**Estimation of Total and Unit Routine Immunization Costs from Facility to National Level**

# Overview

The objectives of the exercise are to:

* Identify recurrent and capital cost components of an immunization program.
* Calculate average total costs of at facility level using sampling weights
* Generate a weighted national estimate of total and unit costs using the averaging method.

# Background

Accurate data on the costs of routine and new vaccines immunization can improve country level planning and financing for immunization. This data can build a base of evidence to provide inputs for policy and resource mobilization domestically and externally. Applying standardized methods to analyze facility based data will make it easier to compare and apply results more widely.

The Expanded Program on Immunization Costing and Financing (EPIC) Project is an initiative that collected facility based data on the costs of immunization across six countries. The study used the [Common Approach](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0ahUKEwjUgYKT0-HWAhUJBMAKHSoIDIEQFggtMAE&url=https%3A%2F%2Fstatic1.squarespace.com%2Fstatic%2F556deb8ee4b08a534b8360e7%2Ft%2F55970258e4b03cf942da51ac%2F1435959896232%2FWEBSITE_Common%2BApproach.pdf&usg=AOvVaw1fCwfVP4igcyz2TbJ5Hfp6) which applies a bottom-up, ingredients-based costing methodology (1). This led to the identification of costs from the perspective of the health service provider. The project merged and analyzed data from these country studies to create a unique pooled dataset of 316 sites to explore cross-country determinants of costs (1).

The exercise below will focus on the data collected from Uganda EPIC study.

Uganda had a population of approximately 34.5 million people in 2011. The types of health facility in Uganda are: Health Centres (HC) II, III, IV; general hospitals, regional general hospitals and national general hospitals. An estimated 72% of the population lived within 5 km of a health facility in 2010, and coverage with most vaccines has remained above 80% but with variations between districts (2).

The Uganda study applied a multi-stage, purposive and stratified random sampling approach (1). All 10 regions were represented and one or two districts per region were purposively sampled to represent a range of typical service contexts (2). 52 health facilities were randomly sampled from the strata of health facilities in these districts (general hospitals and HC II, III and IV) and 49 of them were included in the study (2). The costs were estimated retrospectively for 2011, and were captured in Ugandan Shillings (UGX)\*.

*\*The exchange rate for 2011 is 1 UGX = 0.0004 USD (obtained from www.xe.com)*

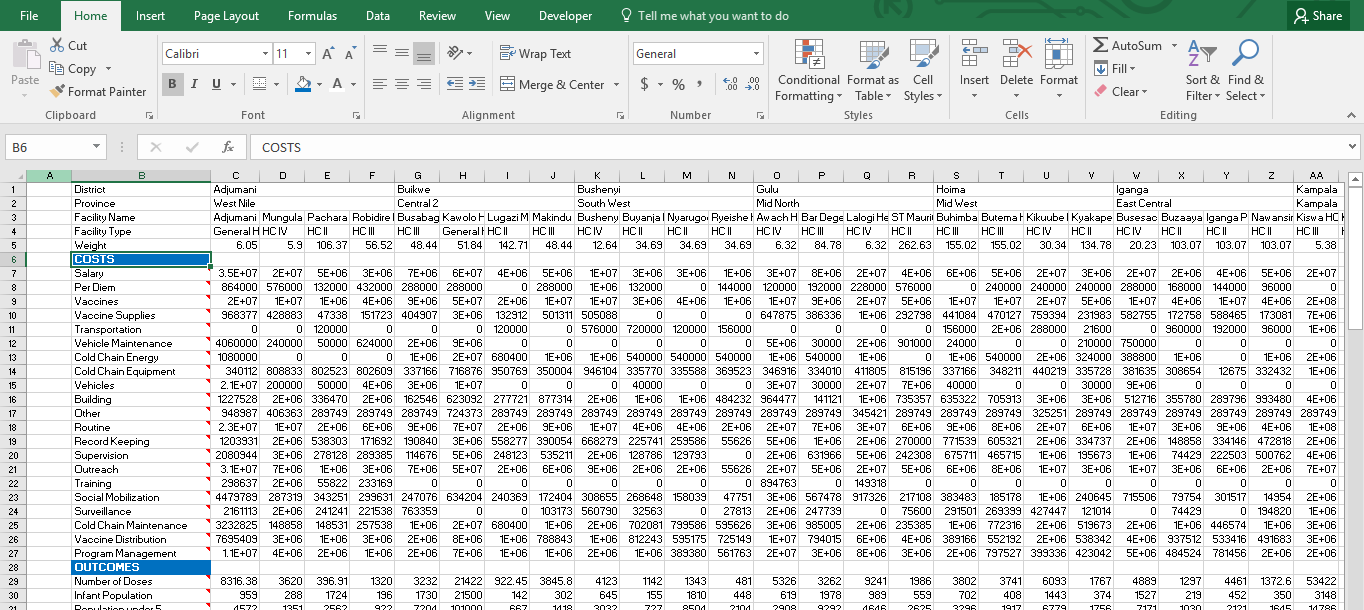
# Exercise

We will be analyzing a part of the data collected during the Uganda study.

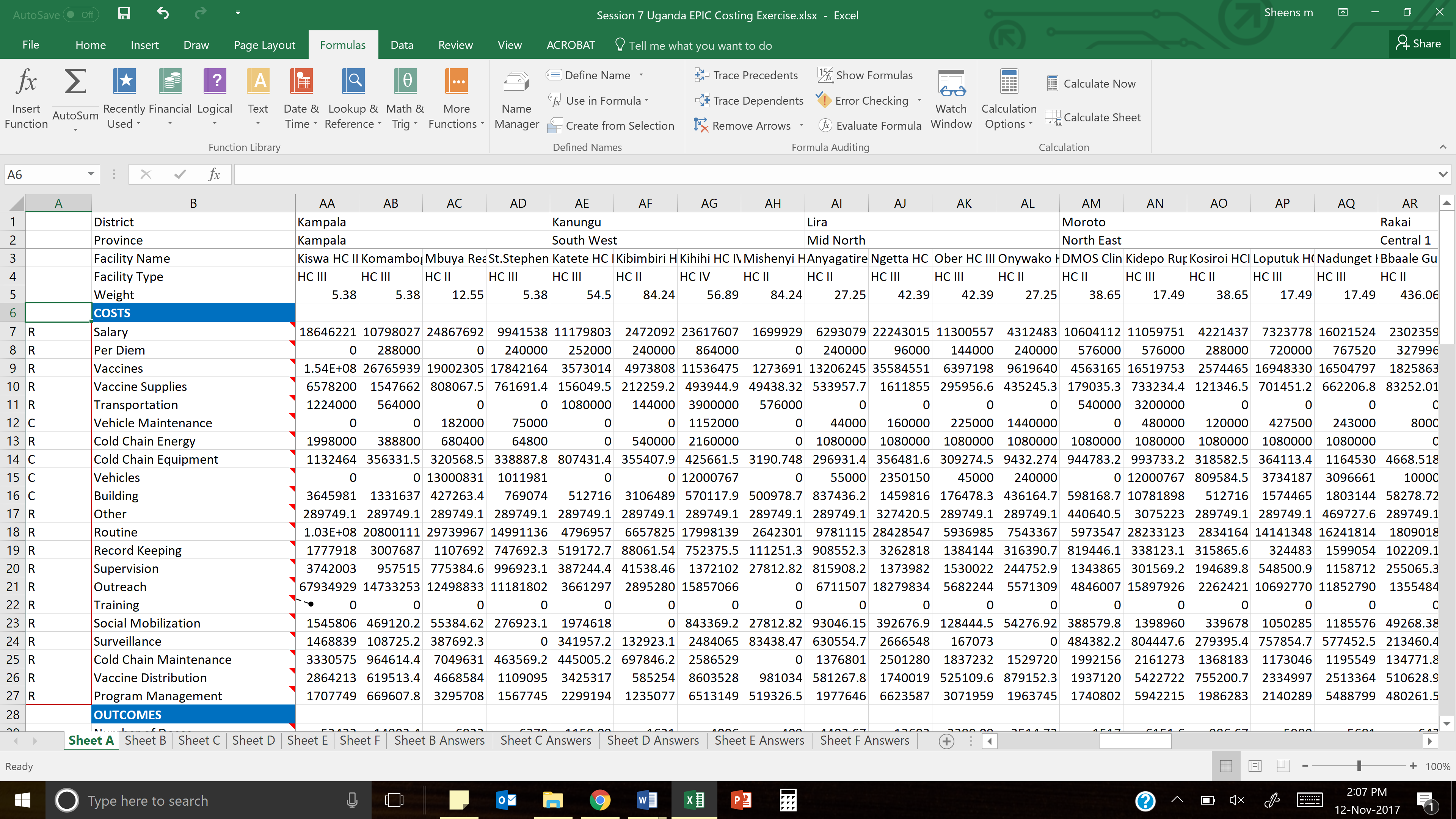
1. Open the excel document named *Uganda EPIC Costing Exercise*. On Sheet A, you have been provided with the raw data collected during the Uganda study. On the subsequent sheets, you will be analyzing the data.
2. Go to Sheet A and briefly go through the data provided. You will notice that Column B contains the cost and output items, and Columns C – AY contains the values of the items corresponding to each facility.
   1. Hover on the cells in Column B to see a more detailed definition of the item.

