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SPECIAL CONTRIBUTION

Optimizing Clinical Operations as Part of a Global Emergency Medicine Initiative in Kumasi, Ghana: Application of Lean Manufacturing Principals to Low-resource Health Systems

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Abstract

Background: Although many global health programs focus on providing clinical care or medical education, improving clinical operations can have a significant effect on patient care delivery, especially in developing health systems without high-level operations management. Lean manufacturing techniques have been effective in decreasing emergency department (ED) length of stay, patient waiting times, numbers of patients leaving without being seen, and door-to-balloon times for ST-elevation myocardial infarction in developed health systems, but use of Lean in low to middle income countries with developing emergency medicine (EM) systems has not been well characterized.

Objectives: To describe the application of Lean manufacturing techniques to improve clinical operations at Komfo Anokye Teaching Hospital (KATH) in Ghana and to identify key lessons learned to aid future global EM initiatives.

Methods: A 3-week Lean improvement program focused on the hospital admissions process at KATH was completed by a 14-person team in six stages: problem definition, scope of project planning, value stream mapping, root cause analysis, future state planning, and implementation planning.

Results: The authors identified eight lessons learned during our use of Lean to optimize the operations of an ED in a global health setting: 1) the Lean process aided in building a partnership with Ghanaian colleagues; 2) obtaining and maintaining senior institutional support is necessary and challenging; 3) addressing power differences among the team to obtain feedback from all team members is critical to successful Lean analysis; 4) choosing a manageable initial project is critical to influence long-term Lean use in a new environment; 5) data intensive Lean tools can be adapted and are effective in a less resourced health system; 6) several Lean tools focused on team problem-solving techniques worked well in a low-resource system without modification; 7) using Lean highlighted that important changes do not require an influx of resources; and 8) despite different levels of resources, root causes of system inefficiencies are often similar across health care systems, but require unique solutions appropriate to the clinical setting.

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Conclusions: Lean manufacturing techniques can be successfully adapted for use in developing health systems. Lessons learned from this Lean project will aid future introduction of advanced operations management techniques in low- to middle-income countries.

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Academic emergency departments (EDs) are becoming increasingly involved in global health initiatives that seek to improve the care of injured and acutely ill patients[1,2] in countries where emergency medicine (EM) systems are underdeveloped.[3] These health systems are interested in establishing long-term partnerships that collaborate on optimizing all aspects of the medical system, including medical education, health systems development, and improved patient care. Although most global EM initiatives provide bedside care and clinical education that serves as a short-term stopgap for human capacity deficits, many fall short of long-term, sustainable systems change. As academic centers become more involved in global health, building programs that emphasize optimization of health care delivery systems will help demonstrate a broader commitment to developing countries. This in turn will strengthen mutually beneficial global health partnerships. EM has a natural role to play in these global health partnerships and confronting the challenge of optimizing the delivery of acute care.

Emergency department operations management and research methods are gaining acceptance in U.S. academic institutions as a means of applying manufacturing concepts to the health care system to decrease variation in health care delivery, improve the quality of patient care, and decrease overall health care costs.[4–6] Understanding and optimizing measures such as patient arrival patterns, occupancy level, length of stay, and time until seen by a nurse or physician aid in improving clinical operations and patient satisfaction. Private industry has led the way in using operations management tools such as Lean management, six sigma, queuing theory, statistical process control, and mathematical simulation modeling to improve industrial operations. Recently, these tools have been applied to improve the dynamic setting of EM and have demonstrated success in improving ED patient care metrics.[4,7–13]

Lean process improvement, one of the operational tools that has increasingly been applied to the ED, was developed in post–World War II Japan by Toyota's plant manager, Taiichi Ohno, for use in process development and improvement in Toyota's production system.[14,15] These techniques were studied and designated as ''Lean techniques'' by Womack and Jones in their MIT review of Toyota, *The Machine That Changed the World*. Lean techniques use the scientific method to eliminate wasted steps from production processes while focusing on only those aspects of the process that add value to the customer. Lean improvement projects employ a three-step process: 1) observation and documentation of the current state of operations using frontline workers involved in the process; 2) analysis of the waste within the current state and root causes for system inefficiencies; and 3) redesign, testing, and implementation of a future state. The goal of Lean implementation is for workers to adopt the core philosophy of continuous process improvement and function as empowered agents of change, conducting process improvement throughout the organization.[10,11,14–16] Lean has been effective in improving patient satisfaction scores as well as decreasing important ED metrics of care, including ED length of stay, patient waiting times, numbers of patients leaving without being seen, and door-to-balloon times for ST-elevation myocardial infarction.[10–13]

