USES AND LIMITATIONS OF MORTALITY DATA

I. Introduction

A. Death is a universal and recognizable outcome

1. Every person is destined to die

2. Being dead is easy to classify and count

B. When coupled with at-risk population or community data...

1. Deaths are used to derive mortality per unit time

   a. A risk measure
      (1) in a cohort study
         (a) probability of death
         (b) deaths arise over time from the population-at-risk

   b. A rate measure
      (1) in a cohort study
         (a) deaths per at risk (i.e., alive) person-time
      (2) in a community study
         (a) deaths per midterm population per interval of time (usually a year)

   c. A ratio measure
      (1) for neonatal, infant and maternal deaths
         (a) numerator - variable one
            i) deaths per interval of time (usually a year)
         (b) denominator - variable two
            i) number of live births during the same time interval as the deaths
      (2) most often termed a “rate”

C. When coupled with case data...

1. Deaths are used to derive case-fatality

   a. a risk measure
   b. indicates the virulence or severity of a disease

D. When coupled with “all deaths” data and cause of death is known...

1. Deaths are presented as proportionate mortality

2. In “verbal autopsy” literature, proportionate mortality is termed “cause-specific mortality fraction” (CMSF)

E. Death rates are the most widely available of vital and health statistics
1. Developing countries
   a. Crude (or “total” or “all causes”) mortality rate
      (1) Limited usefulness
   b. Infant mortality rates
      (1) Often used as an indicator of the level of health

2. Developed countries
   a. Total mortality rates are often age-adjusted
      (1) The standard population
         (a) International – no standard
         (b) United States – 2000 midterm population, as estimated in 1999
   b. Can be used to estimate incidence when...
      (1) case-fatality is high
      (2) the duration of disease (i.e., survival) is short

II. Cause-specific Mortality

A. While death is easy to classify, cause is not

1. Developed countries
   a. Diagnosis of cause of death
      (1) Attending physician
         (a) often does not include an autopsy
         (b) may rely on next of kin
      (2) Coronel
         (a) if death is unattended or of suspicious origin
         (b) may or may not include an autopsy
   b. Listing of cause of death
      (1) Death is classified by physician or coroner as to immediate cause and to underlying cause
      (2) Government nosology computer program classifies death as to underlying cause
         (a) Codes death according to International Classification of Diseases (ICD) categories
            i) Now in 10th revision (ICD-10)
   c. Autopsies are infrequent
         (a) “Once considered the ‘gold standard’ in medical diagnosis, the autopsy has declined in use from 19.1% of all deaths in 1972, when the US National Center for Health Statistics (NCHS) first began its systematic tracking of this procedure, to 9.4% in 1994, when the NCHS ceased collecting and collating national autopsy data.”
         (b) “The rate of autopsies on unnatural deaths (including accidents, homicides, suicides, and other unusual deaths, commonly referred to as "e-code" deaths) remained relatively constant over the period from 1972 to 1994
and, consequently, have represented a higher proportion of all autopsies over time. Time series data provided by three states (Minnesota, Oregon, and Washington) suggest that the increasing dominance of e-code autopsies continues to this date. Virtually all of these are medical examiner or coroner cases by legal mandate.”

(2) Likely reasons
(a) Available clinical and laboratory tests
(b) Cost

d. Figure

2. Developing countries

a. Death occurrence may be listed in a death registry
   (1) Possibly need for burial and disposal certificate
b. Specific cause of death is often not listed
   (1) May be available only for hospitalized patients
   (2) May be estimated by “verbal autopsy”
      (a) interview given to care-givers or family members after a death occurs

III. Cause of Death

A. Death in Lithuania – An Example of a Developed Country


   a. Jonava District of Lithuania
      (1) Compared findings of local death causes with reported Lithuania death causes
      (2) Local “truth” based on
         (a) autopsy findings
            i) for questionable cases, consensus of three experts
         (b) analysis of clinical records
         (c) interviews with next of kin and attending medical professionals
b. Findings
   (1) “The nature of mistakes varied with disease class. Circulatory system diseases were more often over-estimated both in hospital and out of hospital whereas malignant neoplasms ... was underestimated.”

