CASE STUDY
The Zambia Medical Mission: An Operations Management Perspective

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ABSTRACT: *The Zambia Medical Mission is an annual short term medical mission conducted in the remote bush of southern Zambia, providing medical treatment and ministry to thousands of people each year. Planning and executing this large-scale project embodies many opportunities for application, teaching, and learning of operations management techniques within a Christian mission context.*

INTRODUCTION

It was a hot, dusty July afternoon in rural southern Zambia. Long lines of men, women, and children stretched off into the distance. Jay Starkey was assigned to line control that day. "Where did all these people come from?" There appeared to be a few scattered huts along the way as the convoy of vehicles drove here, but crowds of people emerged all morning from the tall elephant grass. The crowd, estimated at 2,000 people, may have walked for hours or days to seek medical help. It seemed like the people had to wait for hours in the hot sun, including some who were very ill. The clinic's goal was to effectively treat as many people as possible. A process for planning and operating these traveling clinics in the African bush had evolved over about 10 years, but could it be improved? The mission was rife with applications for project management planning and risk assessment, process modeling, and methods improvement to better serve real people with real needs.

BACKGROUND

Zambia is a country in south central Africa about the size of Texas. Dr. David Livingstone was one of the first Europeans to travel in this part of the continent and discovered the great water falls on the Zambezi in 1855 which he renamed in honor of Queen Victoria. The area came under the colonial control of Great Britain in 1888 and remained so until Zambia's independence in 1964. Current estimates of the incidence of HIV/AIDs is about 17% of the population of about 11.5 million, contributing to the limited life expectancy of 40 years (CIA World Fact Book, 2006). According to the UNDP Human Poverty Index scale, Zambia ranks among the poorest nations in the world — 90th poorest out of the103 nations in the index (World Health Organization, 2006). From a business and economic perspective, the primary drivers have been copper mining in the north and agriculture. However, copper market prices are cyclical, and much of sub-Saharan Africa is subject to periodic severe droughts, so neither mining nor agriculture serve as the basis of a long-term thriving economy. The GDP per capita is $900 per year, and unemployment is at 50% (CIA World Fact Book, 2006).

Drs. Kelly Hamby and John Estes from the United States began the first medical mission in the southern province of Zambia in July 1995 using one vehicle and treated 500 people. The mission has since evolved and grown into an annual effort involving about 220 people (120 Americans and 100 Zambians) who are transported several hours out into the bush to provide care for people who otherwise receive little or none. The doctors and their staff offer clinic services in the dry Zambian winter season because vehicles could not travel to the remote sites during the rainy season.