While operations management principles and Lean methodology have demonstrated success improving ED operations in many developed countries, use of these techniques in developing country health care systems has been limited. Previous international EM programs have identified clinical operational development as a key early intervention for the success of these global initiatives[17–19] but the current literature offers little guidance on successful tools for improvement of clinical operations in this unique setting. In our investigation, we sought to: 1) describe how Lean methodology can be applied to improve clinical operations for hospital admissions at Komfo Anokye Teaching Hospital (KATH) and 2) identify key lessons learned from our application of these operational management tools in the global health setting to aid future academic institutions involved in similar global health medical education and system development programs.

APPLYING LEAN METHODOLOGY AT KATH

University of Michigan–Ghana EM Partnership

In 2008, the Ghana College of Physicians and Surgeons approached the University of Michigan department of EM to assist with the development of EM as a recognized medical specialty in Ghana. This led to the formation of the Ghana EM Collaborative, a partnership between University of Michigan, Ghana College of Physicians and Surgeons, Ministry of Health, Kwame Nkrumah University of Science and Technology, and KATH to develop residency and nurse training programs. EM residents began training in October 2009 at KATH. As part of the development of a residency training program, clinical operational improvements have been a critical focus.

KATH is the major tertiary care center in the Ashanti region of Ghana. The capital city of this region, Kumasi, is the second largest city in Ghana. KATH has more than 800 hospital beds and serves as the principal referral hospital for the northern two-thirds of Ghana.[20] A new state-of-the-art accident and emergency center for the management of traumatic injuries and acute

medical emergencies was constructed in 2008, and the first floor has been operating as an ED since May 2009.

The Lean project was conducted as a 3-week ''kaizen event,'' a Japanese term for a workshop that engages a cross-functional team to improve a designated process within the organization while educating the team members about Lean methods and concepts. After initial educational sessions, team members analyzed the current hospital admissions process using the step-by-step process outlined in Table 1. The steps of the process outlined include problem definition (Figure 1), scope of project definition (Figure 2), value stream mapping (Figure 3), root cause analysis (Figure 4A and B), and future state planning (Figure 5). Each daily session began with a short educational lecture about Lean tools, followed by use of these tools to address the next step of the Lean process. The hospital admissions process was chosen for review by KATH medical leadership after suggestion by the KATH business manager because it represented an example of a significant challenge to their current clinical operations and one that they expected would need modification as EM was introduced into the clinical facility. The lessons learned are observations that resulted from debriefing sessions

Table 1
Lean Admissions Project at KATH

Step	Activities
Lean team formation	After approval by medical director and CEO, 14-person Lean team was formed from various hospital departments: • Three EM residents • Three EM nurses • EM pharmacist • EM accountant • EM business manager • ICU nurse • Internal medicine resident • Ward nurse • Medicine consultant • Surgical resident • UM EM faculty facilitator
Problem definition	Hospital admissions process identified as a problem in current system. Team members defined process characteristics (Figure 1). Key metrics identified to define the admissions process: • Lead time = time physician decision for admit to arrival on ward ■ Average lead time = 13 hours–data collected in small project during week 1 of Lean project • Number of patients remaining in the ED at shift change after an admission order was completed Lean team defined institutional standard for the lead time: • Patients should be transferred to an available bed within 1 hour of the decision to admit to an inpatient ward Project goal defined to move closer to institutional standard: • Decrease the number of patients waiting longer than 1 hour by 50% within the next 12 months
Defining the scope	Use of SIPOC tool (Figure 2) to define the scope of the Lean analysis of the admissions process and identify any additional team members to add to the current team.
Value stream mapping	• Current state of process extensively mapped by team ■ Physical flow of patients within institution ■ Information flow among staff within institution • ''Gemba waste walks'' performed to observe current process and help identify wasted steps • Team identified waste (Table 2) within process and labeled the waste on the value stream map (Figure 3)
Root cause analysis	• ''Forced prioritization matrix'' was used to determine complex problems within the process that should be examined in detail by root cause analysis • Root cause analysis using standard Lean tools (Figure 4): ■ ''Five whys'' questions asking method ■ ''Ishikawa fishbone diagrams''
Future state planning	• Brainstorming sessions used to develop solutions • New future state developed with goal of creating a single flow system that addressed root causes of problems and eliminated wasted steps (Figure 5)
A3 summary document and implementation plan	• Team summarized all aspects of the process visually • Detailed implementation plan was constructed to guide each step of the transition phase • Team members were assigned tasks to ensure completion of transition to future state • Final report submitted to CEO/medical director

