Descriptive Epidemiology for Public Health Professionals - Part 2

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I am Ian Rockett, a native of Australia and Professor of Epidemiology in the Department of Community Medicine at West Virginia University. Before you move through this module on descriptive epidemiology I would like to set the scene. The initial target audience was public health professionals, but in the spirit of the Supercourse I now seek to reach any audience who might find this material of interest or use.

ABOUT SUPERCOURSE:

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Models of disease and injury facilitate our understanding of their etiology or causes. Etiology is the science of causation.

The Epidemiological Triad

The best known, but most dated model of communicable disease is the Epidemiologic Triad (Figure 1). This model comprises a susceptible host *(the person at risk for the disease*), a disease agent (*the proximate cause*), and an environmental context for the interaction between host and agent.

Figure 1: The Epidemiological Triad

In the case of many communicable diseases, such as malaria, the agent can only reach the host via a third party, called the vector (Figure 2). The vector is animate. For example, the vector for malaria is the female anopheles mosquito. She can convey the malaria parasite to a susceptible host when she consumes a blood meal.

The Epidemiologic Triad has been applied to the study of injury by scientists at the Centers for Disease Control and Prevention (CDC) (Figure 3). For injury, the agent is any one of the five forms of physical energy: kinetic or mechanical energy, chemical energy, thermal energy, electricity, and radiation. This energy is conveyed to the host via a vector, such as a biting dog or snake, or its inanimate counterpart, the vehicle. Examples of potential injury vehicles are crashing automobiles and speeding bullets.

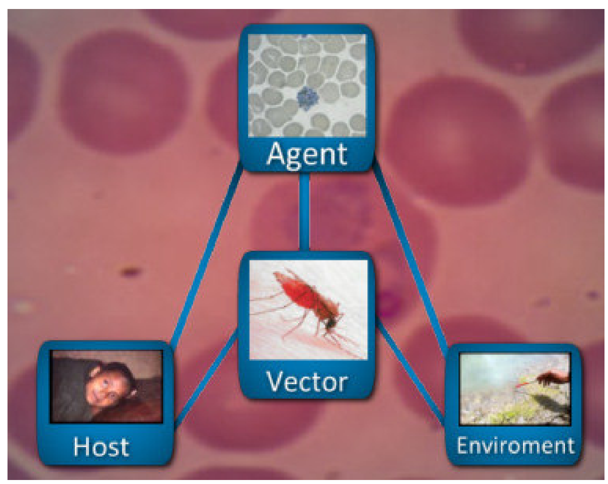


Figure 2: Factors involved in the Natural History of Disease

Levels of Prevention:

In the world of public health, we delineate three levels of prevention: primary prevention aims at preventing occurrence of a disease or injury; secondary prevention aims to minimize damage when it occurs; and tertiary prevention covers follow-up medical and hospital care and rehabilitation.

The Haddon Matrix, a framework named for its creator, the engineer-physician-epidemiologist William Haddon, combined the three levels of prevention with the

Epidemiologic Triad (Figure 4). This framework can greatly enhance our understanding of injury events (Figure 5).

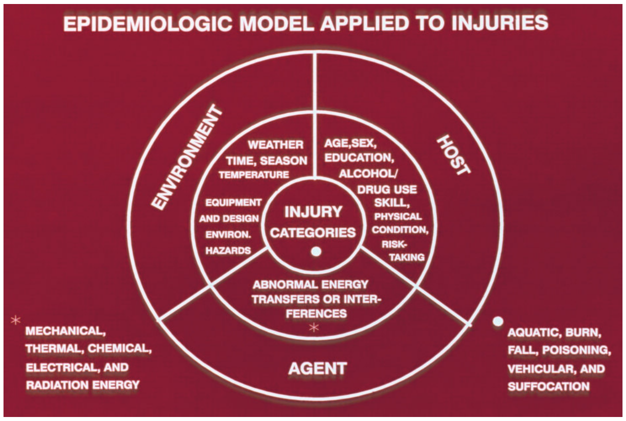


Figure 3: The Epidemiologic Triad applied to Injury

Epidemiologists in the Injury Prevention Research Center at the University of North Carolina in Chapel Hill applied the Haddon Matrix to an injury problem about which we in the United States harbor much more concern since the September 11, 2001 terrorist attack on the World Trade Center (Figure 6).