Figure 1: Overview of Clinic Process

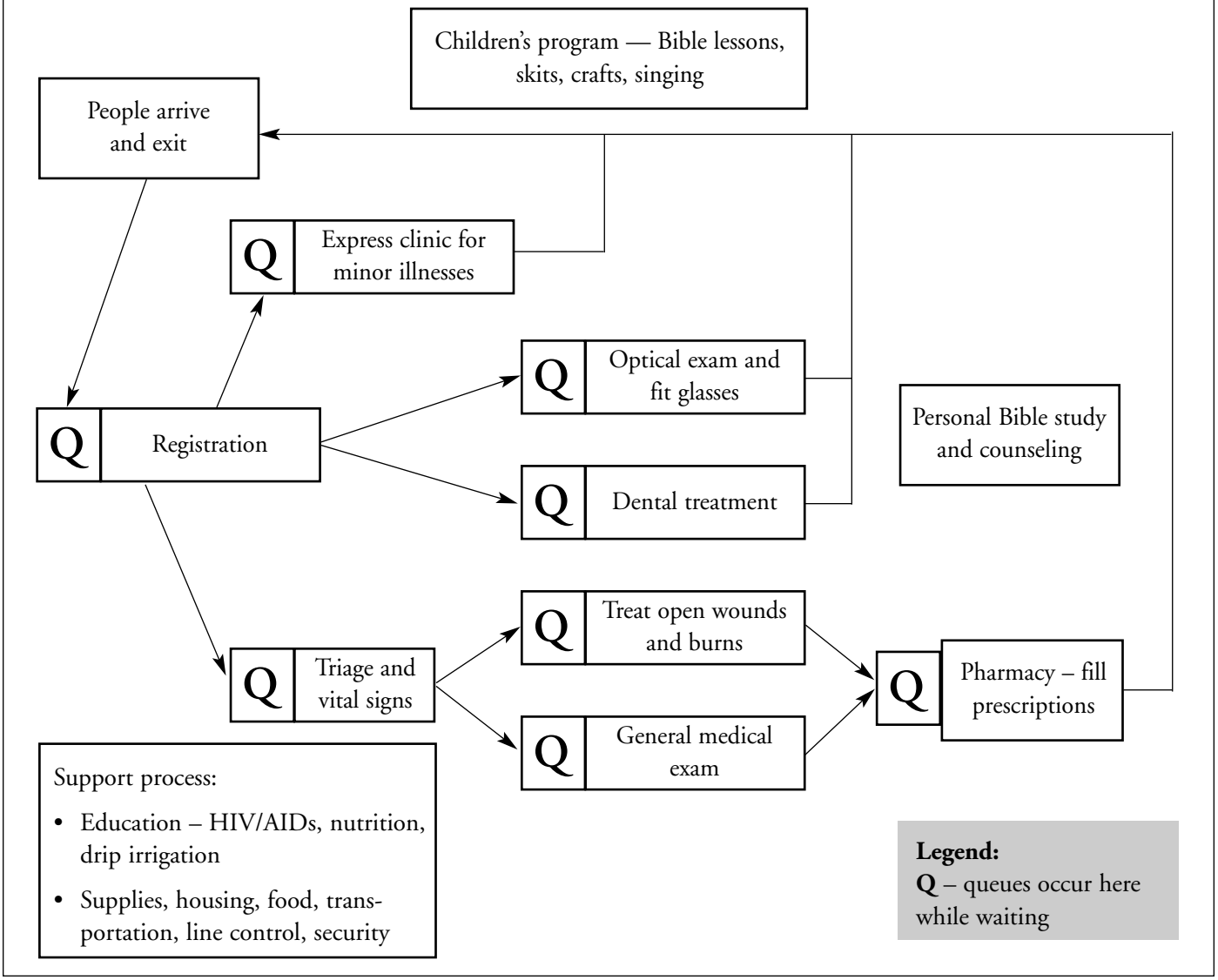


Figure 2: People arriving to the registration queue

Figure 3: Nurse measuring body temperature in the triage process

CLINIC PROCESSES

The overall goal of the clinic is to provide as much quality care and dignity to as many people as possible and help them understand the gospel of the Great Physician. It is essential that the core medical processes be operated as effectively as possible to assist as many people as possible per day. The processes, as summarized in Figure 1, have evolved to include these basic elements:

- Registration to obtain basic information about medical needs and then route the people to the next process. The arrival of people and the registration queue are shown in Figure 2.
- Recording of vital signs (temperature, weight, and blood pressure), as shown in Figure 3. People with fever, very high blood pressure, infants with low weight, or any person with an open wound are taken to the front of waiting lines for medical treatment. Otherwise, the doctors need the information for each patient in determining appropriate medical treatment.
- Express clinic for minor illnesses – many people come to the clinics along with sick relatives who do not require significant medical consultation themselves. These people consult with a nurse who provides vitamins, pain relievers as required, and redirects people with serious health problems to the queue for the general medical exams.
- General medical exams – a core process for the majority of people who come to the clinic. The process includes several parallel stations, each of which has a medical doctor and a nurse/translator. The doctors examine the people, prescribe needed medications, and identify the most severe cases for immediate transportation to an urban medical facility (possibly several hours away) or other medical follow up as needed.
- Wound care for open sores and wounds, leprosy, ringworms, etc. – an area segregated from the other processes because of blood and concerns with HIV/AIDs. The open wound cases are not as common as general medical needs, but require significantly longer time to treat, and may involve surgical procedures.
- Dental care – extraction of teeth and treatment of abscesses, as shown in Figure 4. Each station includes a dentist assisted by a nurse/translator. This area is also segregated from the other processes because of hypodermic needles, blood, and the HIV/AIDs concern. Dental instruments are processed through a series of washing/chemical sanitation steps after each use. Several support staff are required to wash the instruments and prepare injectable medications.

