UC DAVIS GRADUATE GROUP IN EPIDEMIOLOGY
WRITTEN PRE-QUALIFYING EXAMINATION
STUDY TOPICS 2022

This topic list is meant as a guide for studying and mastering key concepts in epidemiology and biostatistics but is not all-inclusive, so please use your judgement and discuss with the faculty any additional topics that may be relevant or core to the Graduate Group in Epidemiology.

BASIC EPIDEMIOLOGY AND EPIDEMIOLOGIC STUDY DESIGN (EPI 205A & EPI 206)

Causation
- Necessary, Sufficient
- Koch-Henle Criteria
- Bradford-Hill Criteria

Measures of Accuracy
- Precision
- Validity

Bias and types of Bias
- Selection
- Information/misclassification (differential/non-differential)
- Confounding

Random Error/Variability

Measures of Disease Frequency
- Prevalence
- Incidence (understand subject-time)
- Risk/probability
- Rate
- Ratio
- Incidence/disease odds (versus exposure odds)
- Crude and conditional measures

Statistical Measures of Disease Association and Causal Effect Parameters
- Risk Ratio ~~("relative risk")~~
- Incidence Rate Ratio
- Odds Ratio (including matched-pairs odds ratio, and the "rare disease assumption")
- Attributable Risk
- Etiologic Fraction
- Population Attributable Risk

Confounding
- Methods for identifying/detecting confounding
- Methods for controlling confounding

Interaction (effect measure modification)
- Additive

Multiplicative
Absolute vs. Relative Measures of Effect

Standardized Rates
Directly standardized rates
Indirectly standardized rates / Standardized mortality (and morbidity) ratios

Outbreak Investigation

Diagnostic Test Evaluation and Screening Tests
Sensitivity and specificity
Likelihood ratios (binary, ordinal and quantitative tests)
Comparison of sensitivity and specificity of 2 tests
Predictive value positive and predictive value negative
Prevalence/apparent prevalence relationship
Sensitivity, specificity and predictive values of tests in series and parallel
Kappa for interobserver agreement
ROC curves

Study Design
Types of studies
Experimental
Clinical trials
Intervention trials
Prevention trials
Field trials
Observational
Cross-sectional studies
Cohort studies (retrospective and prospective)
Case-control studies (including "nested")
Matched case-control studies
Ecological studies
Know advantages and disadvantages of each study type
Know biases of each study type
Know measures of association in each study type
Know how to analyze each study type
Know how to conduct sampling and select subjects for each study type

ADVANCED EPIDEMIOLOGIC METHODS (EPI 207)
Everything listed under basic epidemiology and epidemiologic study design PLUS:

Directed Acyclic Graphs (DAGs)
Conceptualize DAGS as representations of the relationships between variables in contingency tables
Using DAGs to identify confounding paths and selection of variables for statistical control
Distinguish confounders, colliders, and intermediates in DAGS
Understand direct, indirect and total effects with DAGS

Conditional and marginal independence versus association – statistical meaning and representation in a DAG
Be able to identify (and illustrate) selection bias using DAGs
Understand and illustrate the concepts of nondifferential versus differential misclassification and independent versus dependent misclassification using DAGS

Study Design:
- Observational studies
  - Case-control studies - Methods of control selection
    - Cumulative incidence sampling
    - incidence density sampling

Proportionate Mortality Ratios and Mortality Odds Ratios

Potential outcomes model
- Identifiability/Non-identifiability
  - Including doomed, immune, protective, causal

Causation/Causal Inference
- Selection of comparison groups
- Study base principles
- The counterfactual model
- The randomization assumption

Bias
- Confounding
  - Effects of confounding
  - Directionality of confounding
  - Collapsibility/Simpson's Paradox
  - Comparability
- Selection bias
  - Differentiate between potential causes for selection bias in a follow-up design (cohort or experiment), case-control design, and cross-sectional design
- Information bias
  - Understand how the concepts of sensitivity, specificity, false positive, and false negative can be applied to exposure and outcome misclassification