# Categorize Cost Items and Complete the Cost Table

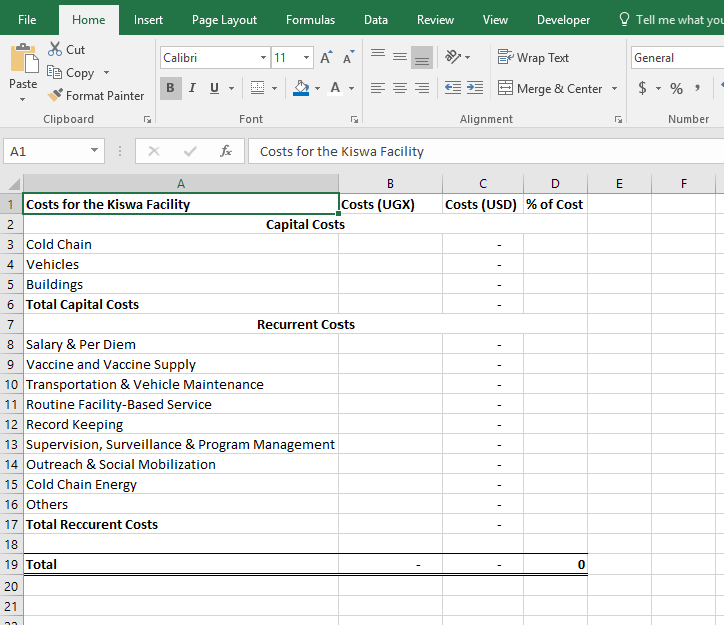
1. Cells B7 to B27 contain cost items. In Column A *(the red box)*, mark the items with a ‘*C’* if they are capital costs, or with a ‘*R’* if they are recurrent costs.



***Answer:***



1. Go to Sheet B and you will find Table B-1, the cost table for the HC III facility Kiswa.



1. Complete Column B of the table by filling in the values for the cost items. Column C will automatically be filled in with the USD values. The values for Kiswa will be found in Sheet A, Column AA.
2. Calculate the total capital cost (cell B6), the total recurrent cost (cell B17) and the overall total cost (cell B19) for Kiswa.
3. Complete Column D of the table in Sheet B by calculating the share of the total cost for each item.
4. What are your observations about the costs of the Kiswa facility?

The majority share of the total costs is recurrent costs (98.73%), and capital costs in only 1.27%. Within the recurrent costs, we observe that vaccine and vaccine supply is a major expense, followed by routine facility-based service (including training). We also observe that the costs for vehicles was missing, which may underestimate the share of capital costs.

# Sampling Weights

Analysts use sampling weights to get nationally representative values estimate of average weighted facility cost. The sampling weights for each facility’s costs were calculated separately based on inverse probabilities of sampling at each sampling stage.

1. A sample of l regions was selected from a total of L regions in the country, and their probability of selection was = .
2. A sample of n districts was selected from a total of N districts in a region, and their probability of selection was thus = .
3. A sample of m facilities have the probability of being selected from a total of similar health units in the same district (i) was thus .

Thus, the overall probability of selection of a health unit in a district

Therefore, the weight of a sampled health unit was the reciprocal of its probability of being selected:

In Uganda, there 10 regions and 112 districts.

All regions were included in the study and so and that simplifies the sample weights to just being

1. Lira is one of the two districts sampled from the region Mid North of Uganda. This region has 15 districts in total. Assuming Lira has been selected at random and that Lira is representative of Mid North Uganda, how much weight do we need to give to observations from Lira when we include them in estimates that are intended to be nationally representative of Uganda?

Probability of selecting Mid North region = 10/10 =1

Probability of selecting a sample district from the Mid North = 2/15 = 0.13

Weight of the sampled district = 1/0.13 = 7.5

1. Ober is one of the two HC III facilities sampled in Lira. There are 14 HC III facilities in this district. Let us assume that Ober has been selected at random and that Ober is a representative HC III facility in Lira.
   1. How much weight do we need to give to observations from Ober when we include them in estimates that are intended to be representative of Lira district?
   2. What weight should we apply to make Ober’s contribution appropriate for a nationally representative estimate?

a. Probability of selecting a sample HC III facility in Lira = 2/14 = 0.14

Weight of the sampled facility = 1/0.14 = 7.14

b. Probability of selecting a sample HC III facility in Lira = 2/14 = 0.14

Probability of selecting a sample district from Mid North = 2/15 = 0.13

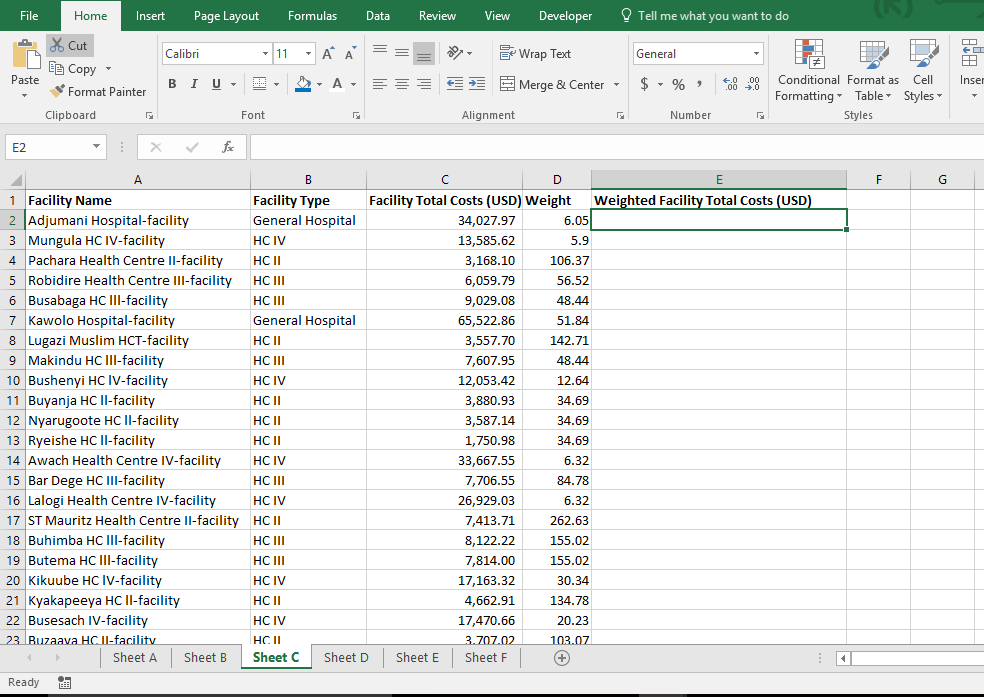
Probability of selecting Ober facility = 0.14 x 0.13 = 0.019

