BA 380N **Anderson** **Homework-5**

SOLUTIONS

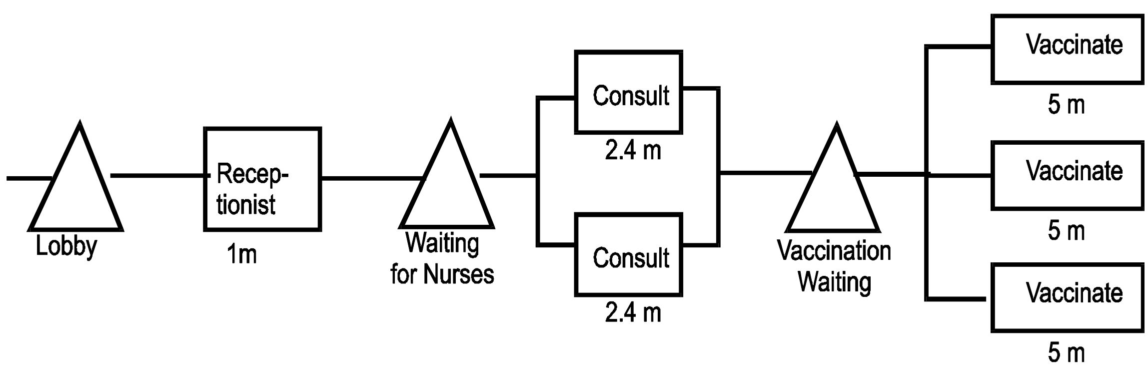
Inventory Buildup Diagrams

The state government has decided to open a clinic in downtown Houston for dispensing the flu vaccine to children from low-income households. The budget is tight and so the process must be as efficient as possible. The program administrator estimates that 450 children will receive vaccinations during each 10 hour day.

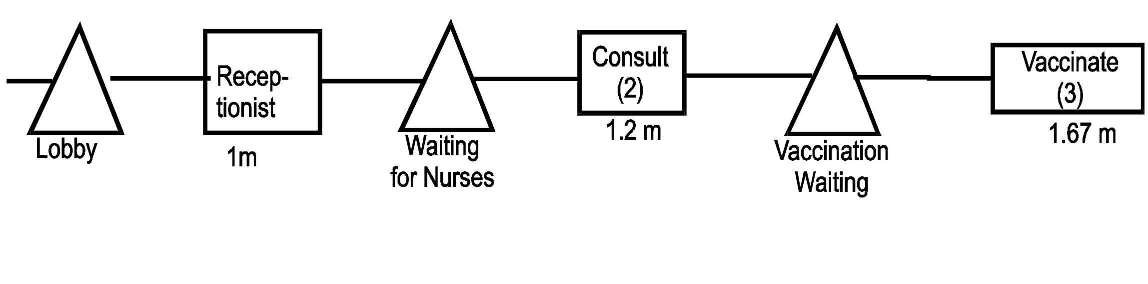
\>> **Hence System Capacity must equal or exceed 45 children/hr**

A child, along with his or her guardian, enters the clinic and waits in the lobby until the receptionist can see them. There is only one receptionist and it takes him about 1 minute to fill out the required form for each child. The next step is to wait for one of the two nurses to become available for drug allergy consultation. Each nurse can handle about 25 patients per hour. After talking with a nurse, the child and his or her guardian go to the vaccination waiting area where three technicians are administering vaccinations. It takes approximately 5 minutes per child to administer the shot.

1. Draw the process flow diagram for the new clinic.



Note that the nurses see 25 patients every 60 mins. This yields a cycle time of 2.4 mins. Note also that the effective cycle time for the two nurses working in parallel is 2.4 m/2 = 1.2 m. Similarly, the vaccinators' effective cycle time working together is 5m/3 = 1.67 m. This means that vaccination is the bottleneck and determines the system capacity of 1 child/1.67 m = 0.6 children/m or 36 children/hr. Shown below in a diagram collapsing together the parallel like tasks.