CEO = chief executive officer; ICU = intensive care unit; KATH = Komfo Anokye Teaching Hospital; SIPOC = supplies-inputs-process-outputs-customers; UM = University of Michigan.

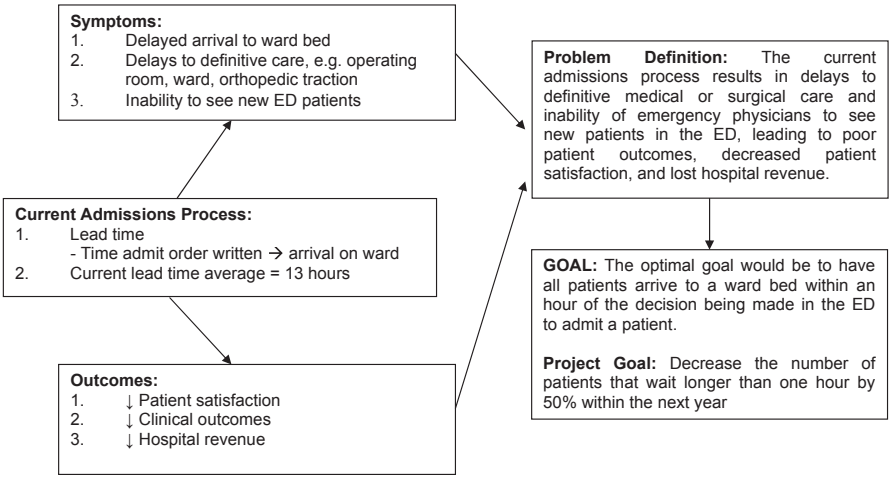


Figure 1. Lean problem definition for admissions process at KATH. KATH = Komfo Anokye teaching Hospital.

High Level Value Stream: Admissions Process

Suppliers	Inputs	Process Steps	Outputs	Customers
Patients	Patient	Admit order initiation process	Physician order in patient folder	
Emergency physician	Admit order	Pharmacy process	Patient medications	
Emergency RN	Pharmacy order			
Healthcare associates	Billing form	Billing process	Patient bill	Patients
Porters	Patient bill		Money	In-patient wards
Revenue collector	Bed order	Bed acquisition process	Ward location	In-patient physicians and surgeons
Pharmacist	Ward location			
	Transfer order	Transport process	Patient arrival to ward	
	Trolley for transport			
	Patient	Admit ward accepts patient	Patient	

Figure 2. SIPOC: scope-of-work tool for Lean admissions process at KATH. KATH = Komfo Anokye teaching Hospital; SIPOC = supplies-inputs-process-outputs-customers.

with individual team members and discussion between the University of Michigan Lean facilitator and KATH project leader after completion of the initial phases of the project.