Figure 4: Patient Receiving Dental Care

- Optical exams and eye glasses – patient vision correction needs are measured and eye glasses in inventory are matched up as closely as possible with the correction needed.
- Pharmacy for providing prescribed medications and non-prescription vitamins and pain relievers. Several support staff are required to fill prescriptions from inventory and dispense to the people along with instructions for proper use. Several other team members are engaged full time in counting out pills from large containers into individual plastic bags with quantities of 30-60 pills each as shown in Figure 5.

Figure 5: Pill Counting and Repackaging Process in the Pharmacy

- Bible study and counseling for adults and programs for children – singing, Bible lessons, crafts.

- Teaching for adults in nutrition, HIV/AIDS, drip irrigation, and other topics.

The clinic processes begin treating people at 9 a.m. in the morning. People who have camped nearby overnight immediately form the queue for registration. At about 4 p.m. in the afternoon, if the clinic will not be located at this site the next day, all capacity is diverted to the express process whereby quick consultations are provided, vitamins and pain relievers dispensed, and any immediate life-threatening illnesses identified for emergency treatment.

SUPPORT PROCESSES

The support processes for the mission encompass a series of year-long activities to raise funds, recruit team volunteers, arrange air travel, acquire and maintain land vehicles, solicit pharmaceutical donations, prepare medications and supplies for shipment in containers, and travel to Zambia. Once in Zambia, the entire team (including Zambians) joins together at a mission school at Namwianga (near Kolomo in the southern province) and loads supplies on vehicles for departure to the remote clinic sites. Like a very large version of a family camping trip, provisions must be made for tent housing for personal shelter and clinic processes, food and water, latrines, supplies, power generators and other items needed for 220 people for several days in the bush. During the time periods of clinic operation, non-medical team personnel are busy preparing food, distributing supplies, directing the flow of the crowds of people, providing site security, and disposing of medical wastes.

APPLICATIONS OF OPERATIONS MANAGEMENT TECHNIQUES

There are a number of opportunities for the application of operations management techniques in planning and executing the mission. These include:

- Project Management – planning project tasks using a work breakdown structure (WBS), risk analysis, scheduling, human resource assignment, and budgeting. Figure 6 is a work breakdown structure (WBS) for the medical mission. In addition to project task planning and scheduling, risk assessment is a vital element in ensuring the successful accomplishment of the project's mission. Table 1 provides an example of a Failure Modes and Effects (FMEA) risk analysis. An FMEA analysis identifies categories of risks, the specific type of failure, the degree of severity (using a 1-10 scale with 10 being the most severe), the event probability (using the same scale with 10 being most probable), and the risk event score, which is the product of the severity times the probability. Those potential risk events having the highest score receive special attention ahead of time in developing mitigation plans.
- Simulation Modeling – analysis of the process flows and capacities required to handle the significant volume of people while minimizing wait times and highly utilizing the critical medical skills. Figure 7 shows a snapshot from a simulation model of the clinic processes using the SIMUL8 (2006) simulation modeling software. The simulation model as been used for the following purposes:
  - balance staffing capacity among the various processes,
  - estimate process staffing capacities to accommodate various levels of patient volume, and
  - better understand the waiting times for each process and the span time to get through the entire clinic.
- Process methods improvements – developing effective methods for labor-intensive processes such as loading and unloading trucks, lifting heavy loads (drums of water, trunks of medicine), and counting very large volumes of pills from large bottles into individual packets. The current pill counting method, as shown in Figure 5, is an especially tedious and labor-intensive task, given the overall demand of up to 200,000 pills dispensed in a single day of clinic operation. This task consumes thousands of volunteer hours all year long in preparation for shipment, and during the days of the actual clinic operation.

CASE CONCLUSION

The planning and execution of the Zambia Medical Mission embodies the responsibility of all Christians to effectively allocate resources at our disposal to best serve God's purposes in the world. The complexities of this particular project – the remote location, technical nature of the medical processes, size of the team, and size of the crowds and the severity of their medical and spiritual needs – provide interesting real-life applications for project management, process simulation modeling, methods improvements, and other techniques. The project serves as a reminder of the unique opportunities and responsibilities of students and practitioners of operations management to make a difference in the world – in the name of Jesus Christ.