B. Verbal autopsy

1. Procedure

   a. Early documents on MCH deaths
      (1) Verbal autopsies for maternal deaths, 1994
         (a) http://www.who.int/reproductive-health/publications/verbal_autopsies/index.html
      (2) A standard verbal autopsy method for investigating cause of death in infants and children
         (b) Comments about assumptions of verbal autopsy method (p. 4)
            i) “An underlying assumption of the verbal autopsy method is that each cause of death investigated has a set of observable features that can be recalled during a verbal autopsy interview.”
            ii) It is also...“assumed that the features of one cause of death can be distinguished from those of any other cause of death.”


   a. Verbal autopsy process and factors influencing cause-specific mortality fractions
      (1) Figure 1, page 241

   3. Validity relationships

      a. Example - measles deaths in young children
         (2) $CSMF_{VA}$ (cause-specific mortality fraction for VA algorithm)
            (a) age $\geq 120$ days, rash, fever $\geq 3$ days
         (3) $CSMF_{M}$ (true cause-specific mortality fraction in mortality data)
(a) measles death - CSMF$_m$ = 2.15%, Se = 98%, Sp = 90%

True Cause of Death

<table>
<thead>
<tr>
<th></th>
<th>Measles</th>
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<tbody>
<tr>
<td>Yes</td>
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<td>B</td>
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<tr>
<td>No</td>
<td>C</td>
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10,000 infant deaths

i) Sensitivity (Se) = $[A/(A+C)]$

ii) Specificity (Sp) = $[D/(B+D)]$

iii) Predictive Value Positive (PVP) = $[A/(A+B)]$

(4) CSMF$_m$

(a) measles death - CSMF$_m$ = 2.15%, Se = 98%, Sp = 93%

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10,000 infant deaths

(5) CSMF$_m$

(a) measles death - CSMF$_m$ = 2.15%, Se = 71%, Sp = 85%

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10,000 infant deaths
(6) CSMF\textsubscript{M}  
(a) measles death - CSMF\textsubscript{M} = 21.5\%, Se = 98\%, Sp = 93\%  

<table>
<thead>
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10,000 infant deaths  

b. Bayesian probabilistic model  
(1) Bayes Formula  
(a) P(S) - probability of symptom, P(D) - probability of disease  

\[ P(D|S) = \frac{P(S|D) \times P(D)}{P(S|D) \times P(D) + P(S|\bar{D}) \times P(\bar{D})} \]  

(b) Modified for VA examples (derive predictive value positive)  

\[ PVP = \frac{Se(CSMF_{M})}{Se(CSMF_{M}) + (1 - Sp)(1 - CSMF_{M})} \]  

c. Related formula for VA examples (derive CSMF\textsubscript{VA})  

\[ CSMF_{VA} = (CSMF_{M}) (Se) + (1 - CSMF_{M}) (1 - Sp) \]  

d. Related formula for VA examples (derive CSMF\textsubscript{M})  

\[ CSMF_{M} = \frac{CSMF_{VA} + Sp - 1}{Se + Sp - 1} \]  

c. “VA is considered to have acceptable level of diagnostic accuracy at the individual level if the sensitivity and specificity are at least 90\%” (p. 243)
(a) death due to disease - $CSMF = 5\%, Se = 90\%, Sp = 90\%$

<table>
<thead>
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<th>Not Disease</th>
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<tbody>
<tr>
<td>D</td>
<td>A</td>
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<tr>
<td>CSMF_{VA}</td>
<td>B</td>
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100,000 deaths

(b) death due to disease - $CSMF = 5\% – 40\%, Se = 90\%, Sp = 100\% – 80\%$


a. Need verbal autopsy (VA) to estimate cause-specific mortality in developing countries.

b. Existing VA programs are not based on a standard approach, making it hard to compare results from one program with those of another.

c. The World Health Organization (WHO) has recently strived to standardize verbal autopsy methods


   b. “For the present, we urge that these new international consensus standards become the foundation of verbal autopsy practices wherever possible.” (p. 571)