EIGHT LESSONS LEARNED IN THE PROCESS OF ADAPTING LEAN PRINCIPLES TO A GLOBAL HEALTH SETTING

1. The Lean Process Aided in Building a Partnership With Ghanaian Colleagues

We found that employing the Lean process strengthened the developing KATH–University of Michigan academic partnership by emphasizing team-based solutions that accounted for KATH health care system priorities. Using a multidisciplinary team approach that focused on worker-identified systems issues and solutions is the hallmark of the Lean process and was very effective at identifying both the problems to be addressed and the solutions appropriate to the clinical setting. This approach reassured hospital leadership that their health system priorities were being addressed and has generated enthusiasm for further interventions. This approach also avoids a common pitfall in development programs where collaborators attempt to directly transfer resource-intensive processes that work in their clinical setting to a low-resource setting where they subsequently fail to work.

In addition to strengthening the high-level institutional partnership, we found that Lean was effective at developing relationships with Ghanaian colleagues within EM and other departments at KATH. Team members were receptive to the inclusion of various medical providers and nonclinical workers from a

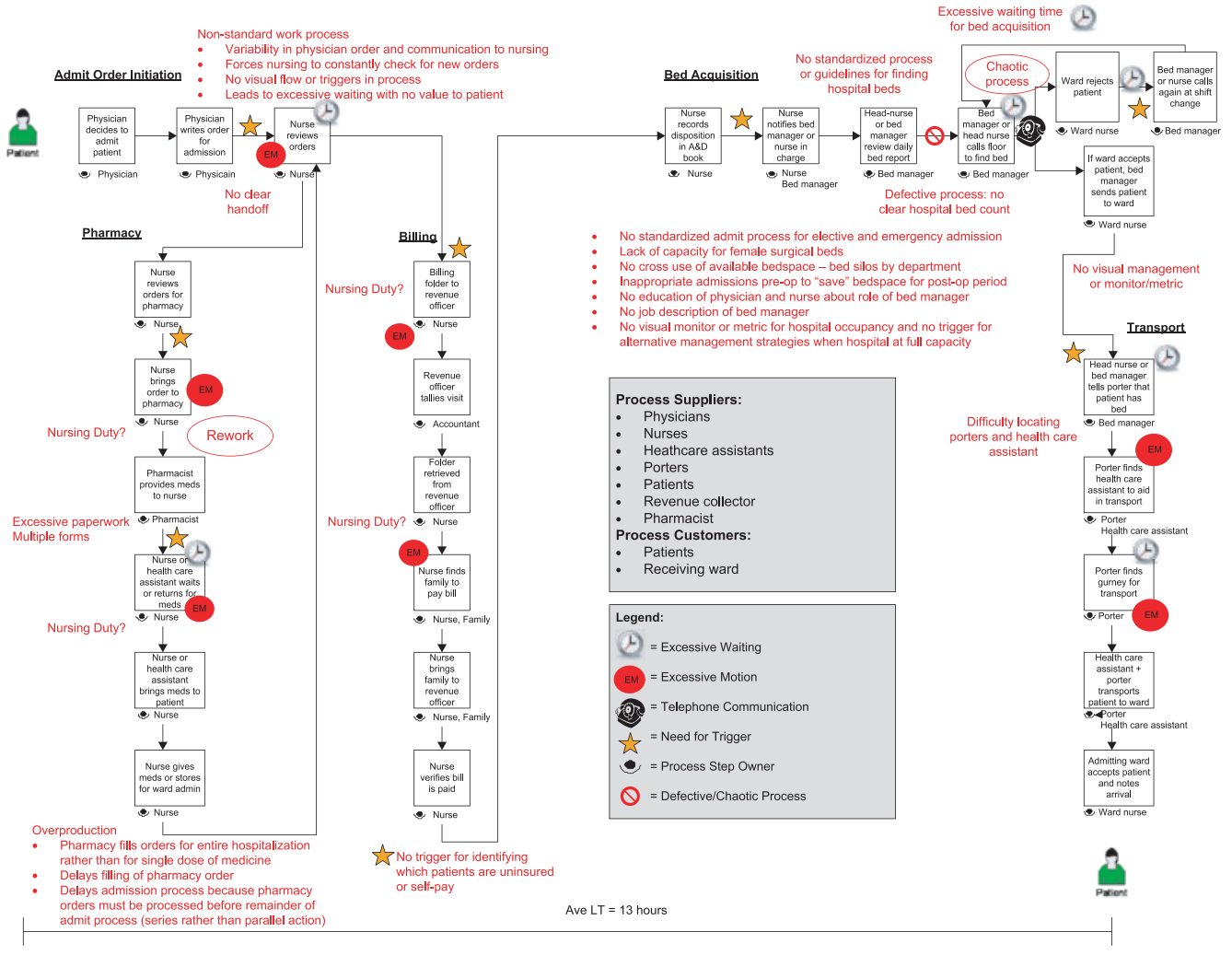


Figure 3. Current state value stream map for admissions process at KATH. KATH = Komfo Anokye teaching Hospital.