Weight of the sampled facility = 1/0.019 = 52.63

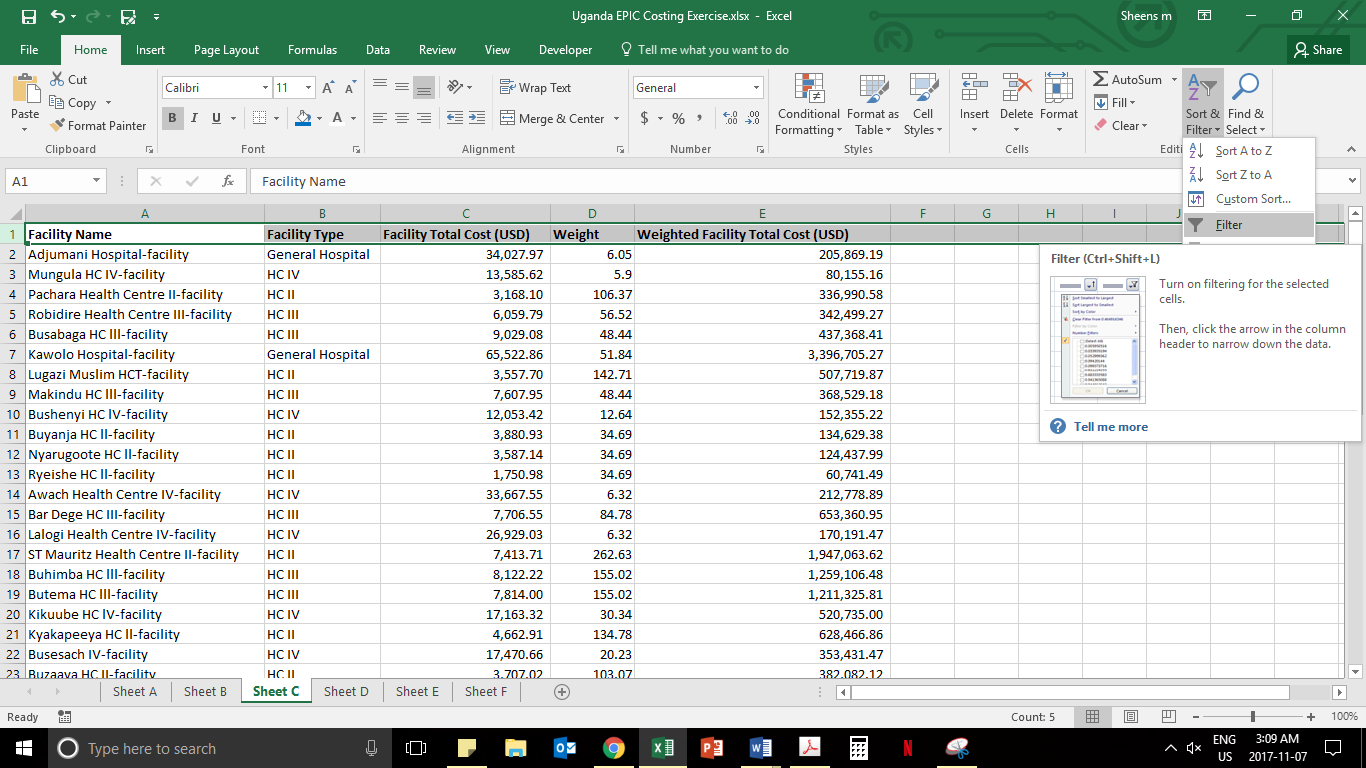
# Making a Properly Weighted Estimate of Total Immunization Costs at Facilities (THF)

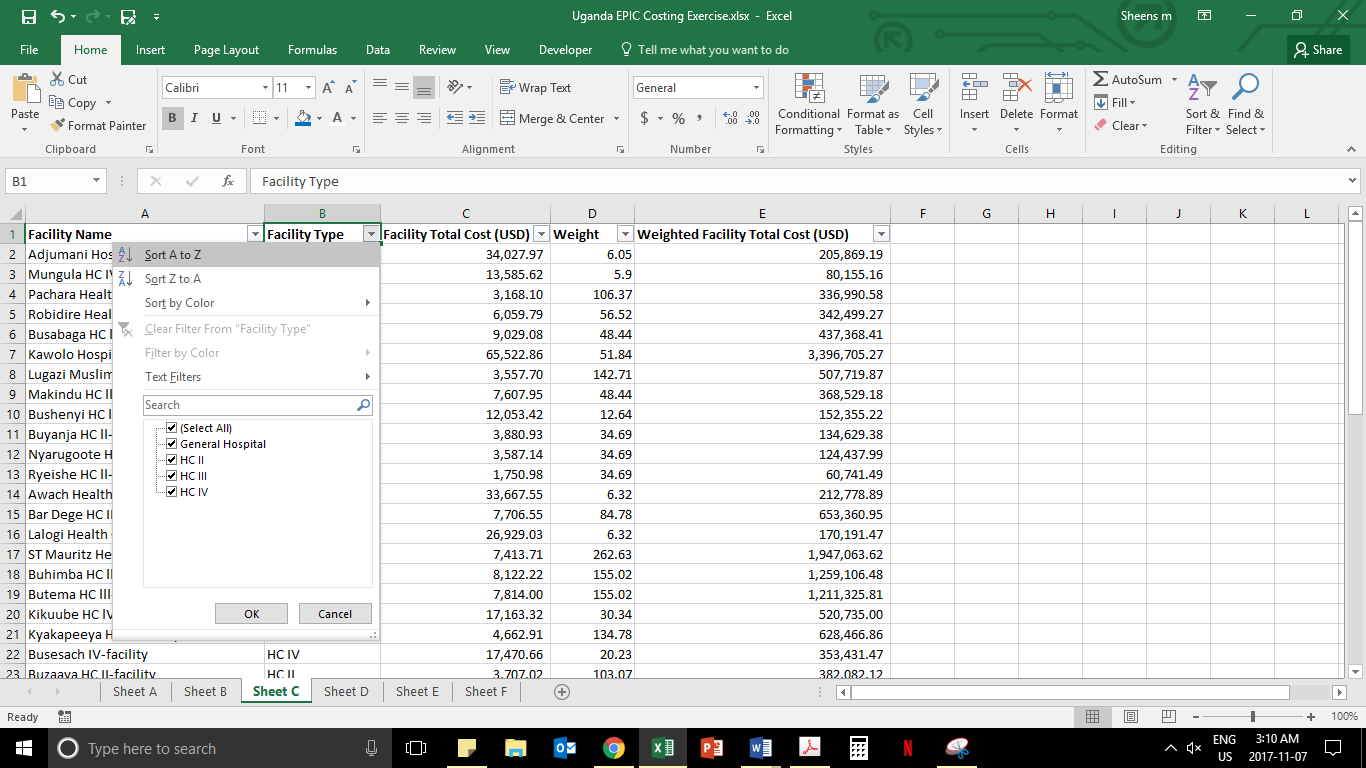
We want to calculate the total cost of carrying out immunization at facilities in Uganda—we want to be able to break this total cost down by the different types of facilities from HC II, HC III all the way to regional hospitals.

