Lecture 6 – July 16, 2003

Linking populations, prevention, and risk assessment

Objectives

- To understand the operating premises of risk assessment
- To be familiar with the different types of risk factors and with risk predictors
- To understand the relationship between risk factors and levels of evidence
- To be able to differentiate between risk models and prediction models
- To be familiar with criteria for prediction models
- To understand the notion of targeting and how it applies to teeth as well as individuals

Operating premises of risk assessment

- For decades our medical colleagues have been developing methods to identify individuals at high risk of diseases such as heart disease, stroke, and cancer
- High risk individuals are then targeted for special programs, such as early detection and treatment for various types of cancer, and risk reduction efforts for heart disease and stroke

Operating premises of risk assessment

- The majority of risk assessment efforts applied to the two major dental diseases, caries and periodontitis, began in the early 1980's
- Interest in risk assessment for dental conditions arose out of a change in prior paradigms regarding the etiology and progression of these diseases

Operating premises of risk assessment

- Under the old paradigm prevalence of the conditions was extremely high and little error in prediction resulted when everyone was categorized as having the disease
- Under the new paradigm, the prevalence of the disease is known not to be as high and it is known that some people are more likely to be affected by the condition than others

Operating premises of risk assessment

- Now from a perspective of assigning risk, caries and periodontitis can be thought to be more like some of our common medical conditions
  - Certain people or subgroups of the population are at higher risk than others and efforts at prevention and intervention involve a combination of personal behaviors and professional practices

Operating premises of risk assessment

That: Clinical, behavioral, and etiological factors can be used to determine caries risk

That: Not all patients require the same level of prevention

Thus: The extent of prevention can be appropriate to the level of risk

Operating premises of risk assessment

- Distribution
  - 60% of caries occurs in 20% of children
- Question
  - Can children at high risk be identified prior to disease development?

Operating premises of risk assessment

- Studies undertaken:
  to develop models to identify children at high risk prior to development of the disease
- Multivariate (multivariable) perspective

Variables used in multivariable models

- There are essentially two types of variables that can be used in the development of multivariable models:
- 1) risk factors
  - those that can be modified (e.g., levels of pathogens)
  - those that are immutable to change (background factors)
- 2) risk predictors

Risk Factors

Recently the World Workshop on Periodontics adopted a working definition of the term risk factor:

- An environmental, behavioral, or biologic factor
  - confirmed by temporal sequence,
  - usually in longitudinal studies
  - if present, directly increases the probability of a disease occurring and, if absent or removed, reduces the probability
- Risk factors are part of the causal chain, or expose the host to the causal chain

Example - variables in multivariable models(I)

- Clinical conditions - referral status, caries in primary teeth, orthodontic care
- Microbiological tests - S mutans, lactobacilli
- Sociodemographic factors - snack consumption, dental health practices, fluoride history, antibiotic use

Immutable risk factor

- Demographic risk factor/genetic risk factor (background characteristic)
  - Meets the definition of a risk factor, but currently is immutable to change
  - Perhaps more likely to expose the host to the causal chain than be part of the causal chain
  - Not useful for intervention, but often useful as a group characteristic when targeting people to apply another intervention
  - May be informative in modeling because of potential for interaction effects

Example - Variables in multivariable models (I)

- Clinical/dental - age, water fluoridation, gingival recession, n teeth with perio pockets over 3 mm in depth, n teeth with calculus
- Measures of general health and physical function
- Behavioral and psychosocial - smoking, sugar consumption, anxiety, social integration, depression, stress

Risk predictor (risk marker)

- Risk predictor (risk marker)
  - A characteristic associated with elevated risk of disease (i.e., it predicts well)
  - Not thought to be part of the causal chain (e.g., tooth loss is a good predictor of future disease)
  - Usually either a byproduct of the causal chain (usually called a risk marker)
  - Or some historical measure of the outcome, such as number of missing teeth, or baseline caries
  - Useful to identify who is at risk, but not useful in identifying likely interventions

Risk predictor (risk marker)

- Usually biologic markers indicative of disease process, but are currently thought not to be etiologic
  - In dentistry tend to be alternative historical measures of the disease being studied, such as the number of missing teeth or past evidence of dental caries or periodontal disease
- The terms risk predictor and risk marker often used synonymously
  - *Risk marker* tends to be used when describing biological predictors, such as C-reactive protein being a marker for inflammation
  - *Risk predictor* often used for any non-etiologic variable that is a good predictor

Example: Variables in multivariable models (I)

- Clinical/dental - age, water fluoridation, gingival recession, n teeth with perio pockets over 3 mm in depth, n teeth with calculus
- Measures of general health and physical function
- Behavioral and psychosocial - smoking, sugar consumption, anxiety, social integration, depression, stress