range of departments. Staff appreciated the attempt to streamline the admissions process while considering the effect on their departments. The inclusion of Ghanaian EM, surgery, and internal medicine residents on the team provided basic education about principles of quality improvement and process development that will aid their career development. Overall, we found that the Lean process was feasible and well received by participating KATH staff, and the process reinforced relationships that were being developed within the institution and between global health partners.

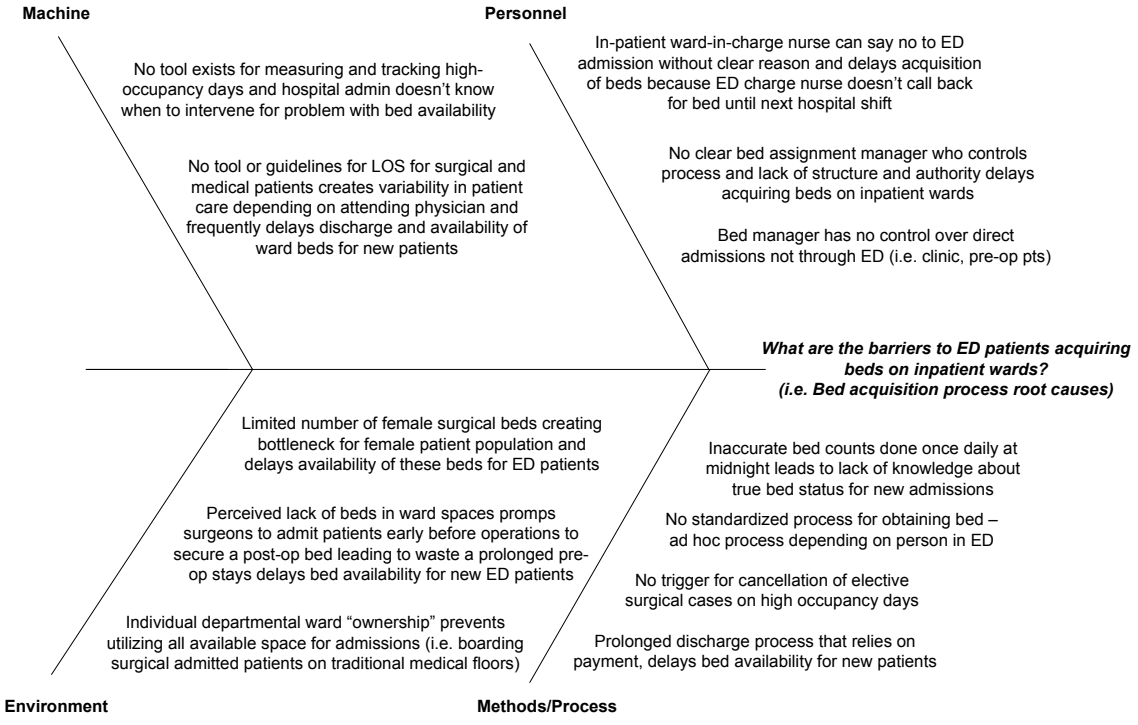
2. Obtaining and Maintaining Senior Institutional Support Is Necessary and Challenging

Lean requires hospital administrators to invert the traditional organizational pyramid, permitting empowered front-line workers to make important decisions regarding their own work processes. Organizations that have successfully implemented Lean have shown that adopting these principles with strong administrative support leads to more adaptive, effective, and efficient organizations. Unfamiliarity with this organizational change principle led some hospital administrators to be uncomfortable with asking lower-level ED staff to have more ownership over their work processes. However, we found that focusing the Lean project on key problems identified in previous high-level stakeholder meetings increased the comfort level of hospital administrators with the introduction of new organizational change techniques and the application of the Lean process. In addition, hospital administrators were invited to Lean educational sessions, which included several examples of Lean use in health care and aided the process of obtaining high-level buy-in and aiding comfort level with new organizational change principles. Regular feedback through process reports at various stages also helped sustain leadership support during initial project development.