Figure 6: Work Breakdown Structure (WBS) Example

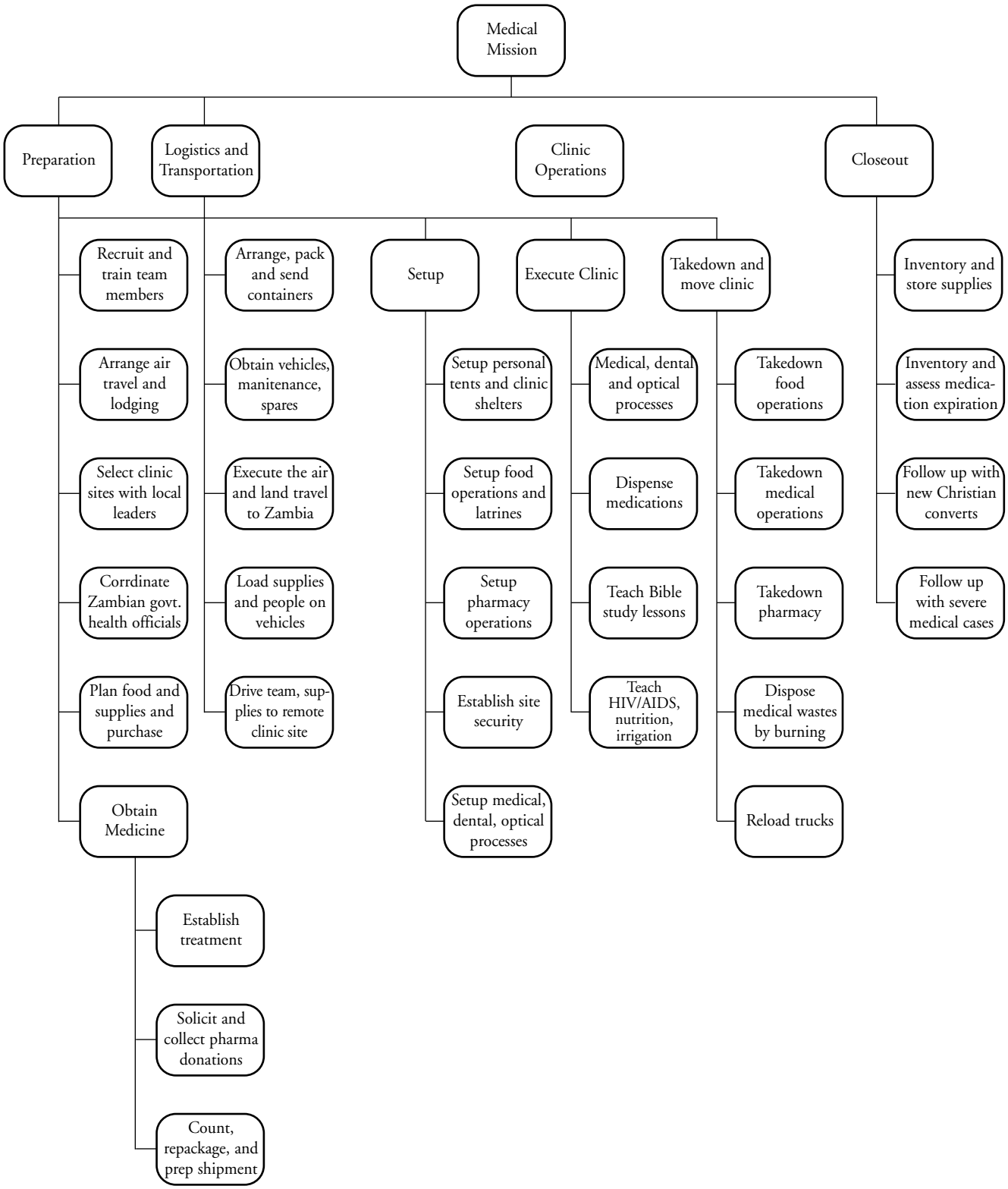
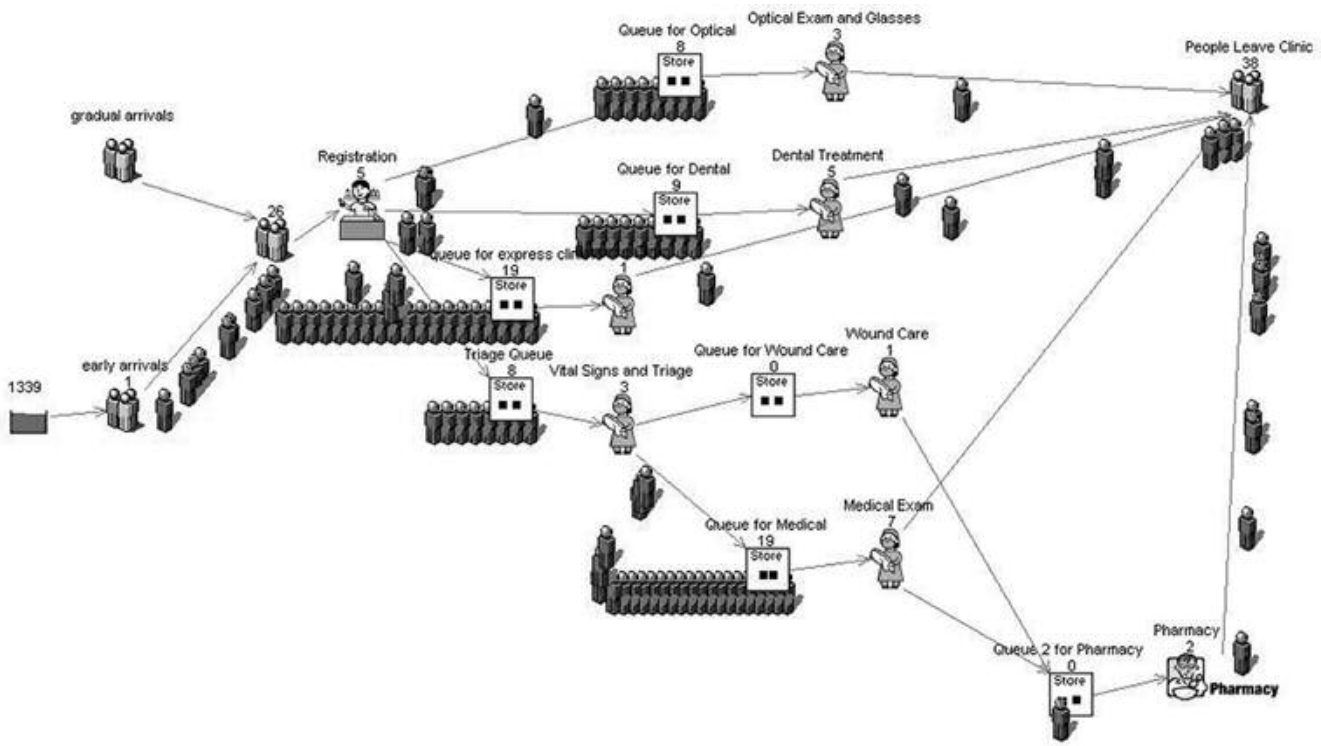


