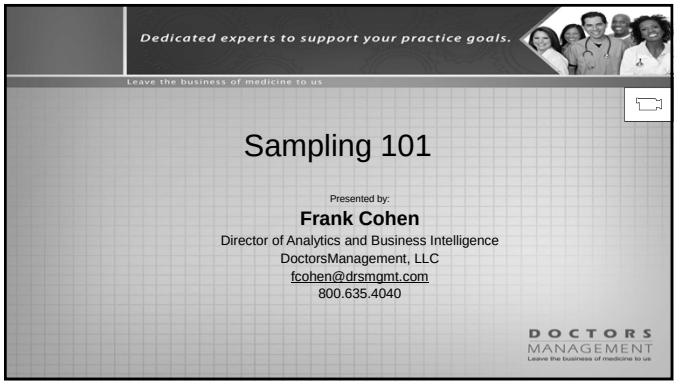


Why Sample?

- Because it is often impossible to collect 100% of the data on 100% of the population (or universe)
  - This is called a census
- It is an efficient and inexpensive way to infer the statistics of a sample to the universe (or sample frame).

For Government Audits

- If a particular probability sample design is properly executed, i.e., defining the universe, the frame, the sampling units, using proper randomization, accurately measuring the variables of interest, and using the correct formulas for estimation, then assertions that the sample and its resulting estimates are “not statistically valid” cannot legitimately be made. In other words, a probability sample and its results are always “valid.”

[CMS Pub.100-08 Chapter 3 Section 10.2]

For Self-Disclosure

- If the financial review was based upon a sample, the review report must also include the Sampling Plan that was followed. At a minimum, this includes:
  - Sampling unit
  - Sampling Frame
  - Sample Size
  - Source of Random Numbers
  - Method of Selecting Sampling Units
  - Sample Design
  - Missing Sample Items and Other Evidence
  - Estimation Methodology

The Sampling Process

1. Define the population of interest
2. Create a sampling frame
3. Determine the sampling method
4. Calculate the sample size
5. Sample the data
6. Analyze the results
7. Infer to the population of interest

Definitions

- Universe or Population
  - A collection of units being studied. Units can be beneficiaries, claims, claim lines, procedures, drugs, tests, etc.
- Sampling Unit
  - A *sampling unit* is any of the designated elements that constitute the population of interest
- Sample Frame
  - A *sample frame* is a collection of units from which a sample will be drawn. The data should be homogenous and share similar characteristics
- Sample
  - a finite part of a statistical population whose properties are studied to gain information about the whole

Definitions

- Parameter
  - Considers the characteristics of the population
- Statistic
  - A numerical value, such as standard deviation or mean, that characterizes the sample from which it was derived
- EPSeM
  - Equal Probability of Selection Method
  - the application of a sampling technique that results in the population elements having equal probabilities of being included in the sample.

What Size Sample?

- Large enough to minimize sampling error and not so small that it no longer fairly represents the population in question
- Too large a sample can cost more money and consume more resources without added benefits
- Too small a sample creates too much error and renders the results useless

Ideally . . .

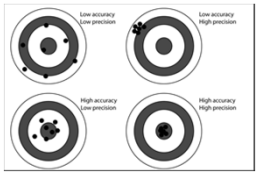
- The sample is representative of the qualities of the population
  - The sample has the same characteristics as the population
- It is of sufficient size to satisfy the assumptions of the statistical techniques used in our analysis
- *NOTE: For self-disclosure, the sample size must be at least 100 claims (or other sampling units)*

Sample Size Rules of Thumb

- Any probability sample will have some inaccuracy, or sample error
- The larger the sample, the smaller the error (not always a good thing)
- The more homogenous the variables, the smaller the error (always a good thing)
- Sample size determination is a fairly complex undertaking

Precision vs. Accuracy

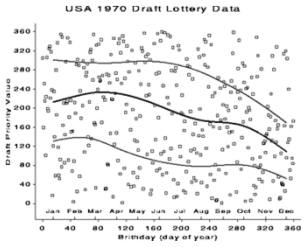
- Accuracy measures how close the statistic is to the true value
- Precision measures how close the variables are to one another
- Accuracy is easier to fix; just move the model
- Precision is harder to fix as it is indicates instability

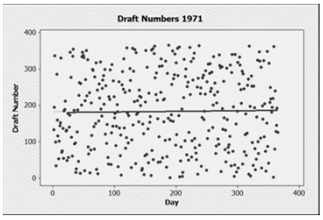


Why Random Sampling?