Risk factors - criteria

- Three criteria need to be satisfied in order to identify a characteristic as a risk factor:
  1. the factor must be observed to covary with the disease
     - i.e., the factor must be statistically associated with the development of the disease
     - or equivalently, the frequency of disease must be observed to differ by category or value of the factor
  2. the presence of the risk factor (or a relevant change in the risk factor) must precede occurrence of the disease

Risk factor – criteria:

- 3 – the observed association must not be entirely due to any source of error
  - including chance or sampling error
  - the involvement of other (extraneous) risk factors
  - or other problems with the study design or data analysis

E.g., study should reflect design and analytic methods that make it less likely to produce:

- biased findings
- or associations unadjusted for potential confounders

Risk factors – level of evidence

- If the criteria for identifying a risk factor are to be met, longitudinal studies must be used
  - However longitudinal studies are expensive to conduct and may take many years to complete
  - Consequently variables thought to be risk factors frequently are uncovered through associations seen in prevalence (cross-sectional) studies

Risk factors – level of evidence

Indicator for Caries Management -
From the patient history:
past and present fluoride availability

Risk factors – Level of evidence

Level 1 -

Strong evidence from at least one published ***systematic review of multiple*** well-designed ***randomized controlled trials***
(*multiple,reviewed) (rct's) (pop-based)*

Risk factors – level of evidence

Indicator for Caries Management **-**
From the patient history:
dietary component in smooth surface caries

Risk factors – level of evidence

Level 3 -

Evidence from published well-designed trials ***without randomization***

- *single group* pre-, post- comparisons
- *cohort*, time series or matched *case controlled* studies

(no randomization) (population-based)

Risk factors – level of evidence

- Term "risk indicator"
- used to differentiate factors that have only been identified by means of prevalence data and can be defined as a probable or putative risk factor
  - Often detected in cross-sectional studies, that has not been confirmed by longitudinal studies
  - Other terms used to label factors derived from prevalence studies are putative (or potential) risk factors

Example - variables in multivariable models (I)

- Clinical/dental - age, water fluoridation, gingival recession, n teeth with perio pockets over 3 mm in depth, n teeth with calculus
- Measures of general health and physical function
- Behavioral and psychosocial - smoking, sugar consumption, anxiety, social integration, depression, stress

An example: caries risk assessment (CRA)

- Screen populations for model risk variables
- Use the model to predict risk

An example: caries risk assessment (CRA)

- A total of ***nine factors*** considered
- Each factor has assigned ***weighting score***
- Weights summed to ***arrive at a CRA score***: 0-3, low; 4-8, moderate; 9, high risk

An example: caries risk assessment (CRA)

Evidence of Prior Infectious Disease

4. Number of filled surfaces = 5 or > (2)

5. Last filling for caries was placed less than 1 year ago (1)

An example: caries risk assessment (CRA)

Secondary factors that influence the rate of progression of the carious lesion

8. Fluoride exposure is/was adequate (1/2)

9. Unstimulated saliva flow is below normal (<0.2 ml/min) (2)

An example: caries risk assessment (CRA)

- **Three risk categories: *high, middle, low***
- **Weights summed to *arrive at a CRA score*:**
  - **0-3, *low***
  - **4-8, *moderate***
  - **9, *high risk***

Risk model vs. prediction model

Distinction based on the intended use of the model:

- prediction of people at high risk
- or prediction of people at high risk and delineation of risk factors

Risk model

- If the purpose is prediction and delineation of risk factors
- in order to develop the most effective prevention or treatment interventions
- then a "risk" model should be developed

Prediction model

- If are mainly interested in identifying who is at high risk
  - The main goal is to maximize sensitivity and specificity of the prediction,
  - so any good predictor may be included in the model

Prediction models

Some situations favor the use of a prediction model

- When the appropriate interventions are known
  - the objective may be to maximize the ability of the model to identify high-risk and low-risk individuals
  - i.e., maximize sensitivity and specificity
    - the proportions of people who have
    - and do not have the disease, respectively, who are correctly classified by the model

Prediction models

- While prediction models may predict more accurately (greater sensitivity and specificity) than risk models
  - they contain predictor variables that will not influence the incidence of disease if changed
  - or are characteristics that are immutable to change

An example: caries risk assessment (CRA)

The following series of factors are considered: *Presence of active caries*

1. **Presence of frank lesions in mouth (3)**
2. **Frank carious lesions = 3 or more (5)**
3. **Incipient caries surfaces = 3 or more (4)**

Prediction models

- These same predictors (such as past history of disease or number of teeth) may be powerful predictors that are easy and inexpensive to obtain
  - In contrast, risk factors, such as microbiologic activity, salivary buffering capacity, and immune status, are more expensive to determine and increase the cost of assessment

An example: caries risk assessment (CRA)

Factors consistent with the current paradigm of the cause and progression of caries

6. **Mutans streptococcus count in saliva is high (>= 106 cfu/ml) (2)**
7. **Sugar/diet history (2)**