Table 1: Example of Failure Modes and Effects (FMEA) Risk Analysis

Process	Failure Mode	Effect	Severity (10 max)	Probability (10 max)	Score: Prob* Severity	Mitigation
Transportation	Lost luggage	Lack of personal items needed by team	4	8	32	Send as much as possible ahead of time via shipping container. Pack essential items in carry-on back packs.
Transportation	Missed flight connections	Team arrival may be delayed up to 24 hours	5	3	15	Schedule flights with plenty of time between flights to allow for flight schedule variation and collection of large amount of luggage.
Transportation	Vehicle breakdown in rural areas	Late arrival to clinic site	5	7	35	Carry commonly used spare parts and tires. Include a mechanic on the team. Use multiple vehicles.
Logistics	Container late arrival	Lack of food, supplies, and medication	10	3	30	Send container 6 months in advance of clinic operation. Use experienced freight forwarder.
Clinic Operations	Illness among the team	Team members unable to function in clinic operation	8	5	40	Perform infection control, especially in food areas and latrines. Encourage team members to seek immediate medical assistance from team physicians. Require physicals and immunizations before start of clinic.
Clinic Operations	Small crowds in attendance	Fewer people are treated than desired	5	1	5	Effective coordination and communication ahead of time with local officials and village and church leaders
Clinic Operations	Theft of medications or supplies	Supplies or medications unavailable for treatment.	8	6	48	24 hour security from a team comprised of both local villagers and team members.
Clinic Operations	Seriously ill patient not identified or not able to be treated because of waiting	Possible death of patient	10	5	50	Visual check of initial waiting lines for severe cases. At vital signs station, take people with high blood pressure or temperature or low infant weight to front of lines. Zambian team members talk to people in lines to identify worst cases.

