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**Introduction to Quantitative
Data Analysis**

Disclaimer 1

Fellow Evaluators,
First, this workshop is **not** about “statistics” or “statistical methods”. Here, statistical methods will only serve as a “vehicle”. Second, this workshop is **not** about “STATA” or “XSTAT” or any software for that matter. Any software used will only serve as a “vehicle”.

Finally, this workshop is about data analysis “principles”, “time tested principles”, designed to help us produce “evidence based” and “utilization-focused” evaluations which conclusions and recommendations are useful.

Disclaimer 2

The contents, findings, and conclusions in this presentation are those of the author and do not necessarily represent the official position of the NEC nor that of UNDP.

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1. **Quantitative Data Analysis: The Foundation**

# Quantitative Data Analysis and Evaluation

In evaluation, the aim of a quantitative data analysis is to provide **unbiased** facts as well as some **evidence-based** answers to the evaluation questions and hypothesis. Let’s illustrate this with two examples, namely, the “Food Security Assessment in Mago Village” and the “Zuglu Land Health Insurance Subsidy Program Evaluation”

## Evaluation of the Food Security in Mago Village

### Context and justification

For the past six years, Diamonds Republic (DR) has been devastated by series of wars and civil unrests. Many rebel groups are fighting for the control of various natural resources. These brutal conflicts have already claimed over 700,000 lives and causing injury to hundreds of thousands more.

In the face of such devastating circumstances, over seven million DR citizens have fled their homes and sought out safety in refugee camps. While many remain displaced inside the country, more than four million have fled to neighboring countries in a desperate bid to reach safety. According to the United Nations High Commission for Refugee (UNHCR), over 1,200,000 DR refugees now lived in Mago village of the neighboring country of Zouglou land.

For the millions of DR refugees, hunger and undernutrition are major issues. Even with the help of foreign aid, host countries do not have the means to provide for the needs of refugees. In 2015, the World Food Program’s (WFP) reported that an estimated 4,000 tons of food a month are required just to feed DR refugees in Mago village. According to the WFP Global Food Security Update of 2015, 4 million people are unable to buy sufficient food for their usual consumption and 2.5 million people have been identified as “highly vulnerable” and “in critical need of sustained food assistance.”

It is in this context that UNHCR, WFP, and the Government of Zouglou Land conducted a Comprehensive Food Security Monitoring Exercise (CFSME) to evaluate the level of food insecurity among **registered DR refugees** living in Mago, between March and May 2016. About 10 focus group discussions and 2,000 interviews were conducted to provide a robust understanding of food security and economic vulnerability of registered DR refugees living Mago. The data are stored in ….

### Evaluation Objectives and Questions

The various stakeholders would like to answer, among others, the following questions:

* What is the current prevalence and severity of household food insecurity among DR refugees living in Mago?
* What is the relationship between household food security status and the socio-demographic characteristics of DR refuges living in Mago?
* Specifically, are more female affected than male? Are people fifty years or older more affected than their younger counterparts?
* What is their weekly average amount spent on food?
* What are the main coping strategies used and how they are ranked by these refugees?
* What are the perceived barriers to food security experienced by the DR refugees living in Mago?
* What strategies are most commonly used by these refugees to overcome barriers associated with food insecurity?

NB: the data related to this evaluation is in the first workbook of the “quant\_anal data base”.

## Evaluation of the Zuglu Land Health Insurance Subsidy Program

### Context and Justification

In Zuglu land, the government is concerned that poor rural households are unable to afford the costs of basic health care, with detrimental consequences for their health. To address this issue, Zuglu land government and international partners launch the Health Insurance Subsidy Program (HISP}.

The role of HISP is to subsidize health insurance for poor rural households, covering costs related to primary health care and medicine. HISP main goal is to reduce the cost of health care for poor families and to improve health outcomes. The ultimate objective of HISP is to improve the health of the country’s population.

HISP has being piloted in 100 villages covering 63,000 households in the last 2 years and policy makers are considering expanding HISP to cover the whole country, which would cost hundreds of millions of dollars. Therefore, after 2 years of piloting, Zuglu land government commissioned an evaluation to help them make the decision of HISP expansion

### Evaluation Hypotheses and Questions

The central objective of HISP is to reduce the cost of health care for poor families. The hypotheses related to the HISP assume the following:

* costs are preventing rural populations from accessing available health care and

medicine;

* out-of-pocket expenditures on health-related costs are a core contributor to poor health outcomes;
* households will enroll in HISP once it is offered;
* enrollment in HISP will lower households’ out-of-pocket health expenditures.

The evaluation would like to answer among others, the following questions:

* What are the socio-demographic traits of households enrolled in HISP?
* Were these socio-demographic traits different for non-enrolled households?
* What was the average health expenditure of a household before enrollment to HISP?
* What was the average health expenditure of a household after the two years enrollment in HISP?
* Was it a meaningful difference between enrolled household out-of-pocket health expenditures before and after HISP experience?
* Did the average out-of-pocket expenditures for a non-enrolled household remain the same after the 2 years of HISP implementation?
* Compared to a non-enrolled household, did an enrolled household experience a decrease in his out-of-pocket expenditures?