Interpretation of effect measures from longitudinal studies
- Equate incidence odds ratios to exposure odds ratios: be able to derive one from the other, provide appropriate interpretations

Concepts of Interaction
- Trend
- Homogeneity/heterogeneity on additive and multiplicative scales

Matching in Observational Studies

Direct standardization, indirect standardization, and Mantel-Haenszel methods
- Be able to conduct direct and indirect standardization
- Know the rates, weights, and estimated parameter outcome for each method
- Be able to calculate a Mantel-Haenszel Odds Ratio

BASIC BIOSTATISTICS (EPI 202)

Probability:
- Definition and properties
- Exponential and logarithm functions
- Conditional probability
- Law of total probability
- Bayes Theorem
- Applications to epidemiology: sensitivity, specificity, predictive value +/-, prevalence

Random variables (RVs) and their distributions:
- Discrete distribution models
- Continuous distribution models
- Applications to epidemiology: when are specific distributions appropriate
- Marginal, conditional and joint distributions
- Properties of RVs
- Expectation and conditional expectation
- Correlation and covariance
- Variance and covariance of linear combination of RVs
- Cumulative distribution function
- Transformation methods
- Applications and interpretations of all techniques in epidemiology

Large sample properties:
- Limiting distributions
- Convergence in probability
- Law of large numbers
- Central limit theorem
- Asymptotic normal distribution
- Standardization

BASIC STATISTICAL INFERENCE (EPI 203 AND PREREQUISITES)

Parametric Tests
- z-statistic
- t-statistic
- ANOVA and general linear models
- Linear regression

Non-parametric Tests
- Mann-Whitney
- Wilcoxon Rank
- Kruskal-Wallis
- Friedman

Tests of proportions (Chi-square statistic)
- Chi-square 2 x 2 contingency table
- McNemar's test for paired data

Types of Data (continuous or discrete (dichotomous/categorical/count, etc.)

Hypothesis testing
- P-value and type I error
- Confidence intervals
- Power and type II error
- Sample size calculations

ADVANCED BIOSTATISTICS
EPI 203
Sampling Distributions:
- Meaning
- Examples
- Large sample approximation

Point Estimation:
- Criteria for evaluating estimators--e.g. bias, variance, mean square error (MSE)
- Large sample properties
- Minimum variance
- Cramer-Rao lower bound
- Fisher Information (variance covariance matrix)
- Maximum likelihood (ML) estimation
  - Likelihood
  - Properties of ML estimators
- Method of moments estimators
- Delta method and Taylor series

Confidence interval (CI) estimation:
- Methods for CI construction
- Interpretation of confidence intervals
- Relationship with p-value

Hypothesis testing:
- Hypothesis testing framework
- Criteria for evaluating tests
- Neyman Pearson Lemma and Best Critical Region
- Level/size of tests
- Power of tests
- Likelihood Ratio Test

EPI 204
Know all assumptions for all general linear statistical models

Modeling binary outcomes: Logistic regression for binary outcome data in prospective and retrospective studies; models for matched and unmatched data; logits/log odds; logistic models for categorical (ordinal/nominal) outcomes.

- Model and model interpretation
- Assumptions and limitations
- Estimation of model parameters
- Model-based inference (CI, hypothesis testing)
- Model-building
- Interaction and confounding
- Model diagnostics and goodness of fit

Modeling count data: Poisson regression

- Model and model interpretation
- Assumptions and limitations
- Estimation of model parameters
- Model-based inference (CI, hypothesis testing)
- Model diagnostics (goodness of fit)

Modeling time to failure (censored) data (survival analysis): life tables, Kaplan-Meier, log-rank tests; Cox proportional hazards (PH) model, stratified Cox PH model

- Model and model interpretation
- Assumptions and limitations
- Estimation of model parameters
- Model-based inference (CI, hypothesis testing)
- Model-building
- Interaction and confounding
- Model diagnostics and goodness of fit