2. How much waiting do you expect to find in front of the receptionist and the nurses, respectively? Why?

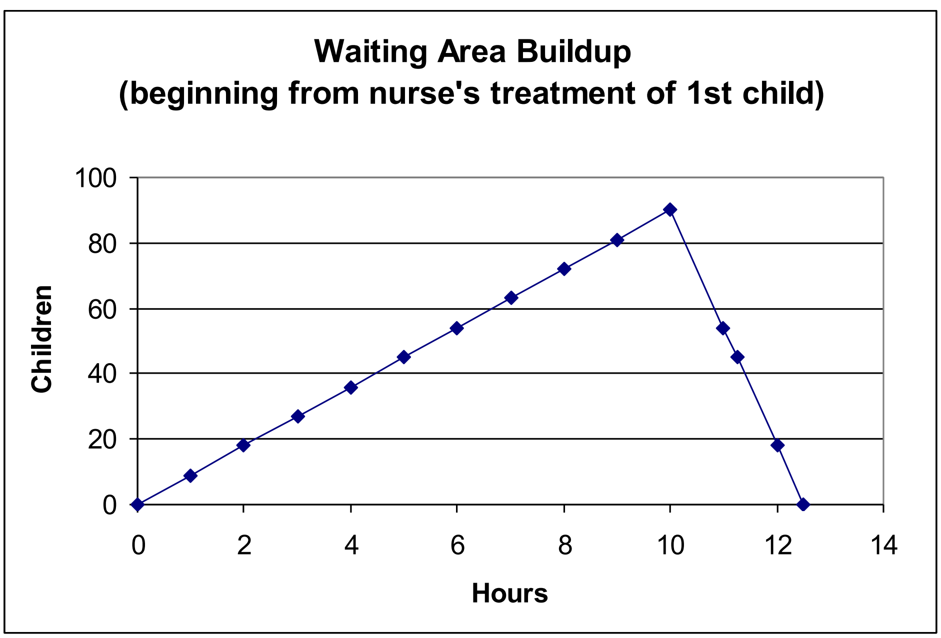
If the arrival rate of the new patients is smooth, there should be no waiting before the nurse and receptionists because their capacities of 60 children/hr and 50 children/hr respectively are greater than the expected arrival rate of 45 children/hr. If, however, there is some lumpiness in the arrival rate, there may occasionally be short lines before the two stations.

3. Do you expect much waiting in the vaccination waiting area? Why?

Yes, quite a bit. The arrival rate is 45 children/hr, which the receptionist and nurses can handle, but the vaccinators cannot. The vaccination rate is 36 children/hour. Hence the line in the waiting area will grow with time at a rate of 9 children/hr until the 10 hour shift ends.

4. Assuming that patients arrive evenly during the day, draw the inventory buildup diagram for children waiting in the vaccination waiting area. How much overtime will the technicians have to work each day?

Once all the vaccinators begin work, children will arrive at vaccination at 45 per hour. They will be vaccinated at 36 per hour. Hence, the build up rate will occur at 45 – 36 = 9 per hour for the 10 hour day. Ultimately the max inventory will be 90 patients. This will take (90 patients)/(36 patients/hr) = 2.5 hrs to work off. Hence the total worktime will be 10 hrs +2.5 hrs to finish off the children in the waiting area. So the overtime will be 2.5 hours per shift per technician.



5. On average, how many people will be waiting in the waiting area? How long?

From the figure above, from time 0 to time 10.0 there are Avg Inv = (Ta + Tb)/2 = 45 children. Similarly there is an avg inventory of 45 children from time 10 to time 12.5, hence the average number of children throughout the shift is 45. Since there is one guardian for each child, the total number of waiting people on average will be 90.

The average exit rate of patients from the vaccinators is 36 children/hr. Including parents, that means the avg. exit rate is 72 people/hr.

Using Little's Law, we know that Avg Wait Time = Avg Inventory/Avg Outflow. So, Avg Wait time = 90 people / (72 people/hr) = 1.25 hours

6. How many seats do you need in the seating area to ensure that everyone (child and guardian) waiting can have a seat at all times during the day?