NB: HISP data is the” hisp2\_dat” workbook in your data folder

# Key Outcome(s) and Covariates

A critical step in data analysis is to identify the key outcome or outcomes as well as the associated covariates. Let’s illustrate with the example in section 1.1.2 and section 1.1.2.

## The case of the Evaluation of the HISP

|  |
| --- |
| **ACTIVITY 1.1: Outcome and Covariates for the HISP**Using the illustration in section 3.1.1, find the outcomes and the associated covariates |
| **NOTES:** |
| ***SOLUTION***1. **Outcomes**
* Out of pocket health expenditure per capita per year
1. **Covariates**:

The main covariates are socio-demographic traits such as:* Survey round: baseline / follow-up
* Was the household enrolled in HISP?
* Was the Household enrolled in HISP under the randomized promotion?
* Was the Household eligible to enroll in HISP?
* Was the Household located in treatment community?
* Was the Household located in locality randomly assigned promotion of HISP?
* Head of the Household Age in years
* Head of the Household' Spouse Age in years
* Head of household's completed years of schooling
* Spouse completed years of schooling
* Does the household Head speak an indigenous language?
* Was the household headed by a female?
* Number of household members at baseline
* Did the Home has a dirt floor at baseline?
* Did home has a private bathroom at baseline?
* Number of hectares of land owned by household at baseline
* Distance to closest hospital
 |
|  |

## The case of the evaluation of food security of DR refugees

|  |
| --- |
| **ACTIVITY 1.2: Main Outcome and Covariate for the Food Security in Mago Village**Using the illustration of section 1.1.2 found the main outcome and the associated covariate(s) . |
|  |
| **NOTES:** |
| ***SOLUTION***1. **Main Outcome**

In this illustration, there are 4 main outcomes, namely:* Food security status of the DR refugees living in Mago
* Perceived barriers to food security of DR refugees living in Mago
* Strategies most commonly used by these refugees to overcome barriers associated with food insecurity
* Weekly amount spent on food
1. **Covariate**

Socio-demographic characteristic such as:* Gender
* Age
* Etc..
 |

# Dummy Tables

## Definition and Importance

Dummy tables are “mock tables”, or “blank table shells” with variable names, labels of statistical measures such as (n, percentage, mean, median, 95% C.I., etc.) and title. Dummy tables are completely blank, i.e., they do not include data. Ideally, dummy tables are constructed before data collection.

However, dummy tables are smart tools to use for the following reasons:

* Dummy tables provide a template for systematic steps in the analysis;
	+ - they ensure that all correct or reasonable data were collected;
		- they help you to visualize your data in relationship to the evaluation overall goal;
		- they help you test the evaluation hypotheses;
		- they help you stay focused on relevant analyses;
		- they are powerful communication tool in that they get all stakeholders to agree on the important data items during the design stage, and allows advance planning of various analyses;
		- they constitute a centralized record of analyses, results, and decisions.

The structure of dummy tables is as follows:

* Table of participants’ baseline socio-demographic characteristics
* Table(s) of bi-variate analysis of main outcome and key covariate (s)
* Table(s) of subgroup analyses, for example, male vs. female
* Table(s) of regression analysis or other models building

## Illustrative Example

Using the “Evaluation of Food Security among DR refugees” of section 1.1.2 as an example, let us illustrate how to make dummy tables. For the analysis of this evaluation, the main dummy tables are as follows:

Table 1 a. Sociodemographic characteristics of DR Refugees in Mago, 2015, N = 1388

|  |  |  |
| --- | --- | --- |
| Sociodemographic characteristics | **n** | **%** |
| **Gender** |  |  |
| Female |  |  |
| Male |  |  |
| **Marital status** |  |  |
| Married |  |  |
| Single |  |  |
| Divorced |  |  |
| Widowed |  |  |
| Education Level |  |  |
| None |  |  |
| Primary and beyond |  |  |
| **Occupation** |  |  |
| None |  |  |
| gainful employed |  |  |
| Other |  |  |
| **Parent** |  |  |
| No |  |  |
| Yes |  |  |
| **Living Arrangement** |  |  |
| With Support |  |  |
| Without Support |  |  |
| **Food Security Status** |  |  |
| Secure |  |  |
| Insecure |  |  |
| **Total** |  |  |

Table 1b:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Min** | **Mean** | **Mode** | **Max** |
| Age (years) |  |  |  |  |
| Weekly food expenses |  |  |  |  |

Table 2: Bivariate Analysis

|  |  |
| --- | --- |
|  | Food Security Status |
| Gender | Secure | Insecure | Total |
| Female |  |  |  |
| Male |  |  |  |
| Total |  |  |  |
|  |  |  |  |

Table 3: Regression Analysis:

|  |  |  |
| --- | --- | --- |
|  | Bivariate | Multivariate |
|  | uOR | 95% CI | P-value | aOR | 95% CI | P-Value |
| Gender |  |  |  |  |  |  |
| Female |  |  |  |  |  |  |
| Male |  |  |  |  |  |  |
| Marital status |  |  |  |  |  |  |
| Married |  |  |  |  |  |  |

## Dummy Tables Practice

Please, take 15 minutes to try these two activities:

### Additional Bi-variate tables for the Food Security of DR Refugees

|  |
| --- |
| **ACTIVITY 1.3: Bi-variate table for the Food Security in Mago Village**Using the illustration of section 1.1.2 suggest additional bi-variate dummy tables. |
| **NOTES:** |
| ***SOLUTION*** |