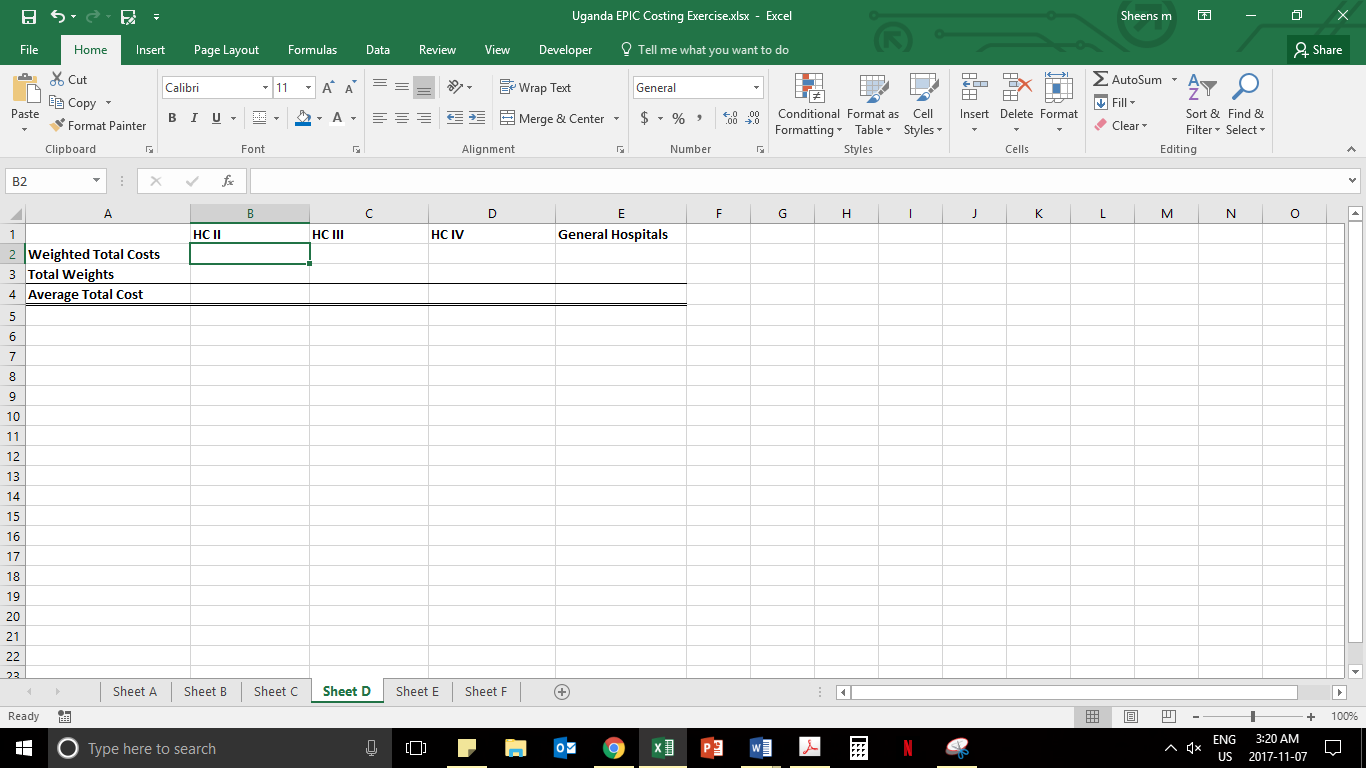
1. Go to Sheet C. Here you will find data on the facility name, facility type, total facility cost and provides the adjusted sample weights of all facilities. In Sheet D, calculate the weighted estimate of total cost for each health facility type that is nationally representative.
   1. For each facility, multiply the total cost with their sample weight in Column E to obtain the weighted facility total cost.