Factors / Phases	Human Factors	Agent or Vehicle	Physical Environment	Socio-cultural/ Environmental
Pre-event				
Event				
Post-event				

Figure 4: The Haddon Matrix

Haddon's Matrix Applied to Motor Vehicle Crash Injury

Phases	Factors: Human	Vehicle	Environment
Pre-event	Educate public in the use of seat belts and child restraints	Safe brakes and tires	Improve road design; restrict alcohol advertising and availability at gas stations
Event	Prevent osteoporosis to decrease likelihood of fracture	Air bags and a crash-worthy vehicle design	Install breakaway utility poles and crash barriers
Post-event	Treat hemophilia and other conditions that impair healing	Safe design of fuel tank to prevent rupture and fire	Ensure adequate emergency medical care and rehabilitation

Source: Ian R.H. Rockett. Injury and Violence: A Public Health Perspective. Population Bulletin 53(4); 1998: 18. Adapted from G.S Smith and H. Falk, Unintentional Injuries. American Journal of Preventive Medicine 3(5) Supplement; 1997:143-163.

Figure 5: The Haddon Matrix applied to Motor Vehicle Crash Injury.

Haddon Matrix (bombings)

Factors / Phases	Person	Vehicle/ Vector (bomb / bomber)	Physical Environ.	Social Environ.
Pre-event	Teach to recognize suspicious persons	Detectable bombs	No vehicle zones	Reduce animosity
Event (explosion & collapse	Wear protective clothes	Slower acting explosives	Shatter-proof glass	Strengthen norms for rescue volunteers
Post-event	Train people in first aid	??	Emergency call boxes	Strengthen public health infrastructure

Figure 6: The Haddon Matrix applied to Terrorist Bombings

The Wheel of Causation

The Wheel of Causation (Mausner & Kramer, 1985) de-emphasizes the agent as the sole cause of disease, while emphasizing the interplay of physical, biological and social environments (Figure 7). It also brings genetics into the mix.

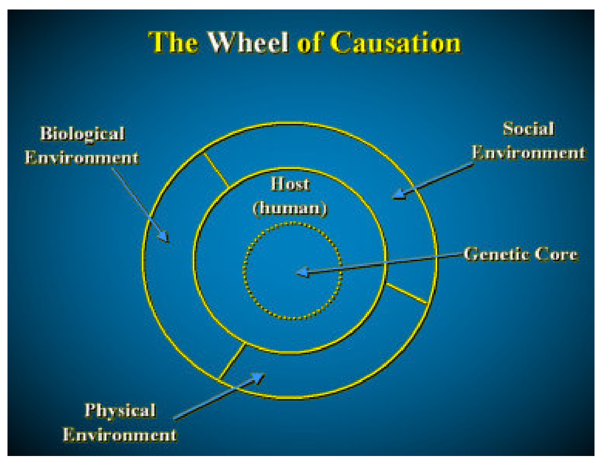
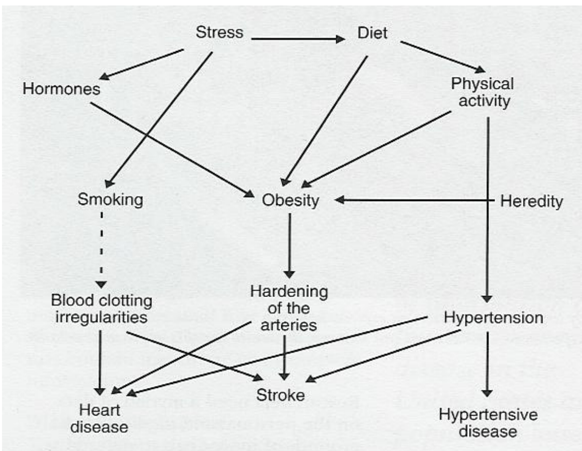


Figure 7: The Wheel of Causation

One application of The Wheel of Causation model was to elucidate the potato famine that devastated Ireland in the mid-19th century. The famine was the synergistic product of a fungal invasion of potato crops, a predominantly peasant population subsisting on a potato diet, and repressive British colonial rule.