### Dummy tables for the evaluation of the HISP

|  |
| --- |
| **ACTIVITY: Dummy Tables for the evaluation of the HISP**Using the illustration of section 1.1.1 suggest appropriate dummy tables. |
| **NOTES:** |
| ***SOLUTION*** |

# Data Analysis Steps

|  |
| --- |
| **Step 1: Prepare the data** |
| **What** | Data must be cleaned and organised for analysis. (Note that coding and nature of the data should be thought through before the data gathering process starts and should be pre-tested.) |
| **Action** | You should**:*** code/ input the data in the analysis software;
* check the data for errors and accuracy;
* transform the data as needed;
* determine what analysis tools can be used for each variable.
 |
| **Outcome** | **A clean dataset with a “data dictionary”.** |

|  |
| --- |
| **Step 2: Describe your sample** |
| **What** | Here you summarize the data using measures of central tendency and of variation. This help you to put the data into context, to give meaning and life to the data. You begin to uncover the message hidden in the data.  |
| **Action** | Compute summary statistics such as:* **Measures of central tendency**: mean, mode, median
* **Measures of variation**: standard deviation, range, interquartile range.
 |
| **Outcome** |  **useful summary statistics using tables and graphs**. |

|  |
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| **Step 3: Assess differences and Significance** |
| **What** | Assess whether the differences between two different groups are statistically relevant. For example, you found out that 80% of female headed households are food insecure compare to only 60% of male headed household. Can you confidently say this difference is meaningful or could this difference have arisen by chance? |
| **Action** | Compute measures of significance such as:* t-test
* Chisquare
* Kruskall-wallis
* Wilcoxon-signed test
* t-test
* ANOVA or ANCOVA
 |
| **Outcome** | **Meaningful and statistically significant comparison** |

|  |
| --- |
| **Step 4: Explore relationships**  |
| **What** | Examine what relationships exist among the main outcome and the various covariates. Assess and establish if those relationships are statistically significant.  |
| **Action** | * Formulate **hypothesis** on what relationships are likely to exist amongst your main outcome and the other variables. Assume the “null hypothesis” of “No relationship” conduct statisticaltests to provide enough evidence against the “null”;
* Measure the strength of the relationship;
* Understand the likelihood that this relationship appeared by chance.
 |
| **Report** | Describe and explain * relevant relationships between the main outcome and key covariates;
* Strong and significant relationship;
* Measure of association such as p-values and 95% confidence interval.
 |

|  |
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| **Step 5: Built meaningful models**  |
| **What** | Devise and test explanatory models. |
| **Action** | Use Regression analysis to:* determine key variables that are most likely to influence the main outcome;
* test these key variables to understand if and to what degree they explain the variation in the main outcome;
* determine the most appropriate model or final model;
* test the final model on different subgroups of interest such as female vs. male or young vs. old.
 |
| **Outcome** | **Explain:*** **your variable selection method;**
* **the rationale for the model;**
* **the finding from statistical tests**.
 |





# The DAP: Plan, Plan, and Plan

A successful data analysis requires “**planning**”. Echoing the words of George Bernard Shaw, “**We do not plan to fail but rather we fail to plan**”. Therefore, let us Plan, plan and plan ahead of time. The following worksheet could help greatly in this regard:

**Table 3.5: Data Analysis Planning Worksheet (DAP)**

|  |  |  |  |
| --- | --- | --- | --- |
| Resources | What you have | What you need | How to get what you need or work within resources limitation |
| Funding |  |  |  |
| Time |  |  |  |
| Staff |  |  |  |
| Materials and equipment |  |  |  |

The DAP worksheet is a **good communication tool** and help you in your data analysis journey.
 Make good use of it for it help you **secure the necessary resources and ensure your accountability**.

1. **Descriptive Analysis: Summary Statistics**

# Level of measurement

## Definition:

A **level of measurement** is the **scale** in which a given variable is defined and identified. Each **level of measurement** has certain properties which in turn determines the **appropriateness** and the use of **a certain statistical method**. The **six types** of level of measurement are, **binary**, **nominal**, **ordinal**, **interval**, **ratio** and **Likert scale**.

## The six types of level of measurement

### Binary

A **Binary** (or a dichotomous) variable has **only two** **values,** namely, 1 and 2 (or Yes and No). For example, “gender” is a binary variable, for it has only two levels, namely, male and female. Each unit in the sample takes “one and only one” of those two values.

### Nominal

A nominal variable has 2 or more distinct categories or classes and put each unit in one and only one category. For example, “marital status” is a nominal variable with 5 categories, namely, single, married, separated, divorced, or widowed. For a person cannot be married and single at the same time. He or she can be in one and only one category.

### Ordinal

A variable is said to be ordinal if its values are ordered, in progression, from the smallest to the largest, or from the largest to the smallest. For example, “Education Level” defined as “Primary, High School, College, Graduate and beyond” is an ordinal variable.

### Interval

An interval variable is one in which “differences” or “intervals” have the same interpretation throughout. A perfect example of an interval variable is “temperature in Celsius”. In fact, the difference between 40 degrees and 60 degrees is exactly the same as between 10 degrees and 30 degrees and the same between 100 degrees and 120 degrees Celsius.

