CSEP 590B, Homework 1, Due April 13, 6:30 PM

What is the global requirement for Cold Chain Equipment for a world wide immunization campaign for the Covid-19 virus?

When a vaccine is available for Covid-19, there will almost certainly be a global immunization campaign to ensure that the world's population receives the vaccine. The vaccine will be made available by donors acting through Gavi, the Vaccine Alliance (gavi.org) and organizations such as WHO and UNICEF will support logistics and vaccine roll out.

For this assignment, develop an estimate of the required cold chain equipment to support this massive immunization campaign. There will be a group of people around the world trying to figure this out, so that the necessary upgrades to the vaccine cold chain can be made in time so logistics for the campaign run smoothly.

Here are a set of assumptions you can make:

- Focus on Gavi eligible countries, you can use the list at https://www.gavi.org/types-support/sustainability/eligibility of the 58 countries eligible for Gavi support in 2019.
- The vaccine campaign will take one year, with regular deliveries of the vaccine to the national vaccine warehouse.
- Vaccines will be distributed through a hierarchy of storage facilities, the number of levels will depend on the size of the country.
- Vaccination will be done in a "campaign mode", meaning that everyone in a specific geographic region receives the vaccine at the same time. Over the course of a year, every region must be covered. You may think of the regions as being "districts" (although the size of district does vary from country to country).
- You can make many approximations in your analysis – for example, identify representative countries and extrapolate across the full set of countries.
- You only need to focus on cold storage for vaccines, you do not need to consider the many other logistical issues that need to be managed for a campaign.
- The immunization campaign should target 100% coverage of the population, including all age groups.
- Once installed, refrigerators cannot be moved (in other words, you can't re-use refrigerators in multiple locations).
- The Covid-19 vaccine requires a single dose to give immunity.

For this assignment, you will need to develop an estimate of the total number of cold rooms, and the total number of vaccine refrigerators required for the Covid-19 campaign. You should document the process for coming up with your estimate, including the models of immunization campaigns, models of country cold chains and any numbers you need to rely on. For example, what number do you use for the volume of a single dose of a vaccine. For modelling the storage requirement, you will need to specify the time that vaccines are held at facilities at different levels of the storage hierarchy.

Submit a PDF write up by email to Naveena before 6:30 PM, Monday, April 13. My estimate is that a good solution to this can be done in a four page Word document, and going beyond eight is probably too much detail. The goal of the assignment is to produce an estimate that is plausible to "a constant

factor", and could be refined better access to country data and more refined models of immunization and logistics processes.

Recommended approach: This assignment may look intimidating, and there is a danger of immediately getting overwhelmed with data and details. The best approach is to begin with a simple, abstract approach – just as in introductory physics, one studies point masses and weightless springs (or spherical cows). Start with an abstract country – maybe with a population of 60 million people divided into 150 districts. For the cold chain assume there is a national vaccine store, 5 regional vaccine stores, and 150 district vaccine stores. You will need to determine how vaccine storage is handled within a district for an immunization campaign (maybe the vaccines go to health centers which have a catchment population of 10,000.)

There are some numbers you will need to figure out to make this work. Refrigerator and cold room volumes are easy to find from the WHO PQS list:

https://apps.who.int/immunization_standards/vaccine_quality/pqs_catalogue/index.aspx

Cold rooms are E001 and refrigerators are E003. To simplify things, a standard cold room is 10 cubic meters, and has net vaccine storage of 3000 liters. For vaccine refrigerators, there are many options – but to simplify, assume that you can either use E003/007 (Vestfrost MK 304), 100 Liters storage, or E0033/022 (Vestfrost MK 144), 50 Liters vaccine storage.

The big variable is how big is a dose of Covid-19 vaccine. Of course, no one knows (because it hasn't been invented yet). However, there is lots of information on vaccine volumes. Here is a very interesting document, with far more information than you need:

https://www.who.int/immunization/documents/control/who_ivb_17.06/en/

The key figure you need is the number of cm^3 per dose – and this is given in a table on page 13 for various common vaccines. Note that there is more than a factor of 10 between smallest and largest – so you will need pick a number.

Now that you have an estimate for an abstract country – how do you adapt this to the other countries on the list? India is much bigger, so maybe more analysis and levels are needed. For countries that are close in size (say within a factor of four, either bigger or smaller, maybe you can just scale to population). You might want to do a slightly different analysis for smaller countries or island countries.

Assignment: Develop an estimate for the number of cold rooms and number of vaccine refrigerators that will be needed for a Covid-19 immunization campaign across all 58 Gavi eligible countries. Describe the model for developing the estimate and the assumptions that you make. Submit a PDF write up by email to the TA before 6:30 pm, April 13. Your write up should be about four pages in length.