Figure 7: Simulation Model of Clinic Processes



TEACHING NOTE

The Zambia Medical Mission has been used to accomplish two overall learning objectives in teaching operations management. The first objective is for the student to acquire a sense of Christian mission in learning and using operations management concepts. I begin the discussion with this question: "What majors on this campus are most directly related to serving God and helping people?" Typical responses include ministry, missions, education, social work, pre-med, etc. In my classroom experience, senior business majors do not perceive their major subject areas and future careers as being significant in God's service in the same way as the other degree programs mentioned. And of all possible business subject areas, operations management (engineering, manufacturing, quality, process modeling, queueing theory, etc.) tends to not fit the student's vision of potential Christian ministry.

My next step in this discussion is to describe the Zambia Medical Mission and show photographs from the Web site (Zambia Medical Mission, 2006). At the conclusion of the photographs and discussion of the mission processes, I ask them if such a complex humanitarian relief project could succeed with only medical doctors and ministers involved in the planning and execution. The answer, of course, is a resounding "no!" A project of this magnitude is absolutely dependent on many types of business expertise:

- Project Management in planning and executing the mission tasks
- Marketing – fund raising, communication, government relations
- Accounting/Finance – funds management, budget planning, international banking
- Operations – clinic design and execution
- Purchasing – food, supplies, medicine
- Human Resource Management – volunteer recruitment, matching skills and personalities to specific jobs, conflict resolution
- Logistics – warehousing, shipping, loading, unloading, vehicle management
- Information Systems – developing data bases and query/reporting for volunteer data, donors, accounting records, and supply inventories

- Facilitie/Equipment Management – planning, acquisition, maintenance

The second overall learning objective facilitated by use of the medical mission example is to understand and properly apply specific operations analysis techniques. The following specific assignments have been used:

Assignment Questions and Discussion

1. Develop a work breakdown structure (WBS) outline of the tasks necessary to execute a medical mission or other humanitarian project in a remote area like the Zambia Medical Mission. Include all aspects of travel, food and housing, and medical care. Develop a project schedule using the Microsoft Project software.
2. Develop a project risk analysis for a large project to build housing for the poor in a city in a developing country in the world using a failure modes and effects (FMEA) format similar to that shown in Table 1. Identify the project tasks with the highest risk score and discuss possible mitigation strategies.
3. Develop a simulation model of the core medical processes (those having a queue) shown in Figure 1 using the process time data summarized in Table 2. Answer questions such as the following:
   - What is the system output in eight hours?
   - What is the average wait time for each process?
   - What is the overall span time in the clinic?
   - What is the effect of variability in process time?
   - What capacity is required for various volumes of people per day?
   - On a more complex level, assess the impact of the lunch break on the throughput of the system. Study the effect of a simultaneous lunch break versus a "rolling lunch break" through various processes.

   Table 3 contains partial results of an analysis of this system using the SIMUL8 (2006) simulation modeling software. The data in Table 3 are not intended to be "the correct answer." They are merely representative of the type of results expected. The students should analyze system behavior under a variety of conditions. Any simulation software package will be sufficient to provide analysis of the clinic processes for the baseline case. In general, increasing process time variability in the model will increase the amount of waiting, which is consistent with queuing theory.
4. Improve process methods for dispensing medications from large containers with 500-1000 pills into plastic bags for individual use, typically containing 30-60 pills as prescribed by a physician. Develop and demonstrate simple (non-electronic) devices to assist in the following steps:
   a. Print information on a sticky label which indicates the type of medication, number of pills, how many to be consumed per day, and the expiration date.
   b. Attach label to a small plastic bag.
   c. Count out the small quantities from the large container.
   d. Place the desired number of pills into the bag and seal.