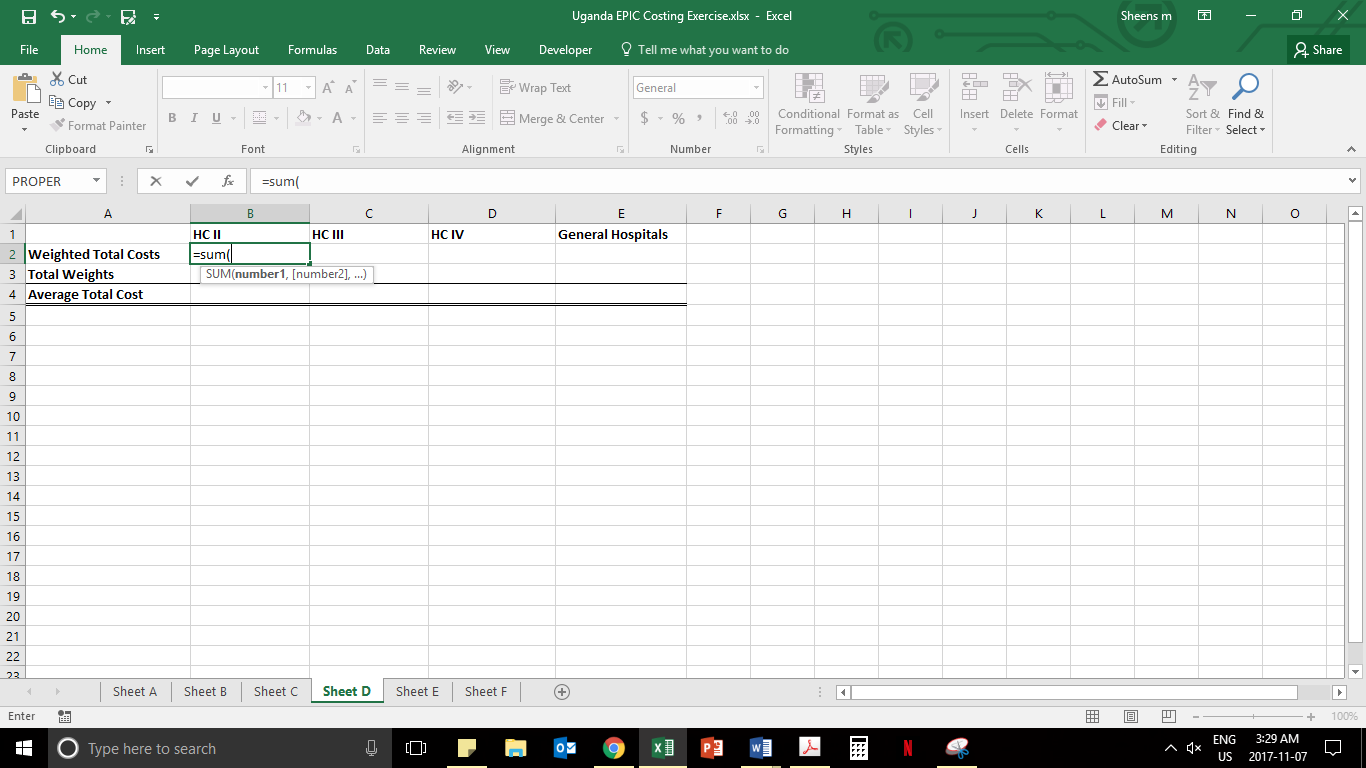
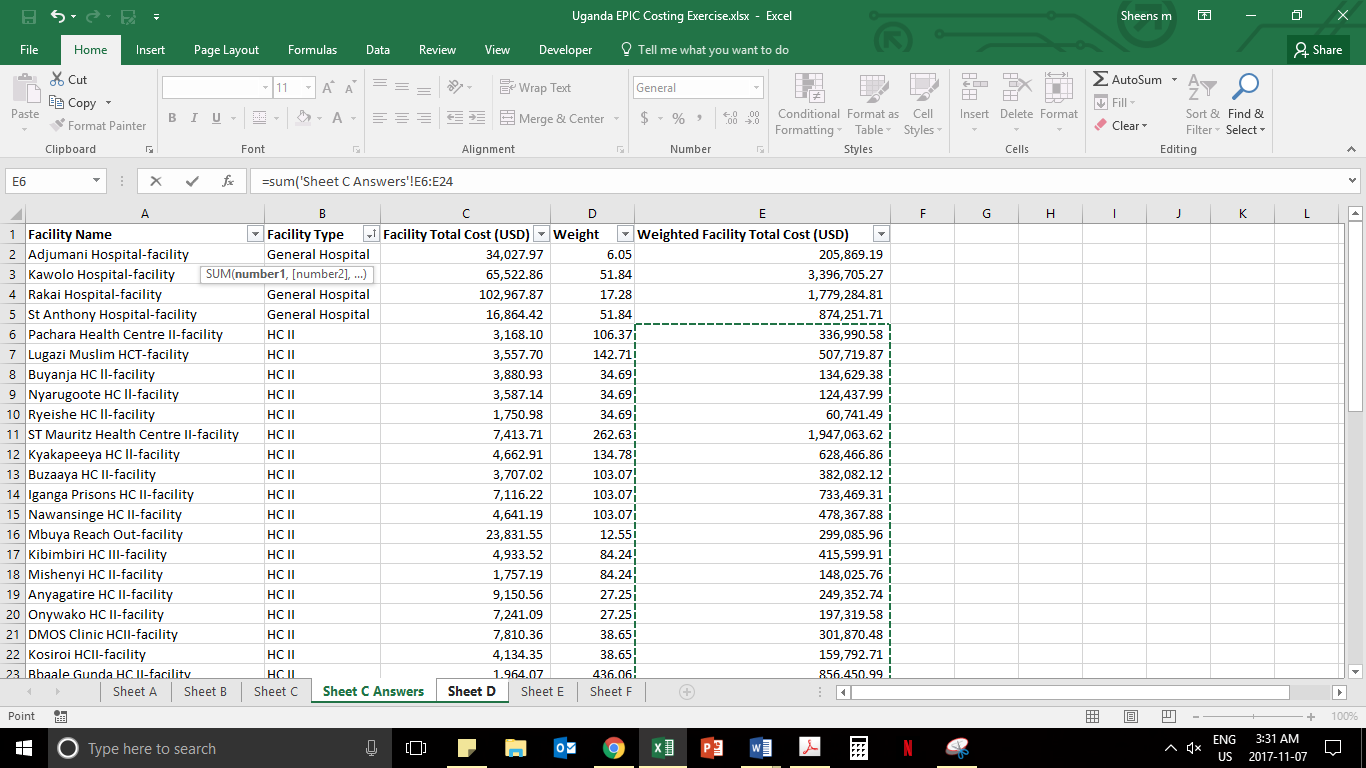


* 1. Select Row 1. Click on Sort & Filter button in the toolbar (on the right-side). Select Filter.



* 1. Click on the drop-down button on the column B header, cell B1. Select Sort A to Z.
  2. Go to Sheet D, where you will Table D-1 set up to calculate average total cost by facility type.



* 1. In cell B2 of Sheet D, sum all the weighted total costs for HC II.
  2. Similarly, in cell B3 of Sheet D, sum all the facility weights for HC II.
  3. In cell B4 of Sheet D, divide the weighted total costs by the sum of the facility weights to obtain the weighted average facility cost for HC II facilities.
  4. Repeat steps *e-g* for other facility types*.*

# Total costs and unit costs of the Ugandan Routine Immunization

The total national cost of routine immunization in Uganda can be calculated as

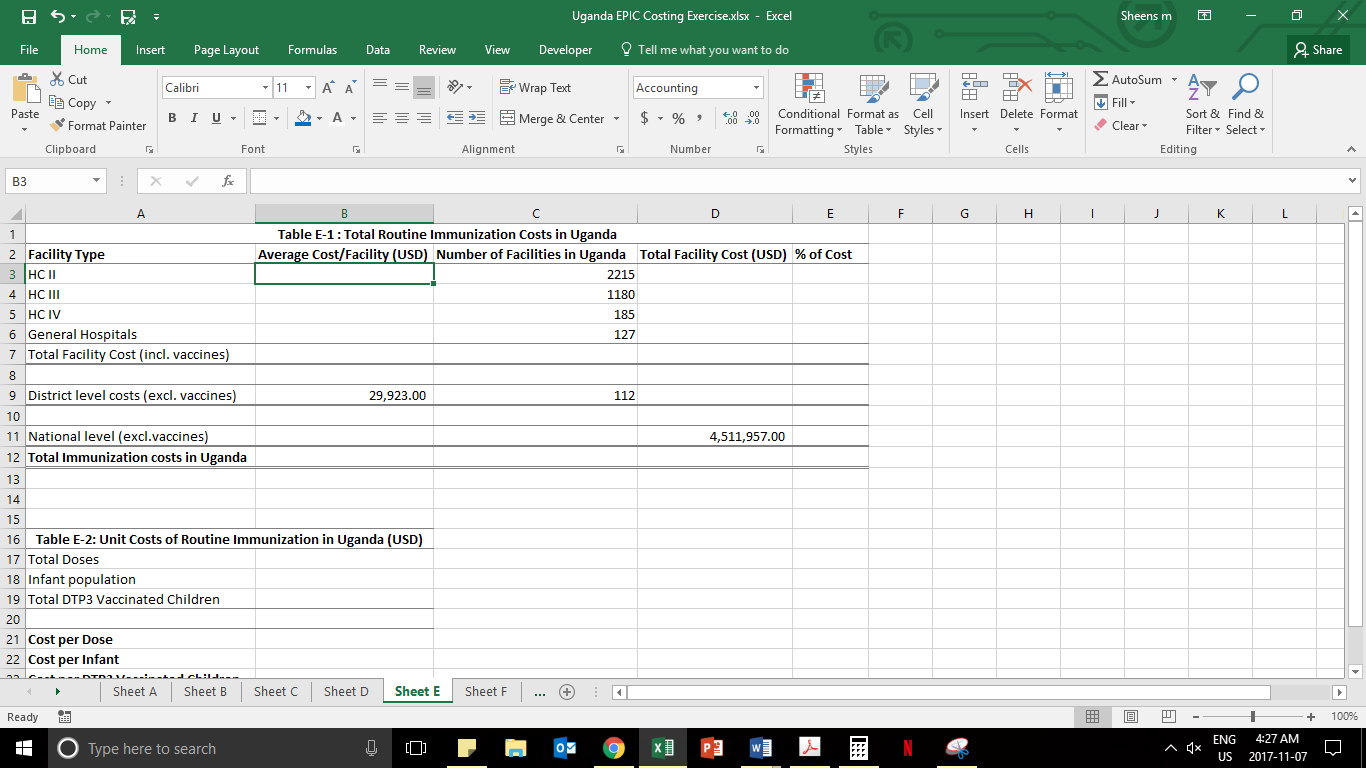
TCountry = THF + TDistrict + TNational

In the previous step we calculated a weighted estimate of the total cost (including vaccines) for each facility type. We apply this to all the same type of facilities in the country. The average total cost of the sampled districts, excluding vaccines, was then applied to all the districts in the country. These aggregated facility and district level estimates were then added to the national level spending (after excluding the national level vaccine costs).

