance measures statistically infrequent events, there is variation from month to month in counts and rates. Where this variation shows no trend over a longer period (ie is invariant around a mean over time), it is called 'common-cause variation'. Use of control charts makes it possible to detect 'special-cause variation'; this is used to describe changes in the data that indicate a significant shift in the mean, perhaps due to a particular factor, such as a change in process (e.g. a sterilisation failure or a new surgeon whose practice is above average). Changes detected may still represent false-positive signals; therefore, data need to be checked before action is taken.

Case detection or survey method: **a**im for high specificity for outcome of interest, accept lower sensitivity (not always). Unambiguous surveillance definitions required that do not change over time. Need to evaluate surveillance intensity regularly (e.g. blood culture utilisation or *C. difficile* testing etc).



[4] ACSQHC Reducing harm to patients from health care associated infection: the role of surveillance 2008

Risk adjustment: patients vary widely in their intrinsic and extrinsic risk of infection. Cases with similar risk factor(s) (numerators) grouped against denominator that reflects exposure to that risk- eg. central line associated BSI / central line-days of exposure. CDC NHSN risk-stratified surgical site infection rates (cases and denominators stratified by score derived from wound class (clean, clean/contam,contam), duration of surgery (point given if duration > 75 centile) and ASA score (1-5)- see HISWA table below.

	ICU A	ICU B
patient-days	1000	1000
c-l utilisation	80%	30%
infections/1000 patient-days	5	7 NS
infections/1000 line-days	6	23 p <0.05

HISWA, WA

Table 1 Hip arthroplasty SSI rate, by risk index

Risk Index	Number of contributing hospitals	Number of procedures	Number of SSI	Aggregate rate (95% CI)	Cumulative aggregate rate (95% CI)
Risk All *	5	85	1	1.18 [0.00 – 7.12]	0.85 [0.57 – 1.26]
Risk N/A	1	5	0	0.00 [0.00 – 49.38]	0.00 [0.00 – 22.08]
Risk index 0	17	644	4	0.62 [0.19 – 1.66]	0.76 [0.66 - 0.87]
Risk index 1	17	432	6	1.39 [0.58 – 3.09]	1.84 [1.63 – 2.08]
Risk index 2	17	73	3	4.11 [0.99 – 12.00]	3.63 [2.82 – 4.67]
Risk index 3	17	5	0	0.00 [0.00 – 49.38]	4.76 [1.82 – 11.02]
Total hip arthroplasty	**22**	**1,244[#]**	**14**	**1.13 [0.66 – 1.91]**	**1.22 [1.12 – 1.33]**

*Refer to Appendix 1- SSI Data Notes

[#] Includes 5 procedures classed as NA index

Impact of surveillance[5]

Table 1.1 Effectiveness of national surveillance networks in Europe

Surveillance component	National or regional surveillance system	Period (years)	Units (hospitals) included	Method or comparison	Relative risk (RR)/odds ratio (OR) (95% confidence interval)
SSI	Denmark	2	13	2nd vs 1st year	No preventive effect
SSI	The Netherlands	5	37	4th/5th vs 1st year	4th year: RR = 0.69 (0.52–0.89) 5th year: RR = 0.43 (0.24–0.76)
SSI	Germany	4	130 (86)	Multivariate analysis	3rd year: OR = 0.76 (0.69–0.85)
ICU	Germany	3	150	3rd vs 1st year	VAP: RR = 0.71 (0.66–0.76) CVC-BSI: RR = 0.80 (0.72–0.90)
NICU	Germany	3	48	Multivariate analysis	Primary bloodstream infections: OR = 0.73 (0.60–0.89)

CVC-BSI = central venous catheter-associated bloodstream infections; ICU = intensive care unit; NICU = neonate intensive care unit; SSI = surgical site infection; VAP = ventilator-associated pneumonia

Source: Gastmeier (2007),[68] reproduced with permission

[5] ACSQHC Reducing harm to patients from health care associated infection: the role of surveillance 2008