However, interval scales have two shortcomings. First, they do not have a true zero point. That it is, zero degree Celsius does not represent the complete absence of temperature. If zero degree were a “true point”, at zero degree you will “feel absolutely nothing; you feel absolutely normal”. In fact, you feel cold, very cold.

Second, for an interval variable, ratio “makes no sense at all”. That is, if it is currently -40 degrees in Saskatoon and only -10 in Rome, would you say that the people in Saskatoon feel “4 times colder than” the people in Rome? No, no one would dare say that. This means, the ratio 40 over10 has no meaning. The same is true of the ratio of 50 over 25.

### Ratio

A great example of ratio variable is “Income” or “Amount of money”. A ratio variable has 4 properties. First, its values are ordered. Second, like an interval variable, “differences” or “intervals” have the same interpretation throughout. Third, a ratio variable has a “true zero”; that is “zero” represents “a complete absence”. For example, if you had zero Euro in your pocket right now, this means, there is a complete absence of money in your pocket. Finally, if Sally has 800 Euros and John has only 200 Euros, this means that Sally has “4 times more” money than John. The ratio 800 over 200 make sense and it is the same as the ratio of 20 Euros over 5 Euros.

### Likert scale

A Likert scale (named after its inventor, the psychologist Rensis Likert) is a scale that measure respondents’ opinion or attitude to a given statement. The scale asked respondents to express the extent to which they are asked to agree or disagree with a particular statement; or the degree they were satisfied or dissatisfied with a certain product. An example of such scale is "strongly agree, agree, not sure/undecided, disagree, and strongly disagree." Another example is “Not satisfied at all, somehow satisfied, satisfied, and very satisfied”

## Importance of the level of measurement

One might ask what the usefulness of scales of measurement. The scale of measurement of a variable, specially, that of the main outcome determine the correct statistical analysis to use as we will see in the next sections.

# Measures of Central Tendency

## Definition and type

A measure of central tendency (also called measure of location) is **single value** that describe the **center** of the data. The most popular measures of central tendency are the mean, the mode, and the median.

## Popular Measures of Central Tendency

### Mean

The arithmetic mean (or simply the mean) is the average value in the data. That is, the mean is equal to the sum of all the values in the data set divided by the number of values in the data set. It is the most widely known measure of central tendency.

### Mode

The mode of a set of data is the value in the set that occurs most often. In other words, the mode is the most frequent value (the value with the highest frequency) in the data.

### Median

The median is the middle value in an ordered data set. That is, to find the median, first order the data from the smallest to the largest value. Then the middle value is the median, the value that cuts the data into half.

## When to use

* + The mean is a perfect central location measure when the data is symmetric. That is when the mean equals to the median.
	+ However, when the data is skewed (mean > median or mean < median) then the median or the mode is a much better measure of central location. A good example here is the income variable
	+ In the case of an ordinal variable or a Likert scale variable, only the median is the appropriate measure of central location.

# Measure of Variation

## Definition

A measure of variation tells us **to which extent the data is spread out, stretched or squeezed** around the central tendency value. In other word, a measure of variation describes **the dispersion** in the data. The most common measures of variation are the variance, the standard deviation and the interquartile range (or iqr). Let’s look at each of them

## Popular Measures of Variation

### Variance and Standard Deviation

The variance measures how much or how far a typical value of a data set differs from the average. And the standard deviation is just the squared root of the variance. A large standard deviation is an indication that the values in the data set are “spread out” while a small standard deviation tell us that the values are “closed together”.

### Interquartile Range

The IQR is the difference between the first quartile (Q1) and the third quartile (Q3). In an ordered data set, 25% of the values in the data set are less than Q1 while, 75% of those values are less than Q3. Therefore, the IQR, is meant to contain approximately 50% of the data.

# What Summary Statistics to Use

For a symmetric distribution the standard deviation is a good measure of variation. For skewed distribution as well as for ordinal or Likert scale, the IQR is preferred. The following table summarizes the above suggestions:

Table 4.4: Descriptive Statistics: When to use?

|  |  |  |
| --- | --- | --- |
|  | Central Tendency | Variation |
| Variable Scale | **Mean** | **Median** | **Mode** | **Standard Deviation** | **Inter-Quartile Range** |
| Binary | No | No | Yes | Yes | No |
| Nominal | No | No | Yes | Yes | No |
| Ordinal | No | Yes | No | No | Yes |
| Likert scale | No | Yes | No | No | Yes |
| Interval | Yes | Yes | Yes | Yes | Yes |
| Ratio | Yes | Yes | Yes | Yes | Yes |

# Summary Statistics for the Food Security Status of DR Refugees

Using the data “refugees” located in your data folder construct table 1a and table 1b for the DR refugees living in Mago.