- It eliminates bias in selecting units
- It enables us to infer (extrapolate) the results to a larger population based on what is learned from sample results
- It allows us to estimate sampling error, which is critical for extrapolation
- Randomness *does not* guarantee representativeness, particularly if the population is biased

Nonrandom Risk: The 1970 Draft Lottery





Random Sampling Methods

1. Simple Random sample
   - Every unit has an equal (non-zero) chance of being selected
     - Selecting claims to study payer behavior
2. Stratified sample
   - Breaking the universe into homogenous sampling frames from which a homogenous sample is drawn
     - Procedure type (E&M v. Surgical)
     - Beneficiary type (age, sex, etc.)
     - Diagnosis
     - Paid amounts

Random Sampling Methods

3. Cluster sampling
   - Organizes the units into similar subsets
   - Two stage
     - i.e., random sample of beneficiaries and then random sample of claims for each
   - Multi-stage
     - i.e., random sample of beneficiaries from which we draw a random sample of claims from which we draw a random sample of claim lines

Cluster Sampling

How Do I Randomize?

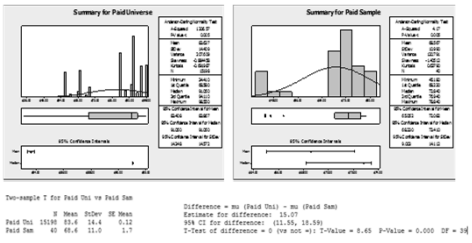
- You can use a software program
  - RAT-STATS, MiniTab, Excel, SQL, etc.
- You can systematize the sample
  - Every n^{th} unit, such as every 10^{th} or 25^{th} or 50^{th} unit
- You can sort by some variable (such as claim ID or claim code) that is not otherwise ordered

How about Statistically Valid?

- There is a difference between a sample being random and it being statistically valid
- Random just means that every unit had an equal chance of being selected
- Statistically valid has to do with the representativeness of the sample

Representativeness

Universe **Sample**



Two-sample T for Paid Uni vs Paid Sam

	N	Mean	StDev	SE Mean
Paid Uni	15190	83.6	14.4	0.12
Paid Sam	40	68.6	11.0	1.7

Difference = mu (Paid Uni) - mu (Paid Sam)
Estimate for difference: 15.07
95% CI for difference: (11.55, 18.59)
T-Test of difference = 0 (vs not =): T-Value = 8.65 P-Value = 0.000 DF = 39

Simple Random Sampling

- SRS works well when the population is homogeneous & readily available
- Each element of the frame has an equal probability of selection.
- Each unit in the sampling frame is assigned some unique identifier

Systematic Sampling

- First, arrange the sampling frame (or population) using some ordering technique and select at regular intervals
  - i.e., every 4th or all odd or even
- Start from a random position

Stratified Sampling

- When the population can be described by a number of different characteristic groups, the frame can be organized into separate "strata"
- Each stratum can then sampled as an independent sub-population, subject to SRS
- Most often, the strata are sampled proportionate to the population
- If done properly, it reduces variability and increases precision

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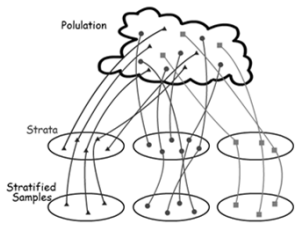
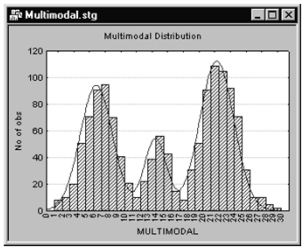
Stratified Sample Example



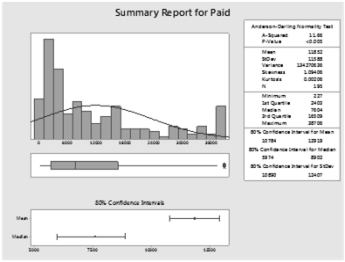
Types of Stratified Samples

- Proportionate
  - The sample for each stratum **has the same distribution proportion** as the universe
- Disproportionate
  - The sample has a **different percent distribution** than the population

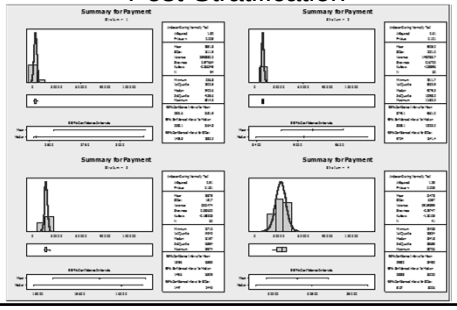
Example of Multimodal Distribution



Pre-Stratification



Post-Stratification



Certainty Stratum

- The statistical reason for selecting a certainty stratum is to capture and isolate the largest unit values so that their extremely large values do not influence sampling variability
- This is a great way to deal with outliers
- Certainty strata are *not* part of the extrapolation calculation but rather the face value is added on to the total