Prediction models

- Thus prediction models often may be the models of choice
- However when using prediction models, one should always remember that the models may not make much sense
- because the presence of powerful predictors in a model may mask the effects of related risk factors
  - E.g., the presence of "number of teeth" or "baseline DMF score" in a model may mask the role of microorganisms in diseases known to be infectious in nature

Prediction model criteria

- Criteria for predictive model for high-caries risk:
  - quick
  - inexpensive
  - easy to use
  - limited equipment needed
  - readily acceptable

Prediction model criteria

Needs to be within acceptable parameters of accuracy, precision:

- sensitivity, specificity
- positive and negative predictive values

Prediction model criteria -

- Assessing Model Utility

  Compare actual and predicted scores
- Model sensitivity - The % of people that actually have the disease and were correctly predicted to get it
- Model specificity - The % of people that did not get the disease and were correctly predicted to be disease free

Prediction model criteria

Choices between sensitivity and specificity must be made:

- Where to draw the line?
- What are the costs of misclassifying patients?
- Answer is not statistical

Prediction model criteria

- When we attempt to improve the sensitivity of procedures, we become less selective
  - include people who do not have the disease
- Can be more restrictive
  - by raising the specificity of the test …
  - reduce the # of false-positive determinations

Result: targeting

Directing preventive services to those at risk

1) For the clinician:

- Tailor the preventive program to the patient

2) For the community planner:

- Target populations

Result: targeting - for the clinician

The CRA score and risk determination help to determine:

- **an *individualized* preventive plan incorporated into the overall tx plan**
- **a reevaluation *interval* determined**

Result: Targeting – for a population

- **Direct preventive services to those at risk**
- **Appropriate levels of care**
- **Greater effectiveness of preventive procedures**
- **Economic efficiency and cost containment**

Example: targeting sealant use

- Changes in epidemiology of caries during the past decades:
  - decrease in prevalence
  - decrease in rate of progression
  - distribution on different tooth surfaces
- Implications
  - predicting risk
  - conducting caries preventive programs

Example: targeting sealant use

With limited resources

- Need to find ways to predict and target children at higher risk for sealant application

Sealant placement on all sound pit and fissure surfaces

- of primary and permanent teeth
- on all children is not feasible

Example: targeting sealant use

If caries levels keep *declining*...

- *smaller* amounts of disease for a sealant program to prevent...
- procedure more *costly* per surface of caries prevented...
- unless *susceptible surfaces* identified

Example: targeting sealant use

Tooth & Surface-Specific Patterns of Caries Attack

FIGURE 3
Attack Rates for Maxillary Tooth Surfaces by Surface Type, US Schoolchildren, 1987 [adapted from Table 3, Li et al., 1993 (39)]

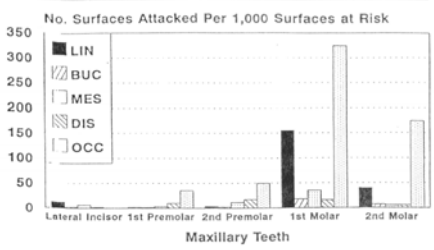
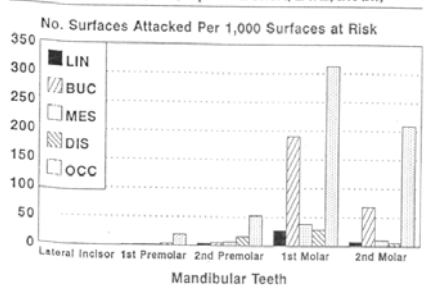
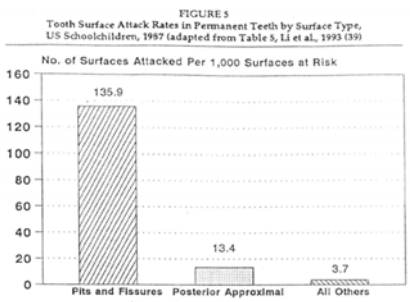


FIGURE 4
Attack Rates for Mandibular Tooth Surfaces by Surface Type, US Schoolchildren, 1987 [adapted from Table 4, Li et al., 1993 (39)]





Example: targeting sealant use

- Figure 3 and 4: occlusal of first molars is the most caries-prone site
- Figure 5: increased caries rate of first molars compared to other surfaces

Example: targeting sealant use

- Differences in risk among tooth surfaces
  - allow effective targeting of disease prevention
  - without incurring cost of population screening

Example: targeting sealant use

- Identifying teeth at highest risk of dental caries is more efficient than identifying high-risk individuals

Example - targeting sealant use

Tooth- & Surface-Specific Patterns of Caries Attack

Providers can more easily predict which tooth surfaces are at greater risk

Can better target sealant resources

Example: targeting sealant use

- ***Given:*** differences in caries risk among teeth/teeth surfaces
  - considerably *larger* than among individuals -
- **By identifying teeth - rather than individuals at highest risk**
  - more effectively *target* preventive efforts w/o need to screen individuals