## Socio-demographics tables

**Table 1a: Socio-demographics traits of DR refugees living in Mago; N = 1388**

|  |  |  |
| --- | --- | --- |
| Socio-demographic traits  | **n** | **%** |
| **Gender** |  |  |
| Female | 894 | 65.78 |
| Male | 465 | 34.22 |
| **Marital Status** |  |  |
| Single | 162 | 11.67 |
| Married | 1,002 | 72.19 |
| Widowed | 156 | 11.24 |
| Div/Sep | 68 | 4.9 |
| **Occupation** |  |  |
| No | 727 | 55.54 |
| Employed | 582 | 44.46 |
| **Living Arrangement** |  |  |
| Yes | 1,010 | 75.04 |
| No | 336 | 24.96 |
| **Food Security Status** |  |  |
| Food Secure | 339 | 24.42 |
| Marginally Food Insecure | 628 | 45.24 |
| Severely Food Insecure | 421 | 30.33 |

Table 1b: Socio-demographics traits of DR refugees living in Mago; N = 1388

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Socio-demographic traits | **Mean** | **Mode** | **Min** | **Max** |
| **Age** | 24 | 22 | 4 | 82 |
| **Weekly Food Expenditures** | 124 | 100 | 0 | 1000 |

## Interpretation

|  |
| --- |
| **ACTIVITY: Interpretation of the Socio-demographics Table of DR Refugees**Using the results in the section above, suggest some clear interpretation of the results |
|  |
|  |
|
|
|
|
|
|
|

1. **Bivariate Analysis and Hypothesis Testing**

## 3.1. What Statistical Analysis to Use?

Bivariate analysis involves the comparison of two variables to each other. Usually we are trying to find out if there is any relationship between the outcome of interest (dependent variable) to one of the covariates (independent variables). In this search, we will use an “appropriate statistical method” to find the best measure of association, and the strength of the relationship between a given covariate and the outcome of interest.

Once we choose the covariate and the outcome of interest, the recurrent question is: What’s the appropriate statistical method to us in order to determine the presence (or absence) of an association as well as its strength?

The following table shows general guidelines for choosing a statistical analysis. The table below covers a number of common analyses and helps you choose among them based on 3 important criteria, namely:

* the number of outcome variable (or dependent variable),
* the nature of your outcome variable
* the nature of your independent variable (IV, sometimes referred to as exposure or covariate)

|  |  |  |  |
| --- | --- | --- | --- |
| **Number of Outcome Variable(s)** | **Nature of  Independent Variables** | [**Nature of OutcomeVariable(s)**](http://www.ats.ucla.edu/stat/mult_pkg/whatstat/nominal_ordinal_interval.htm) | **Test(s)** |
| 1  |  0 IVs (1 population)  | interval & normal  | one-sample t-test  |
| ordinal or interval  | one-sample median  |
| categorical (2 categories)  | binomial test  |
| categorical  |  Chi-square goodness-of-fit  |
|  1 IV with 2 levels (independent groups) | interval & normal  | 2 independent sample t-test  |
|  ordinal or interval  |  |
| Wilcoxon-Mann Whitney test  |
|  categorical  |  Chi- square test  |
| Fisher's exact test  |
| 1 IV with 2 or more levels (independent groups) | interval & normal  | one-way ANOVA  |
| ordinal or interval  | Kruskal Wallis  |
| categorical  | Chi- square test  |
| 1 IV with 2 levels(dependent/matched groups) | interval & normal  | paired t-test   |
|  ordinal or interval  | Wilcoxon signed ranks test   |
|  categorical  | McNemar |
| 1 IV with 2 or more levels(dependent/matched groups) | interval & normal  | one-way repeated measures ANOVA  |
| ordinal or interval  | Friedman test  |
| categorical  | repeated measures logistic regression |
| 2 or more IVs (independent groups) | interval & normal  | ANOVA /ANCOVA |
| ordinal or interval  |  |
| categorical  | factorial logistic regression  |
| 1 interval IV  | interval & normal  | correlation   |
| simple linear regression  |
| ordinal or interval  |  non-parametric correlation  |
| categorical  | simple logistic regression  |
| 1 or more interval IVs and/or1 or more categorical IVs  | interval & normal  | multiple regression |
| analysis of covariance |
| categorical  | multiple logistic regression |
| Discriminant analysis  |
| 2 or more  | 1 IV with 2 or more levels(independent groups) | interval & normal  | One-way MANOVA  |
| 2 or more  | 2 or more  | interval & normal  | multivariate multiple linear regression  |
| 2 sets of  2 or more  | 0  | interval & normal  | Canonical correlation  |
| 2 or more  | 0  | interval & normal  | Factor analysis  |
| **Number of Outcome Variables**  | **Nature of  Independent Variables**  | [**Nature of Outcome Variable(s)**](http://www.ats.ucla.edu/stat/mult_pkg/whatstat/nominal_ordinal_interval.htm)  | **Test(s)**  |

This page was adapted from [Choosing the Correct Statistic](http://bama.ua.edu/~jleeper/627/choosestat.html) developed by James D. Leeper, Ph.D.  We thank Professor Leeper for permission to adapt and distribute this page.

# Principle of Statistical Hypothesis Tests

In the upcoming sections, we will perform some common statistical tests such as the t-test or the Chi-square test. Let’s review some of its principles.

Performing a statistical test is making a choice between a hypothesis of interest (usually labelled H0) and its alternative (called H1). Therefore, the goal of a statistical test is to make an “informed decision” (choose between H0 and Ha) based on the results provided by a sample.