Web of Causation

Like the Wheel of Causation, the Web of Causation de-emphasizes the agent in explaining disease, but this model also provides for multifactoral causes that traverse various pathways. Mirroring reality, these causal webs can be highly intricate and complex.



Note: Some intermediate links were omitted in this example.
Source: Adapted from R.A. Stallones, *Public Health Monograph* 76 (1966): 53.

Source: Ian R.H. Rockett. Population and Health: An Introduction to Epidemiology. Population Bulletin 54(4); 1999: 18. Adapted from R.A. Stallones, Public Health Monograph 76; 1966:53.

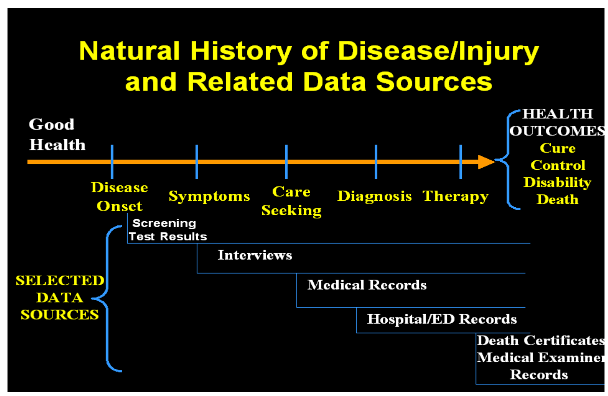
Wider Application of the Web

1. **Epidemiologic Triad** (devised to enhance search for understanding communicable disease)
2. **Web of Causation** (devised to address chronic disease – can also be applied to communicable disease)

While the Web of Causation was conceived to enhance understanding of noncommunicable chronic disease, this model also has application to communicable disease and injury. One interesting communicable disease example involves unanticipated consequences of economic development, and more particularly Trypanosymiosis or "sleeping sickness" that spread across Africa in the wake of new roads. The agent was carried behind trucks by its vector, the tsetse fly, with fly bites being the mode of disease transmission.

DATA SOURCES and DEVELOPMENT of INFORMATION

We now shift our attention from disease and injury models to sources of data. Data sources, of course, are critical to recording and quantifying disease and injury occurrence. The figure below really speaks for itself, with disease stages being matched to data sources. Appreciate that some information is either so sensitive or, anyway, not routinely recorded, that it can only be elicited through interviews. By contrast, in a more developed country, at least, each authenticated death generates a death certificate.



Mortality (Death) Records

Figure 8 shows the part of a standard United States death certificate where causes of death and other contributory conditions are entered. Mortality studies typically rely on the single underlying cause of death that is entered on each death certificate by a registered physician – the condition which initiated the train of events that resulted in the death.

Uncertainty in Reported Causes of Death

Michael Alderson (1988) identified four areas where uncertainties or inaccuracies can arise in reporting causes of death:

1. incorrect diagnosis (last attending physician and/or autopsy)
2. incorrect completion of death certificate
3. inaccurate processing and publication of the mortality statistics
4. invalid classification of diseases/injuries

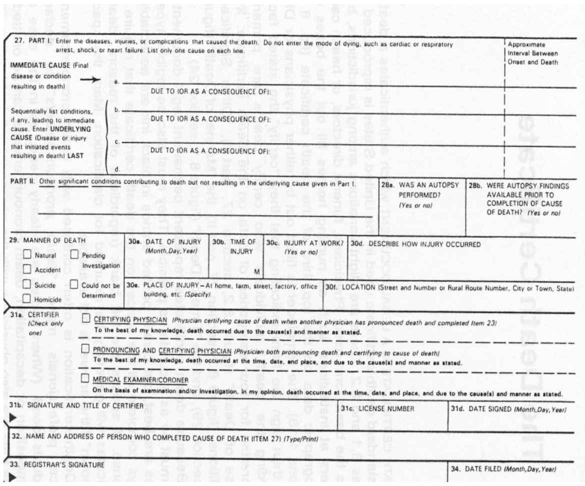
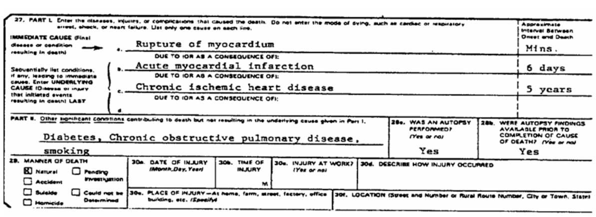