Remember that there are a maximum of 90 patients waiting. If each of them has a guardian, then you will need a maximum of 2 * 90 seats = 180 seats.

7. What is the significance to the difference between the measures in (5) and (6)? What are the limitations to "average" measures in this context?

Many answers are reasonable here. The maximum time a patient is waiting is 2.5 hours vs. an average of 1.25 hours. The problem with the average is that many patients might balk at a wait time greater than say 90 minutes. (A good operation manager should do some market research and determine the exact "acceptable" wait time by speaking with and observing their behavior in the clinic.) However, let's assume that this 90 minute balking time is accurate. In that case, the average wait time appears acceptable. However, the average will miss the fact that many patients (or their guardians) will find the wait at the end of the day much greater than 90 minutes and leave before getting shots, creating a lack of service that may be unacceptable.

ECONOMICS OF INVENTORY

In class, we discussed the cost of holding inventory for the fishing fleet case. If we have an unlimited freezer size, like in the first example in class, the annual holding cost was $2.57MM per year. If we have a maximum inventory size of 2400 tons, on the other hand, the holding cost was reduced to $975 K. However, there is a fly in the ointment. The smaller freezer size leads to 2.5 extra months of starvation for the cannery and hcnce lowers the economic contribution from canning fish.

1. How much economic contribution was lost because of the smaller freezer size of 2400 Tons? To estimate this, recall that a ton of fish has a variable cost/unit of $2500/Ton when delivered to the Cannery. Furthermore, the cannery then sells

the canned product at a markup of 40% over this initial variable cost. You can neglect the cannery's cost of personnel and capital equipment, etc. for this calculation.

1.5 months of reduced economic contribution results from the cannery only being able to process 600 T/mo rather than their capacity of 3000 T/mo.

Hence,

Lost Econ Contr. = 2.5 mo (3000 T/mo -600T/mon) ($2500/T) (40%)

= $6.0 MM

2. Given the lost economic contribution you just calculated, do you go with having a smaller freezer size of 2400 Tons or not? Why?

   The difference in the annual holding cost from having a larger freezer is $2.57MM - $0.975MM = $1.60MM. This is less than the $6.0MM gained from having the large freezer. So, yes, let's go with the larger freezer size.

3. In the electronics industry, the holding rate is approximately 15% per month or 180% per year (not a typo!). For comparison's sake, repeat the annual holding cost (reminder: annual holding cost = h*C*Iavg) and lost economic contribution calculations with the same demand and supply assumptions as for the fishing fleet: the only difference being that the units you're dealing with are PCs vs. tons of fish. (E.g. instead of having an average of 3425 Tons of fish in inventory, you have 3425 PCs). You can assume the same markup, average inventory, price per unit, months of starvation, maximum inventory size etc. The only difference will be the higher holding rate.

   Because none of the numbers have changed w.r.t. the economic contribution, we will still gain $6.0MM in economic contribution from a larger freezer.

   On the other hand, the holding cost will be different. For the larger freezer:

   Ann. Holding Cost = hCIavg = (180%/yr)($2500/PC)(3425 PCs) = $15.4MM

4. Given the annual holding cost and lost economic contribution results for the PC industry, do you prefer having a smaller warehouse or not? Briefly compare this decision with that for the fishing fleet.

   Recall that for the smaller freezer:

   Ann. Holding Cost = hCIavg = (180%/yr)($2500/PC)(1300 PCs) = $5.85MM

   Hence, moving up to the larger freezer gains you $6MM in economic contribution, but also increases your holding costs by ($15.4MM - $5.85MM) = $9.6MM. Hence, a larger warehouse is a bad idea. Thus, because of the higher holding rate, resulting from depreciation, you would go for a smaller warehouse in electronics than you would for fish.

PREPARATION FOR PROJECT PROPOSALS

The following questions refer to the Concentrated Solar Project Mini-case in your folder. You have been asked to provide several pieces of information for a project proposal (refer to FFMBA, chapter 4 for more information) containing the following pieces of information. (Hint: The project proposal will be written assuming that the project will actually be completed. It is not a proposal for "studying" the CSP project.)

Answers will vary.