In order to properly to this, the following steps are taken:

* Step 1: State Ho with clarity;
* Step 2: Clearly state Ha;
* Step 3: Choose your Type I Error, α. In general, α = 0.05;
* Step 4: Select your sample and collect the appropriate data;
* Step 5: Choose the correct statistical test (see section 5.1);
* Step 6: Compute the p-value.
* Step 7: decide between H0 and Ha and then express this decision in practical terms.

Let’s apply the above principles to some selected tests.

# Comparing Two Independent Means

In the HISP evaluation of section 3.1.1, let’s assume we are interested in knowing whether or not the “average health expenditures is the same” for enrolled households and non-enrolled households at follow-up:

* + **Step 1**:

Ho: average health cost for enrolled households at follow-up = average health cost for non-enrolled households at follow-up;

* + **Step2**:

Ha: average health cost for enrolled households at follow-up ≠ average health cost for non-enrolled households at follow-up;

**Step 3**: α = 0.05;

* + **Step 4**: the collected data is the file “hisp2.dta” located in your data folder;
	+ **Step 5**: Since, the sample of “enrolled households” is independent of that of “non-enrolled households”, then, based on table 5.1 of section 5.1, the correct statistical test is the “unpaired t-test”;
	+ **Step 6**: We obtained the **p-value** using STATA and the result is as follows

Two-sample t test with equal variances

Enrolled? | Obs Mean Std. Err. Std. Dev. [95% Conf. Interval]

---------+--------------------------------------------------------------------

 No | 1,995 22.30491 .2854193 12.74837 21.74516 22.86466

 Yes | 2,965 7.840179 .1468178 7.994495 7.552304 8.128054

---------+--------------------------------------------------------------------

combined | 4,960 13.65815 .176129 12.40428 13.31286 14.00344

---------+--------------------------------------------------------------------

 diff | 14.46473 .2946964 13.887 15.04247

------------------------------------------------------------------------------

 diff = mean(No) - mean(Yes) t = 49.0835

**Ho: diff = 0** degrees of freedom = 4958

 Ha: diff < 0 **Ha: diff != 0** Ha: diff > 0

 Pr(T < t) = 1.0000 **Pr(|T| > |t|) = 0.0000** Pr(T > t) = 0.0000

**Interpretation**: The **p-value = 0.000 < 0.05.** Therefore, the data provide a strong evidence that the average health cost for enrolled household is “**statistically different**” from that of non-enrolled household. And that difference is $14.5 USD.

# Comparing Two Dependent Means: The Paired t-test

Once again, using the HISP evaluation, let’s assume we are interested in knowing whether or not, for a non-enrolled household, the “average household remained the same” after the two years of HISP implementations. Therefore, let’s apply the steps in the section 5.3:

* + **Step 1**:
	+ Ho: average health costs for enrolled households at baseline =
	 average health costs for enrolled households at follow-up;
	+ **Step2**:
	+ Ha: average health costs for enrolled households at baseline ≠
	 average health costs for enrolled households at follow-up;
	+ **Step 3**: α = 0.05;
	+ **Step 4**: the collected data is the file “hisp2.dta” located in the subfolder;
	+ **Step 5**: The sample of enrolled households is “the same” both at “baseline” and “follow-up”. Hence the two-samples are “dependent”, then, based on table 5.1 of section 5.1, the correct statistical test is the “paired t-test”;
	+ **Step 6**: We obtained the **p-value** using STATA and the result is as follows

Paired t test

------------------------------------------------------------------------------

 Group | Obs Mean Std. Err. Std. Dev. [95% Conf. Interval]

---------+--------------------------------------------------------------------

Baseline | 2,964 14.48969 .0800166 4.356317 14.3328 14.64659

Follow-U | 2,965 7.840179 .1468178 7.994495 7.552304 8.128054

---------+--------------------------------------------------------------------

combined | 5,929 11.16438 .0940975 7.245509 10.97991 11.34884

---------+--------------------------------------------------------------------

 diff | 6.649515 .1672221 6.321699 6.977331

------------------------------------------------------------------------------

 diff = mean(Baseline) - mean(Follow-U) t = 39.7646

**Ho: diff = 0** degrees of freedom = 5927

 Ha: diff < 0 **Ha: diff != 0** Ha: diff > 0

 Pr(T < t) = 1.0000 **Pr(|T| > |t|) = 0.0000** Pr(T > t) = 0.0000

**Interpretation:** Here the **p-value = 0.0001 < 0.05**. Therefore, the data provide a strong evidence that the average out-of-pocket health cost for enrolled households **decreased from $14.5 at baseline to $7.8 at follow-up**.

