What is statistics and the need for data management!

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 - Definitions: Population, Sample, Parameter(s) and Statistic(s)
 - Descriptive Statistics
 - Inferential Statistics
 - Sampling Methods
 - Sample Size Calculation

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 - Data management cycle
 - Sources of data
 - Softwares for data analysis and management
 - Guidelines for Effective Data Management
 - How to deal with Big Data

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Descriptive Statistics:

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Inferential Statistics:

It's a branch of statistics in which conclusions or generalizations are made about the population parameters by using the sample statistics. The main components of inferential statistics are:

- Point estimation
- Interval estimation and
- Hypothesis testing

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 - Stratified sampling
 - Cluster sampling
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 - Systematic sampling
 - Stratified sampling
 - Cluster sampling
 - Multistage sampling
- Non-Probability Sampling
 - Convenience sampling
 - Volunteer sampling
 - Judgment (Purposive), Snowball, and Quota sampling

Simple Random Sampling (SRS): It's a sampling method in which each subject of the *sampling frame* has an equal chance of being selected into the sample [1]. SRS is the most popular method of random sampling. There are two types of SRS: with replacement and without replacement. SRS with replacement is less common.



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Systematic sampling: It's a sampling method in which subjects are chosen in a systematic way such that one first randomly picks the first subject from the sampling frame and then selects each *kth* subject from the list (k = N/n) [1]. If the sampling frame is randomly shuffled, then systematic sampling is equivalent to SRS.



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Stratified sampling: It's a sampling method in which a sample is obtained by firstly dividing the population into subpopulations (strata) based on some characteristics and then an SRS is taken from each stratum [1]. Combining the obtained SRSs will give the final stratified sample. Minority subgroups of interest can be ensured by stratification. There are two types of stratified sampling: proportionate and disproportionate. In the proportionate one, we draw a sample from each stratum in proportion to its share in the target population. By this method, each stratum should be internally homogeneous.



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Cluster sampling: It's a sampling method in which the target population is first divided into naturally occurring clusters and then a random sample of clusters is obtained such that all subjects in the randomly selected clusters are included in the sample [1]. Sometimes, we include an SRS from each selected cluster instead of including all subjects which makes the sampling method to be called a two-stage sampling method. By this method, clusters should be internally as heterogeneous as the target population itself.



Multistage sampling: It's a sampling method in which we use combinations of two or more sampling methods at least one of which involves randomness [2].

Population cluster 1 cluster 2 cluster 3 cluster Stage I Stage II sample

MULTISTAGE SAMPLING

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Sample Size Calculation: It's an important part of the study design to ensure validity, accuracy, reliability and, scientific and ethical integrity of the study [3]. In general, the main aim of a sample size calculation is to determine the number of participants needed to detect a clinically relevant treatment effect. Formulas for sample size calculation depend on four factors:

- The significance level α
- The power of the test 1-eta
- The type of the conducted test (t-test, z-test, chi-square test, etc.)
- The type of the design (case-control versus prospective)

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For sufficiently large sample size, both the law of large numbers (WLLN) as well as the central limit theorem (CLT) will work: **CLT:**

$$ar{x} \sim N(\mu, rac{\sigma}{\sqrt{n}})$$

WLLN:

$$\bar{x}_n \to \mu, n \to \infty$$

Data management cycle: It's the set of all steps taken starting from the conception of the study (study design) through the reporting of the results and archiving the data for future reusability ¹.



¹This figure is a modification of a figure taken from [4]. $\Box \rightarrow \langle \Box \rangle \rightarrow \langle \Xi \rangle \rightarrow \langle \Xi \rangle \rightarrow \langle \Xi \rangle \rightarrow \langle \Xi \rangle$

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Sources of data:

- Censuses
- Surveys
- Experiments
- Registries
- Electronic Medical Records
- Secondary data (BRFSS, NHIS, Medicare & Medicaid, etc.)
- Social Media Data
- Publications

Softwares for data analysis and management:

- Excel
- Access (only for database management)
- SAS (has its own SQL Structured Query Language)
- SUDAAN (good for complex sample surveys)
- R
- SPSS
- Minitab
- STATA
- S-Plus
- PASS (only for sample size calculation)
- Epi Info (free by the CDC)
- REDCap (is a mature, secure web application for building and managing online surveys and databases)

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Link to REDCap's website: http://project-redcap.org/

Link to REDCap's website from UNM:

http://hsc.unm.edu/research/ctsc/informatics/REDCap.shtml

Workshop on how to use REDCap by the CTSC: Next Class: Wednesday, November 18, 2015 10:00 am - 12:00 pm HSC Library Room 226 Follow link below to register http://hsc.unm.edu/research/ctsc/Informatics/ REDCapTraining.shtml

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- Create metadata/dictionary/codebook.

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 - Decide on the linkage method (Exact versus Probabilistic Linkage [SSN, name, address, etc.])

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- Store data on hard disc and analyze it chunkwise: Keep only relevant variables in the dataset you are analyzing (In this way you minimize dynamic memory allocation overhead)
- Sampling: Work on training sets (A training set is typically a random sample from the complete dataset). Cross-validation is commonly used in statistics and extensively used in machine learning.

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- Bigger hardware: Use super-computers if available.
- Use parallel programming if applicable (There are several packages for parallel computation in R such as: Rmpi, nws, snow, sprint, foreach, multicore, and parallel)
- Store data on hard disc and analyze it chunkwise: Keep only relevant variables in the dataset you are analyzing (In this way you minimize dynamic memory allocation overhead)
- Sampling: Work on training sets (A training set is typically a random sample from the complete dataset). Cross-validation is commonly used in statistics and extensively used in machine learning.
- Integration of higher performing programming languages like C++ or Java

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Thank you. For questions, Email: FQeadan@salud.unm.edu

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