27. PART I. Enter the diseases, injuries, or complications that caused the death. Do not enter the mode of dying, such as cardiac or respiratory arrest, shock, or heart failure. List only one cause on each line.
Approximate Interval Between Onset and Death
IMMEDIATE CAUSE (Final disease or condition resulting in death) → a.
DUE TO (OR AS A CONSEQUENCE OF):
Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST
b.
DUE TO (OR AS A CONSEQUENCE OF):
c.
DUE TO (OR AS A CONSEQUENCE OF):
d.
PART II. Other significant conditions contributing to death but not resulting in the underlying cause given in Part I.
28a. WAS AN AUTOPSY PERFORMED? (Yes or no)
28b. WERE AUTOPSY FINDINGS AVAILABLE PRIOR TO COMPLETION OF CAUSE OF DEATH? (Yes or no)
29. MANNER OF DEATH
☐ Natural ☐ Pending Investigation
☐ Accident
☐ Suicide ☐ Could not be Determined
☐ Homicide
30a. DATE OF INJURY (Month,Day,Year)
30b. TIME OF INJURY M
30c. INJURY AT WORK? (Yes or no)
30d. DESCRIBE HOW INJURY OCCURRED
30e. PLACE OF INJURY – At home, farm, street, factory, office building, etc. (Specify)
30f. LOCATION (Street and Number or Rural Route Number, City or Town, State)
31a. CERTIFIER (Check only one)
☐ CERTIFYING PHYSICIAN (Physician certifying cause of death when another physician has pronounced death and completed Item 23)
To the best of my knowledge, death occurred due to the cause(s) and manner as stated.
☐ PRONOUNCING AND CERTIFYING PHYSICIAN (Physician both pronouncing death and certifying to cause of death)
To the best of my knowledge, death occurred at the time, date, and place, and due to the cause(s) and manner as stated.
☐ MEDICAL EXAMINER/CORONER
On the basis of examination and/or investigation, in my opinion, death occurred at the time, date, and place, and due to the cause(s) and manner as stated.
31b. SIGNATURE AND TITLE OF CERTIFIER
31c. LICENSE NUMBER
31d. DATE SIGNED (Month,Day,Year)
32. NAME AND ADDRESS OF PERSON WHO COMPLETED CAUSE OF DEATH (ITEM 27) (Type/Print)
33. REGISTRAR'S SIGNATURE
34. DATE FILED (Month,Day,Year)

Figure 8: Part of a Standard Death Certificate

Multiple Cause-of-Death Analysis

The fact that the death certificate forces the certifying physician to choose a single underlying cause of death for each decedent can be problematic, especially for an elderly one, who may have been afflicted with as many as eight or more potentially lethal conditions. In the United States, state health departments are now routinely forwarding multiple cause-of-death data to the National Center for Health Statistics to permit more realistic national and state mortality analyses.


27. PART I. Enter the diseases, injuries, or complications that caused the death. Do not enter the mode of dying, such as cardiac or respiratory arrest, shock, or heart failure. List only one cause on each line.
Approximate Interval Between Onset and Death
IMMEDIATE CAUSE (Final disease or condition resulting in death) → a. Rupture of myocardium — Mins.
DUE TO (OR AS A CONSEQUENCE OF):
Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST
b. Acute myocardial infarction — 6 days
DUE TO (OR AS A CONSEQUENCE OF):
c. Chronic ischemic heart disease — 5 years
DUE TO (OR AS A CONSEQUENCE OF):
d.
PART II. Other significant conditions contributing to death but not resulting in the underlying cause given in Part I.
Diabetes, Chronic obstructive pulmonary disease, smoking
28a. WAS AN AUTOPSY PERFORMED? (Yes or no) Yes
28b. WERE AUTOPSY FINDINGS AVAILABLE PRIOR TO COMPLETION OF CAUSE OF DEATH? (Yes or no) Yes
29. MANNER OF DEATH
☒ Natural ☐ Pending Investigation
☐ Accident
☐ Suicide ☐ Could not be Determined
☐ Homicide
30a. DATE OF INJURY (Month,Day,Year)
30b. TIME OF INJURY M
30c. INJURY AT WORK? (Yes or no)
30d. DESCRIBE HOW INJURY OCCURRED
30e. PLACE OF INJURY – At home, farm, street, factory, office building, etc. (Specify)
30f. LOCATION (Street and Number or Rural Route Number, City or Town, State)