# Comparing Two Independent Proportions: The Chi-Squared Test

One of the most popular tests is the **Chi-Squared test**. We use the chi-square test of independence when we have two nominal variables and you want to see whether the proportions of one variable are different for different values of the other variable. For example, if we would like to investigate whether or not “the proportion of female refugees in various food security status are different from that of male refugee, we use the Chi-Squared test. We do this by following the 7 steps in section 5.3 as follows:

* + **Step 1**:

Ho: % food insecurity of female headed households = % food insecurity of male headed households;

* + **Step2:**

Ha: % food insecurity of female headed households ≠ % food insecurity of male headed households;

* + **Step 3**: α = 0.05;
	+ **Step 4**: the data is the file “refugee.dta” located in the subfolder folder;
	+ **Step 5**: Perform the Chi-squared test of independence
	+ **Step 6**: We obtained the p-value using STATA and the result is as follows:

 Food Insecurity

 | Status

 Gender | Secure Insecure | Total

-----------+----------------------+----------

 Female | 232 662 | 894

 | 25.95 74.05 | 100.00

-----------+----------------------+----------

 Male | 94 371 | 465

 | 20.22 79.78 | 100.00

-----------+----------------------+----------

 Total | 326 1,033 | 1,359

 | 23.99 76.01 | 100.00

 Pearson chi2(1) = 5.5191 **Pr = 0.019**

**Interpretation**: The **p-value = 0.019 < 0.05**, therefore the data provide a strong evidence of an “association” between food security and the head of household’s gender. In fact, approximately 80% of refugee male headed households were food insecure compared to vs. 74% of refugee female headed household.

1. **Data Visualization Basics**

# Overview

One of the best ways to “show case” of an “evaluation findings” is in the use of graphs, infographics, and pictures. As eloquently noted by Stephanie Evergreen in her 2017 “Effective Data Visualization”, we visualize because we “have a point”, a “compelling finding” to share, a “big results” or an “interesting story” to tell. In fact, data visualization has two primary functions; first, convey valuable information in a convincing manner; second, narrate a compelling and worth telling story. The end result of data visualization is to drive decision makers to action based on evidence through a compelling story.

To illustrate the above points, we will use the evaluation of “Abou’s Principle” commissioned by the Ministry of Health of Pokou Land.

## Evaluation of Abou’s Principle: Background

In Pokou Land, the Djoula tribe represent only 12% of the entire population. Abou’s Principle is a child first initiative designed to ensure that Djoula children do not experience denials, delays, or disruptions in service due to jurisdictional disputes.

Abou’s Principle was established in honor of five-year old Abou Issa Mossi from the Djoula tribe in Pokou Land. Abou had many health challenges requiring a high level of care and was transferred to a hospital in the province of Katiola. In 2001, after spending 2 years in the hospital, Abou asked to be transferred to a specialized foster home closer to his community but the federal and provincial governments could not agree who should pay for his home-based care. In 2005, Abou passed away in the hospital, never having had the opportunity to live in a family home.

On December 12, 2007, in recognition of Abou, the House of Commons unanimously passed a motion that the government should immediately adopt a child-first principle to resolve jurisdictional disputes. On January 26, 2016, the Pokou Human Rights Tribunal (PHRT) substantiated a 2007 complaint by the Djoula Child and Family Caring Society and the Assembly of Djoula. The PHRT ordered the federal government to cease applying a narrow definition of Abou’s Principle and to take measures to immediately implement the full meaning and scope of the principle. Subsequent orders from the PHRT have followed resulting in a new application of Abou’s Principle. Abou’s Principle applies to all Djoula children, regardless of where they live.

Abou’s Principle is meant to prevent Djoula children from being denied essential services or experiencing delays in receiving services. The focus of Abou’s Principle is to help Djoula children’s families navigate a complex health, social and educational system with often highly complex divisions of jurisdictional roles and responsibilities.

## Context and Justification

In July 2016, Abou’s Principle Child First Initiative was implemented as described in the Pokou Human Rights Tribunal decision of May 26, 2016. The initiative included funding over a 3-year period for Enhanced Service Coordination, Service Access Resolution and Engagement with Djoula and partners to determine a longer-term approach.

The province of Katiola, where more than 60% of Djoula live, responded quickly to establish Service Coordinators by using existing partnerships without disturbing the provision of services to children and families. The existing network of Early Childhood Intervention Program (ECIP) agencies had capacity to provide the enhanced service coordination function with their history of providing services to families for over 18 years. This suggestion was supported by Djoula tribe during a series of 12 engagement sessions. Initially, ECIP provided support to families with children 0-6 years of age who live both on and off reserve. In December 2016 Abou’s Principle was expanded to support Djoula children 7-18 years of age on reserve. In October 2017, 3 Tribal Councils also received funding to provide service coordination for Djoula children living outside of Katiola.

## Objectives

The Government of Pokou Land is committed to ensuring that Djoula children have access to the services and supports they need no matter where they live. Pokou Land is also committed to co-developing, with Djoula tribe, long-term policy options for the implementation of Abou’s Principle.

In July 2013, the Government of Pokou Land announced $382.5 million nationwide over three years for Abou’s Principle services to provide Djoula families with information and awareness sessions about all available services. The objectives of these sessions included:

• raising awareness about the availability of services and funds under Abou’s Principle;

• enabling Djoula families and children with some types of special need to gain knowledge and have the peace of mind that there are services they can access.

In 2017, the Ministry of Health of Pokou Land commissioned an evaluation of the Abou’s Principle to evaluate its effectiveness after three years of implementation. The main purpose of the evaluation is to provide analysis of information gathered from the community and family sessions, together recommendations, to be used to determine the future of Abou’s Principle in the province of Katiola and in the entire Pokou Land.

The data collected for this evaluation is in the “A\_principle.dta” workbook in the “Ipdet\_2018\_data” folder. We will use this data set to illustrate the various visualization tools such as “pie graph”, “bar graph”, “Likert”, etc.