To calculate nationally representative estimates of average cost, we simply divide the total national cost by a denominator. Commonly used denominators are doses, infant population, DTP3 vaccinated children yielding costs per dose, cost per infant, cost per DTP3.

1. Go to Sheet E. Table E-1 is set up to calculate total national routine immunization cost. Table E-2 is set up to calculate unit costs of national routine immunization.

From prior calculations we happen to know that average cost per district-level facility is 29,923 USD and that total central facility cost is 4,511,957 USD. It is also provided that there are 2215 HC II facilities, 1180 HC III facilities, 185 HC IV facilities, 127 General Hospitals and 112 district-level facilities.



1. Complete Column B for the facilities section using the values calculated in the previous step.
2. In Column C, calculate the total facility cost for each row in the facility and district sections.

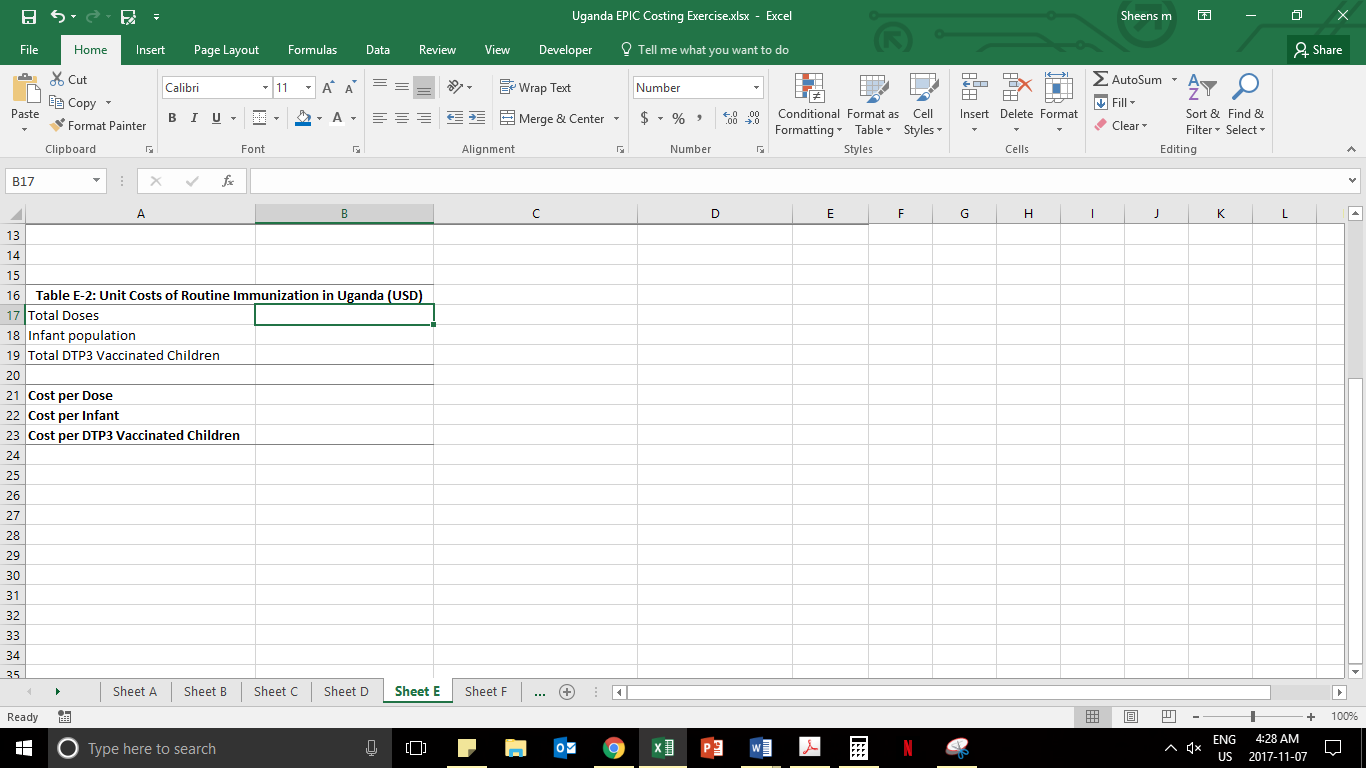
*(Multiply the weighted average total costs with the number of facilities of the same type present in Uganda)*

1. Calculate the total immunization costs in cell D12 (TCountry = THF + TDistrict + TNational).
2. Calculate the share of total cost for each row.
3. What do you observe?

The total costs of routine immunization in Uganda is estimated to be USD 37,799,116.00. The largest share (79%) was incurred at facility level (where the vaccine costs were captured), followed by national level costs (12%, excluding the vaccine costs). The district level only contributed 9% of the total routine immunization cost. Of the facility level costs, the HC II had 29% share of total costs, HC III had 37%, HC IV only 12% and the general hospitals 21%.

The population of Uganda in 2011 was 32,939,800 and the infant population was 1,476,164. The total child doses administered was 11,964,835 and the total DTP3 vaccinated children were 1,219,455. (*Estimates derived from cMYP 2011)*