Distinguishing Natural from Other Causes of Death

It is crucial for legal, as well as for social, psychological, and epidemiologic reasons, to distinguish suicides, homicides and accident deaths (unintentional injury deaths) from deaths due to natural causes.

Use of Medical Examiner and Coroner Records to supplement Death Certificate Data

Only when homicide, suicide and "accident" are ruled out can a death validly be classified as natural. For example, discovery of a dead infant, who apparently had been healthy and sleeping in his or her cot just prior to death, might implicate the Sudden Infant Death Syndrome or SIDS as the killer. Obviously suicide can immediately be ruled out. But more investigation, typically involving the Medical Examiner or Coroner's Office, would be necessary to eliminate homicide or "accident" as the cause of the infant death.

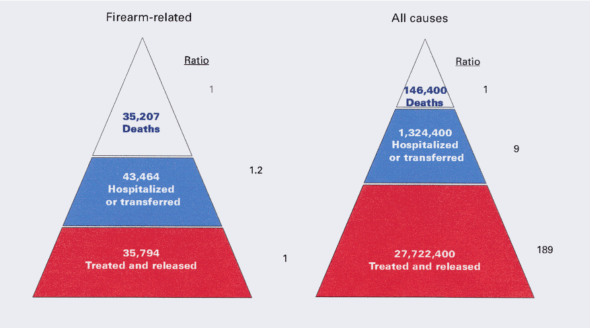
Mortality as Tip of the Iceberg

Whether we are talking about disease or injury deaths, mortality is only the tip of the ill-health iceberg. In proportional terms, morbidity exerts far greater influence.

Morbidity Data Sources

As mortality has its data sources, so too does morbidity. Morbidity is defined in the fourth edition of The Dictionary of Epidemiology (New York: Oxford University Press; 2001:118), edited by John Last, as "any departure, subjective or objective, from a state of physiological or psychological well-being." Epidemiologists generally feel more comfortable analyzing objective morbidity data, as captured in physician-diagnosed diseases, injuries, and disabilities, than subjective morbidity data as self-reported by individuals or reported on behalf of individuals by non-physician third parties.

Prominent morbidity data sources include disease registries, hospital emergency department and admission records, periodic health surveys, public and private health insurance records, and sickness-absence records for schools and workplaces.



Data sources: National Vital Statistics System, National Center for Health Statistics for deaths; CDC's Firearm injury Surveillance Study for firearm-related nonfatal estimates; CDC's National Electronic Injury Surveillance System All Injury Pilot Study for nonfatal estimates for all causes.
* Pyramids represent average annual numbers for 1993–1998 for firearm-related injuries; annual numbers for 1997 for all causes.

Taken from The Injury Chartbook, published by the United States Department of Health and Human Services in 1997, the injury example above clearly demonstrates the limitation of the iceberg mortality tip in reflecting the true dimensions of a public health problem. A much more complete picture can emerge from adding morbidity information.