   Perform a time study on your method and estimate staffing levels, assuming a volume requirement of 200,000 pills per day.

The student response to the use of the medical mission in teaching operations management and project management courses has been very positive. The assignments have proven to be effective learning tools for learning the proper use of project management and simulation modeling techniques. The medical mission example is often mentioned in course evaluations. A number of students have expressed interest in participating in this particular mission or others similar to it. One former student and his wife are participating in the next Zambia Medical Mission.

In addition to the study of operations analytical techniques, another potential use of the medical mission example is to motivate a discussion the application of business skills in economic development and entrepreneurship to help relieve suffering longer term in Africa. Students should research Dr. Livingstone's dream of "Christianity, Commerce, and Civilization," which is inscribed on his statue at Victoria Falls. Livingstone discovered cataracts in the Zambezi that prevented the great river from being the transportation pipeline of commerce into the southern Africa interior that he had envisioned (Dugard, 2003). The students should discuss what obstacles remain to accomplishing Livingstone's dream today, and how business leaders can address these issues in remote areas having little economic infrastructure in place.

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Table 2: Process Data for Simulation Modeling

Process	Average Process Times (all times are distributed exponentially	Capacity for queue and process	Next Destination
Arrival to clinic	Assume that 1,500 people come from nearby or have camped overnight, arrive every .12 minutes. Another type of arrival occurs all day long from people walking in every .6 minutes.		Registration
Registration	1 minute	Queue has unlimited capacity. Process has 5 staff.	10% of people to optical queue, 15% to dental queue, 25% to express clinic queue, and 50% to triage queue.
Express Clinic	1 minute	Queue capacity = 20, process has 1 staff	Exit the clinic.
Triage and Vital Signs	.7 minutes	Queue has capacity = 20, Process has 2 staff	98% enter queue for general medical, 2% enter queue for wound care
Wound Care	20 minutes	Queue capacity = 20, process has 2 staff	Pharmacy queue.
Dental	7 minutes	Queue capacity = 20, process has 5 staff	Exit the clinic.
Optical	7 minutes	Queue capacity = 20, process has 3 staff	Exit the clinic.
Medical Exams	4 minutes	Queue capacity = 200, process has 7 doctors	Pharmacy queue.
Pharmacy	2 minutes	Queue capacity unlimited, process has 3 staff	Exit the clinic.

Table 3: Example Results of Simulation Analysis

Process	Volume of Patients Completed in Eight Hours	Capacity Utilization	Average Waiting Times in Queue
Registration	2,065	4.95 out of 5	115 min.
Express Clinic	505	.78 out of 1	23 min.
Triage and Vital Signs	1,029	2.2 out of 3	1.8 min.
Optical	204	2.94 out of 3	38 min.
Dental	289	4.45 out of 5	36 min.
Wound Care	25	1.1 out of 2	10 min.
General Medical	855	6.85 out of 7	35 min.
Pharmacy	792	3.36 out of 4	1.9 min.
Exit the Clinic	1,854		Total time in system = avg 223 min. with standard deviation = 125 min.

Teaching Resources

Photographs of the medical mission from several years of operation are available at Zambia Medical Mission (2006). The photographs add rich content and motivation to the class discussion. A PowerPoint presentation is available from the author upon request. Information about the SIMUL8 (2006) software is available at their Web site. There are several other such simulation software packages available.

REFERENCES

CIA World Fact Book (2006). Retrieved, November 16, 2006, from https://www.cia.gov/cia/publications/factbook/geos/za.html

Simul8 (2006). Retrieved, November 16, 2006, from www.simul8om

World Health Organization (2006). Retrieved, November 16, 2006, from www.who.int/hac/crises/zmb/en/

Dugard, M. (2003). *Into Africa: the epic adventures of Stanley & Livingstone.* Doubleday.

Zambia Medical Mission (2006). Retrieved, November 16, 2006, from www.zambiamission.org