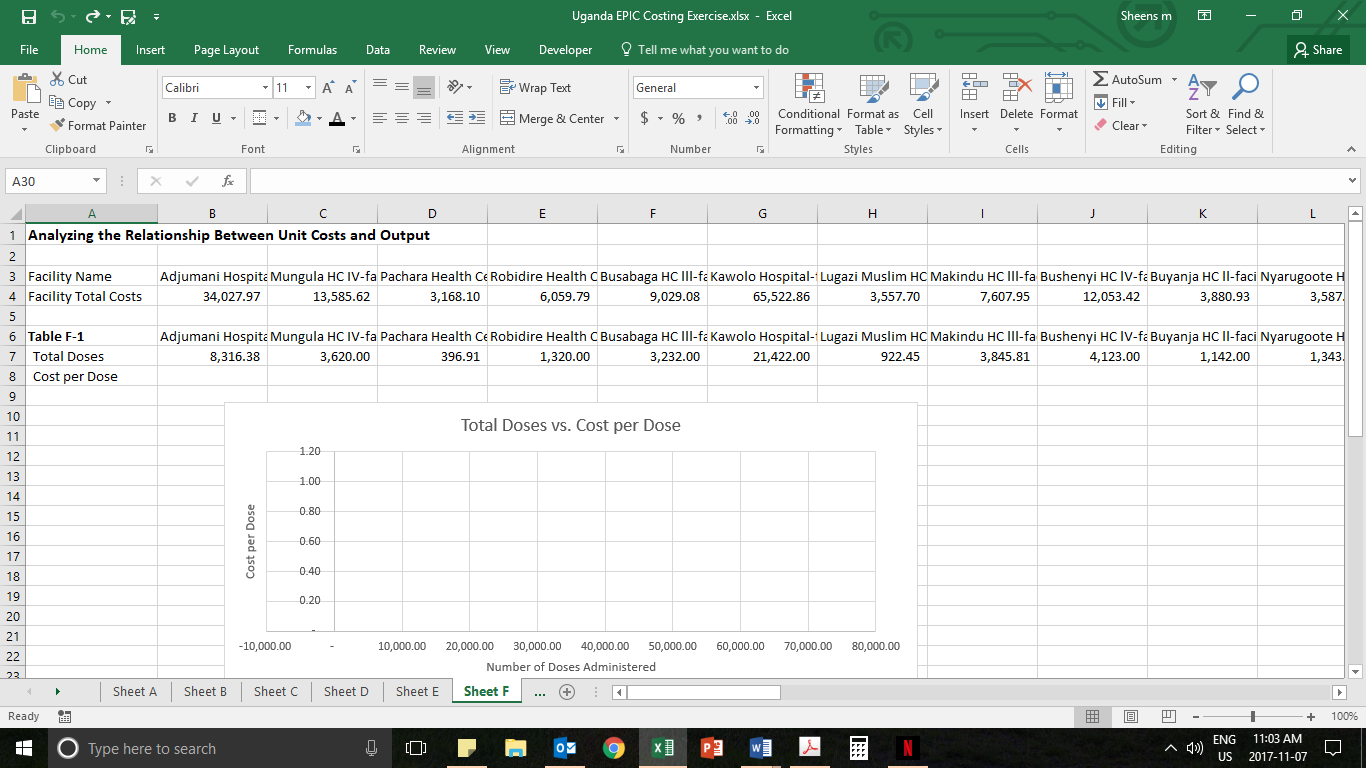
1. Complete the table (Table E-2) below the total cost table in Sheet D with the above estimates.



1. Calculate the cost per dose, cost per infant and cost per DTP3 vaccinated child.

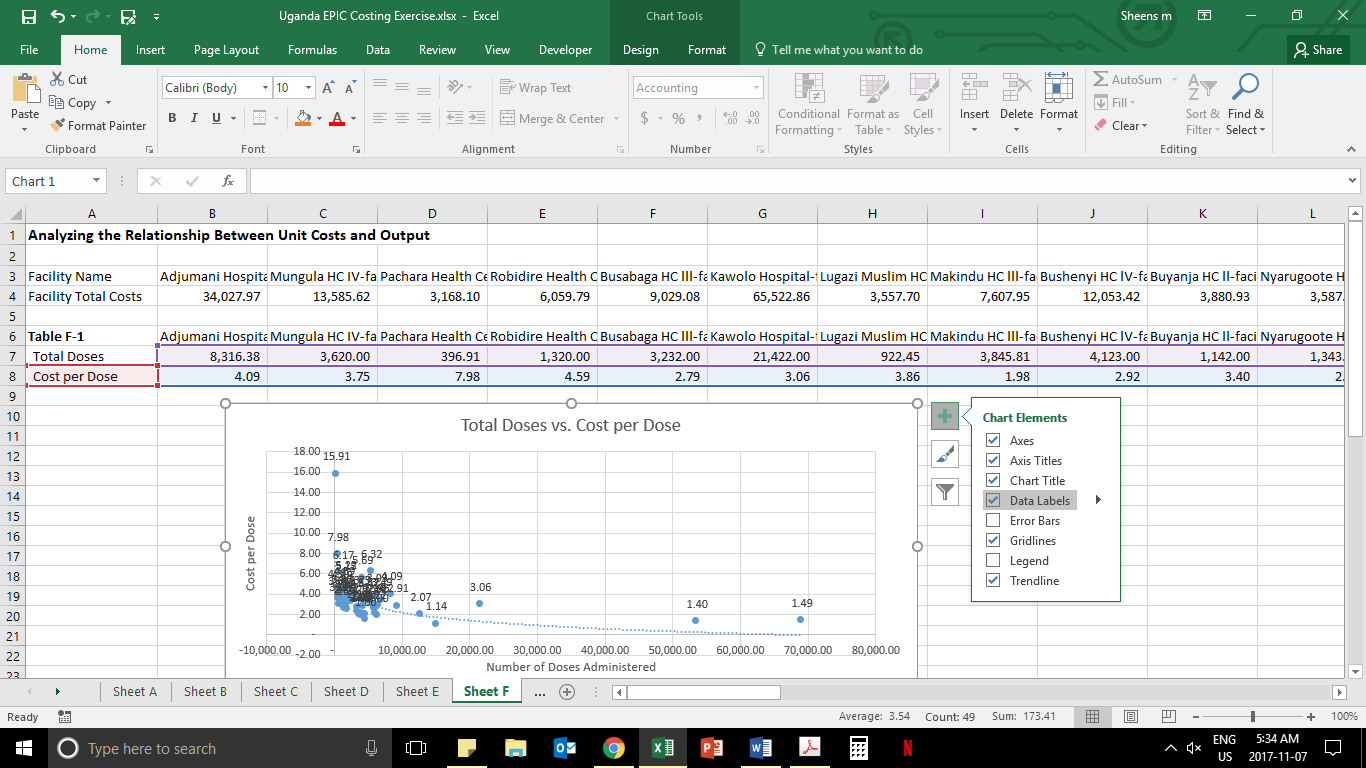
# Analyzing the Relationship Between Unit Costs and Output

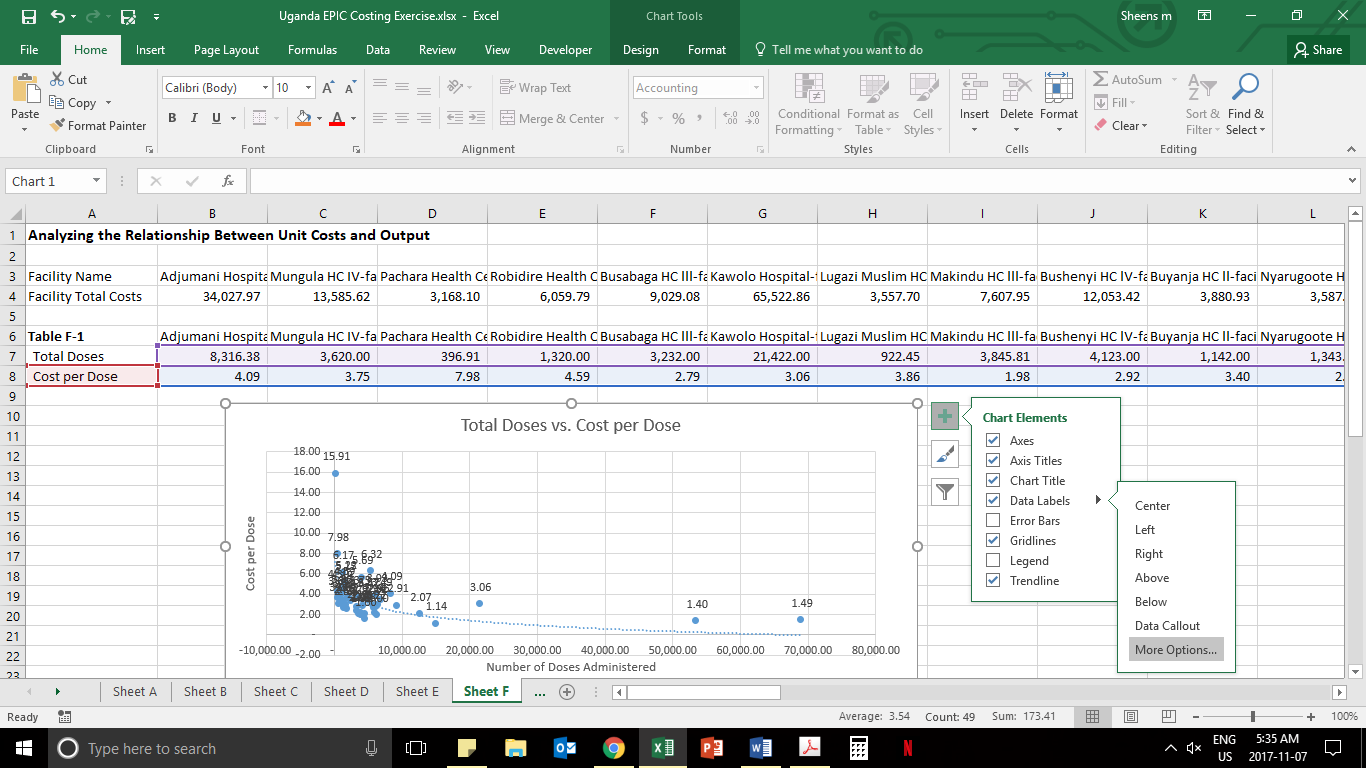
1. Go to Sheet F. For each facility, you are given the total facility cost, total doses administered and total DTP3 vaccinated children.