General Sources of Morbidity Data

Leon Gordis reported diverse sources of morbidity data in the fourth edition of his excellent textbook entitled ***Epidemiology*** (Saunders, 2009: 47):

1. Disease reporting – communicable diseases, cancer registries
2. Data accumulated as a by-product of insurance and prepaid medical care plans
   a. Group health and accident insurance
   b. Prepaid medical care plans
   c. State disability insurance plans
   d. Life insurance companies
   e. Hospital insurance plans
   f. Railroad Retirement Board
3. Tax-financed public assistance and medical care plans
   a. Public assistance, aid to the blind, aid to the disabled
   b. State or federal medical care plans
   c. Armed Forces
   d. Veterans Administration
4. Hospitals and clinics
5. Absenteeism records -- industry and schools
6. Pre-employment and periodic physical examinations in industry and schools
7. Case-finding programs
8. Selective service records
9. Morbidity surveys on population samples (e.g., National Health Survey, National Cancer Surveys)

ICD and ICD-CM

The International Statistical Classification of Diseases and Related Health Problems (ICD) can be used for coding and classifying mortality data from death certificates

The International Classification of Diseases Clinical Modification (ICD-CM) can be used to code and classify disease and injury morbidity data from inpatient and outpatient records

A number of systems exist for classifying and coding disease and injury mortality and morbidity. Now in its 10th revision, the best known is the International Classification of Disease and Injury (ICD). The ICD-Clinical Modification, used in American hospitals, provides extra digits to classify and code more detail on morbid conditions as needed.

Dynamic Classification

Causes of disease, injury and disability may wax and wane. ICD needs to be flexible, especially in responding to new circumstances such as manifested in new diseases and politically-motivated violence: e.g. SARS, terrorism-attributable health outcomes as from such varied causes as asphyxiation, chemical burns, falls and jumping from buildings, and suicide and suicide attempts.

- *Primary data are new data collected by or for the investigator*
- *Secondary data refer to existing data*

Limited epidemiologic research can be conducted using existing data, referred to as secondary data. Frequently, however, important questions can only be answered through collecting new and targeted information, which we label primary data.

Stages of Development of Information

CDC has spelled out four stages in developing public health information: public health surveillance; risk group identification; risk factor identification; and program development, implementation, and evaluation.

1. **Public health surveillance** – development and refinement of data systems for the ongoing and systematic collection, analysis, interpretation and dissemination of information
2. **Risk group identification** – identification of persons at greatest risk of disease or injury and the places, times, and other circumstances that are associated with elevated risks
3. **Risk factor identification** – analytic exploration of potentially causative risk factors for disease, injury or death as suggested by the high risk population and other research
4. **Program development, implementation, and evaluation** – design, implementation and evaluation of preventive interventions based on degree of understanding of the population-at-risk and the risk factors for the outcome of interest

The first two stages fall under the realm of descriptive epidemiology. Stages three and four involve analytic epidemiology, with its capacity to evaluate both putative cause-and-effect relationships and interventions based on this etiologic understanding. Combining stages 1 and 2, and separating program development and evaluation from implementation of a tested program, the Public Health Approach take us from recognition of a public health problem through its solution (Figure 9).

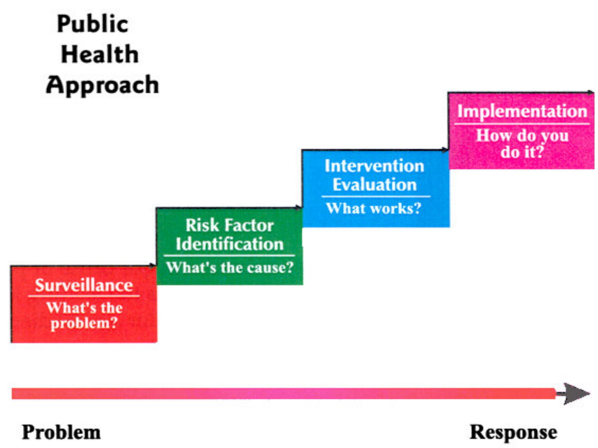


Figure 9: The Public Health Approach to Problem Solving

A Caveat on Data Quality: ("garbage in and garbage out")

On the subject of garbage in/garbage out, a caustic assertion by the inimitable British economist, Sir Josiah Stamp (1880-1941), cautions us about never underestimating the scientific imperative to collect, code, process, analyze, and report data of the highest quality.

"The government is very keen on amassing statistics. They collect them, add them, raise them to the nth power, take the cube root and prepare wonderful diagrams. But you must never forget that every one of these figures comes in the first instance from the village watchman, who just puts down what he damn well pleases".