# Pie Chart

## Definition and Use

A “Pie Chart” is a graph in which a circle is divided into slices (like in a pizza), each represent a proportion of the whole. A “Pie Chart” is best used for “visualizing a single number” or making “part-to-whole” comparisons with categorical variable. They are most impactful with variables with no more than
5 values.

## Illustration

Using the “gender.dta” in “A\_principle.dta”

## Interpretation

**Activity**: Provide a useful interpretation of the Pie Chart above

### The Four Rules of a Pie Chart Design

The following rules allow you to design a meaningful pie chart.

**Rule 1**: Visualize **no more than** **5** slices per chart;

**Rule 2:** Ensure all slices **adds up to 100%**;

**Rule 3**: **Order** slices **correctly** (in ascending or descending order) in clockwise manner;

**Rule 4:** For comparison, **don’t use multiple** pie charts.

### Pie Chart Practice

**Activity**: Using the “DR Refugees” data, provide a visual representation of the gender distribution of the DR refugees**.**

# Bar Chart

## Use

A “Bar Chart” is a graph drawn using rectangular bars to show how large each value is. The bars can be horizontal or vertical. A “Bar Chart” may be used to compare different categories, to compare parts of a whole or to show change over time.

## Illustration

Using the “Q1\_data” in your “A\_principle\_dta.xls” workbook, we obtain the following bar chart:

## Interpretation

**Activity**: Provide a practical interpretation of the Bar Chart above

## Bar Chart Practice

**Activity:** Using the “DR Refugees” data, provide a visual representation of the Marital Status distribution of the DR refugees

## Back-to-Back Bar Chart

A “Back-to-Back Bar” chart is used to assess whether or not two group are “similar” or if two groups have “similar distribution”. Here is an illustration using the “boys\_girls\_dat” from the “A\_principle\_data” workbook

## Interpretation

**Activity:** Provide a useful interpretation of the Back-to-Back Bar Chart above

## Back-to-Back Bar Practice

**Activity:** Using the “HISP 2” data, provide a visual representation of How households socio-demographics differ according to the gender of the household head

# Stack Bar Chart

## Use

A “stacked bar” chart is a graph that is used to break down and compare parts of a whole. Each bar in the chart represents a whole, and segments in the bar represent different categories of that whole. A “stacked bar” chart is best used to visualize, “Likert scale”, “Ranking” and “All-That-Apply” variables.

## How to visualize Likert Scale: An Illustration

To illustrate the best way to visualize a Likert scale variable, we will use the data collected for question # 5 of the evaluation of Abou’s Principle. In question 5, participants were asked:

**Q 5:** To what extent do you agree or disagree with the following statement, “: **Within the past year, I have been able to access services for my children more easily”:**

Strongly Agree Agree Neutral Disagree Strongly Disagree

The data are in the Q5\_data sheet in the “A\_principle\_dta” workbook in your data file. We will use a “Stack Bar” in Excel as follows:

## Interpretation

**Activity:** Provide a practical interpretation of the Stacked Bar Chart above

## Stacked Bar First Practice: Likert Scale Without “Neutral” Category

**Activity:** Using the “Satisfaction\_dat1” in the health\_Services\_dat workbook, provide a visual representation of How participants are satisfied with the health services they receive

##  Stacked Bar Second Practice: Likert Scale with Neutral Category

**Activity:** Using the “Satisfaction\_dat2” in the health\_Services\_dat workbook, provide a visual representation of How participants are satisfied with the health services they receive

## How to visualize Ranking Variable: Aggregated Stacked Bar

Question # 3 of the Abou’s Principle evaluation, participants were asked to:

“Rank who you would want to provide the role of Service Coordinator for your child, with:

**1 = Most Preferred; 2 = Neutral; and 3 = Least Preferred”**

Please, review question # 3 of the questionnaire. We will use the data collected for this question to illustrate the “Aggregated Stacked Bar” as follows:

## Interpretation

**Activity:** Provide a useful interpretation of the aggregate stacked bar above

## Aggregated Stacked Bar Practice

**Activity:** Using the “Q3\_data” in the “A-principle.dta”, replicate the aggregate stacked bar in section 6.4.6

 **APPENDIX A**

 **Sampling Matrix**

 **World Bank Funded Operations** (Simulated Data)

 **Sustain-**

 **Year**  **Cost: US$ Outcome ability**

**ID #** **Country**  **Region Approved Sector Thousands Rating Rating**

01. Algeria MENA 98 d 550 S M

02. Brazil A LAC 91 b 380 S H

03. Brazil B LAC 96 d 180 U L

04. Bulgaria ECA 97 b 120 S L

05. Burundi AFR 98 a 280 U L

06. China EAP 94 c 900 S L

07. Colombia A LAC 95 b 230 S M

08. Colombia BLAC 96 c 170 S L

09. Egypt A MENA 97 a 370 S M

10. Ethiopia AFR 96 c 300 S L

11. Ghana AFR 93 b 150 S M

12. Guatemala LAC 92 a 250 S L

13. Hungary ECA 97 a 220 S L

14. India A SAS 93 c 360 S L

15. India B SAS 96 d 430 U H

**APPENDIX B**

**Random Number Table**



Source: OFPP Pamphlet No. 4, Supplement No. 2 to OMB Circular No. A-76, October 1980