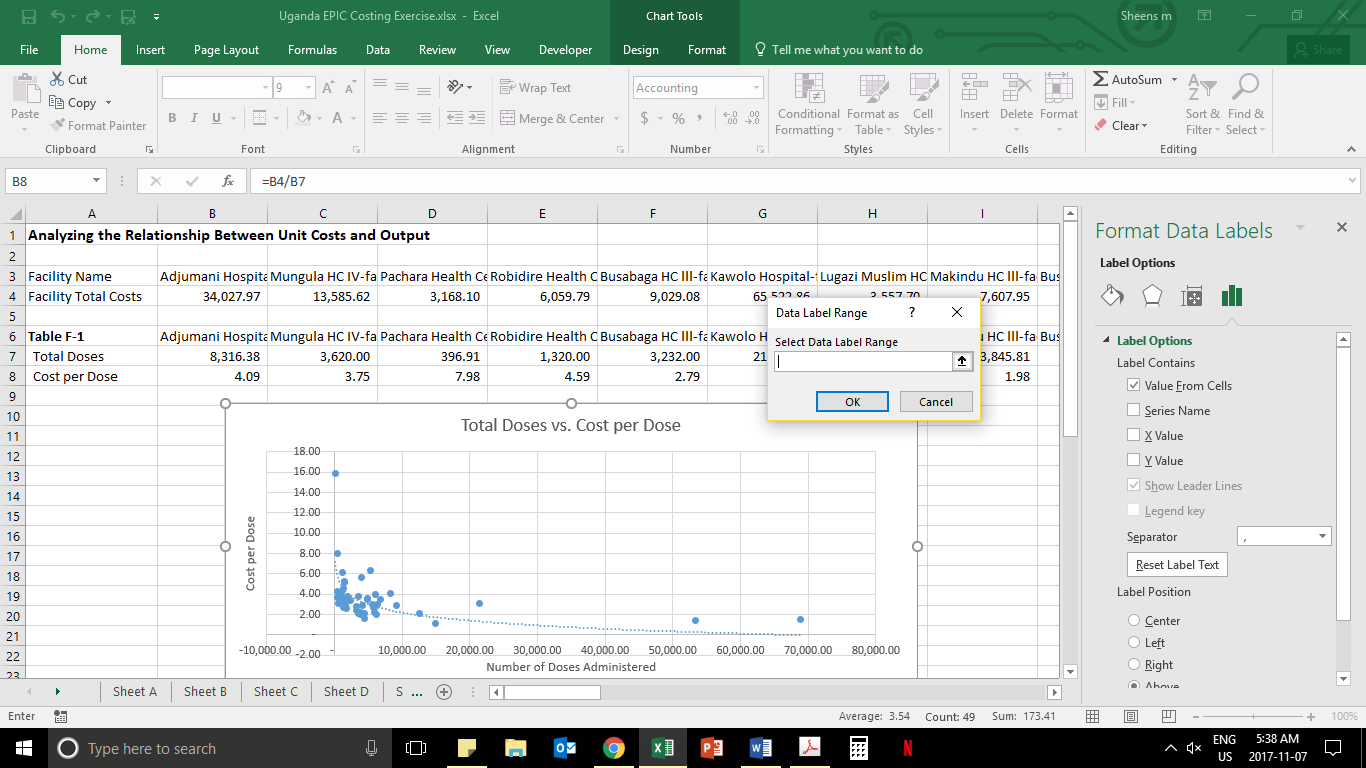


1. In Table F-1, calculate the cost/dose for each facility. *(Tip: Enter the formula in cell B7, select the cell and drag it horizontally to auto-fill the formula in row)*

The graph below the table will plot each data point. To see the facilities corresponding to the data point:

* Click on the green cross and left click on "Add Data Labels".

* Click on the arrow and select click "More Options".
* A new window appears to the right, deselect X and Y Value.
* Enable "Value from cells"



* Select cell range B3:AY3
* Click OK

The graph next to the main graph provides a zoomed-in look at the data points.

1. Can you locate the outliers? What do you observe?

There are 4 observable outliers – Kidoko, Pachara, Kiswa and Rakai. We observe the Kidoko and Pachara have high cost/dose which could be attributed to low output volumes. Kidoko provides immunization only once a month, and Pachara is a hard to reach facility. Kiswa and Rakai have very low cost/dose due to high output volumes.

1. In Table E-2, calculate the cost/DTP3 vaccinated child. Repeat step 21.
2. Can you locate the outliers? What do you observe?

There are 4 observable outliers – Kidoko, St. Mauritz, Kiswa and Rakai. Similar to Q23, we observe the Kidoko and St. Mauritz have high cost/dose which could be attributed to low output volumes. Kiswa and Rakai have very low cost/dose due to high output volumes.

1. What can you say about the relationship between unit costs and output volume?

We observe a strong, non-linear logarithmic relationship between unit costs and output volume. Both unit costs show low values for higher output volumes. The graphs show a steeper curve among facilities with lower outputs, and flatter one among facilities above a certain high threshold of output per annum, but this may be exaggerated by the high volume and high unit cost outliers.

*Discussion Prompt*

1. Mary has analyzed the graphs of unit costs vs. output, and she decided to close down all clinics that have very high unit costs and minimal output. Would you and your team advise Mary to proceed with her decision? Explain you reasoning. *(Think about efficiency vs equity)*

# References

1. Brenzel, Logan, Darwin Young, and Damian G. Walker. "Costs and financing of routine immunization: approach and selected findings of a multi-country study (EPIC)." Vaccine 33 (2015): A13-A20.
2. Guthrie, T., Zikusooka, C., Kwesiga, B., Abewe, C., Lagony, S., Schutte, C., Marinda, E., Humphreys, K., Nombewu, Z., Motlogelwa, K. and Kinghorn, A. (2014). Costing and Financing Analyses of Routine Immunization in Uganda. [online] Health Development for Africa. Available at: https://goo.gl/1jUwSi [Accessed 7 Nov. 2017].