Sampling Bias

- A sampling method is called ***biased*** if it *systematically* favors some outcomes over others.
- Any event that causes one or more variables within a population to have a different chance of selection
- This can lead to over or under representation of a group of variables
- Bias isn't always bad

Examples of Sampling Bias

- Telephone surveys
  - Often exclude cell phone numbers
  - 40% of households do not have land lines
- Voluntary response sample
  - Some people enjoy surveys while others do not
  - Think about a jury pool
- Seasonal selection issues
  - Taking a sample in Florida in January or June
- Self reporting
  - Weight and height for BMI statistics

Types of Appraisal Methods

- Variable Appraisal
  - To measure a quantitative characteristic such as the dollar amount per claim, line or beneficiary
  - Continuous variable
- Attribute Appraisal
  - to determine the number of items that meet a given set of criteria, such as the proportion of lines with improper modifier usage
  - Proportion or ratio (like a percentage of error)

Sample Error

- Sample error is an estimate of the potential error (or precision) the results have in relation to the population (or universe)
- Most often, sample error is measured by confidence intervals

What is a Confidence Interval (CI)?

- The purpose of a confidence interval is to validate a point estimate; it tells us how far off our estimate is likely to be
- A confidence interval specifies a range of values within which the unknown population parameter may lie
  - Normal CI values are 90, 95%, 99% and 99.9%
- The width of the interval gives us some idea as to how uncertain we are about an estimate
  - A very wide interval may indicate that more data should be collected before anything very definite can be inferred from the data

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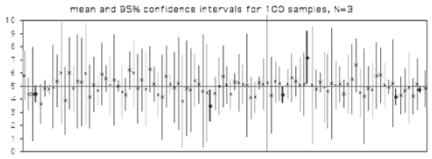
Confidence Interval Example



Note that in only six of the 100, the mean was not within the range of the upper and lower bound.

Ideally, this should have been five, but it's pretty close!

Calculating Sample Error

- For a variable appraisal, sample error is calculated as the standard deviation divided by the square root of the sample size
- For an attribute appraisal, sample error is calculated as the square root of the proportion times 1- proportion, all divided by the sample size

Example of Sample Error (SE)

- A sample of average charges for 99213 was taken from 50 practices in a given area
- Mean = $82.40 and STDev = $15.55
  - Assume normal distribution
  - 68.26% of values between $66.85 and $97.95
- SE = Stdev/sqrt(N), or 15.55/sqrt(50), or
- 15.55/7.07 = 2.2
- The standard error for our estimate of the mean of $82.40 is $2.20
- Our precision is around 2.6% (pretty good!)

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What is Margin of Error?

- The Margin of error is a range of error that is based on the confidence interval we select.
- The higher the CI, the larger the scores and the wider the margin of error
  - 99% = 2.576
  - 95% = 1.96
  - 90% = 1.645
  - 80% = 1.28

Calculating the Margin of Error

- The margin of error is a standard score times the standard error
  - Score values depend on how wide or narrow you want the margin of error to be
  - The higher the value, the higher the margin of error
- Sample of 50, 95% margin of error
  - Mean = 82.40, stdev = 15.55, SE = 2.20
  - Margin of error = score times SE
    - ½ Interval = 1.96 * 2.20 = 4.31

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Calculating the Confidence Interval

- Using our average charge example:
  - Mean = 82.40, stdev = 15.55, SE = 2.20, ME = 4.42
  - CI = 82.40 +/- 4.42, or
  - 95% CI = $77.98 to $86.82
- If I were to take 100 samples, in 95 of them the actual point estimate would be somewhere between $77.98 and $86.82

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Why is this Important?

- In an audit situation, we want to be able to estimate precision
  - OIG states that precision should be no worse than 25% using a 90% confidence interval
- In an extrapolation, we want to use sample error to our advantage
  - Most commonly, the extrapolation uses a point estimate minus the ½ interval of a 90% confidence interval

Creating a Sample for Review

- It is not necessary (and often ill-advised) to create a statistically valid random sample (SVRS) for an internal review
  - Obligates you to extrapolate the overpayments
- Use nonprobability sampling

Nonprobability Sampling

- Convenience samples
  - Selecting units that are easy and accessible
  - i.e., the last five encounters
- Quota sampling
  - A specific quota is established and you choose any unit you want until the quota is met
- Purposive sampling
  - This involves choosing the units for the sample that you think are most appropriate
- Prospective audit
  - Select the next *n* units prior to submitting the claim

For More Information

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