3. Addressing Power Differences Among the Team to Obtain Feedback From All Team Members Is Critical to Successful Lean Analysis

Another challenge we faced in conducting a Lean project at KATH was addressing the need for change in the context of Ghanaian cultural norms and traditional health care roles. Lean projects require all team members to have equal input and influence over decision-making to prevent any single type of worker from dominating project sessions. Failing to ensure equal input leads to imprecise value stream mapping, inaccurate root cause

A *Ishikawa Fishbone problem solving tool*



B *5-Why Problem Solving Tool*

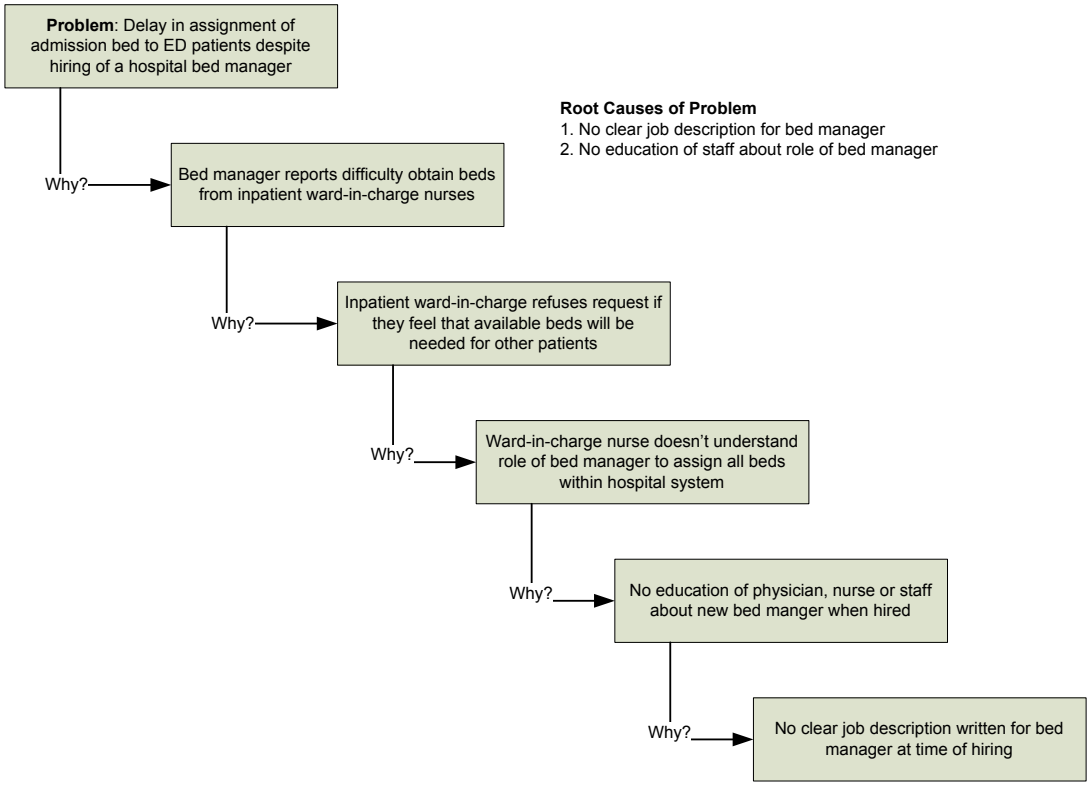


Figure 4. Lean problem-solving techniques applied to hospital admissions at KATH. KATH = Komfo Anokye teaching Hospital.

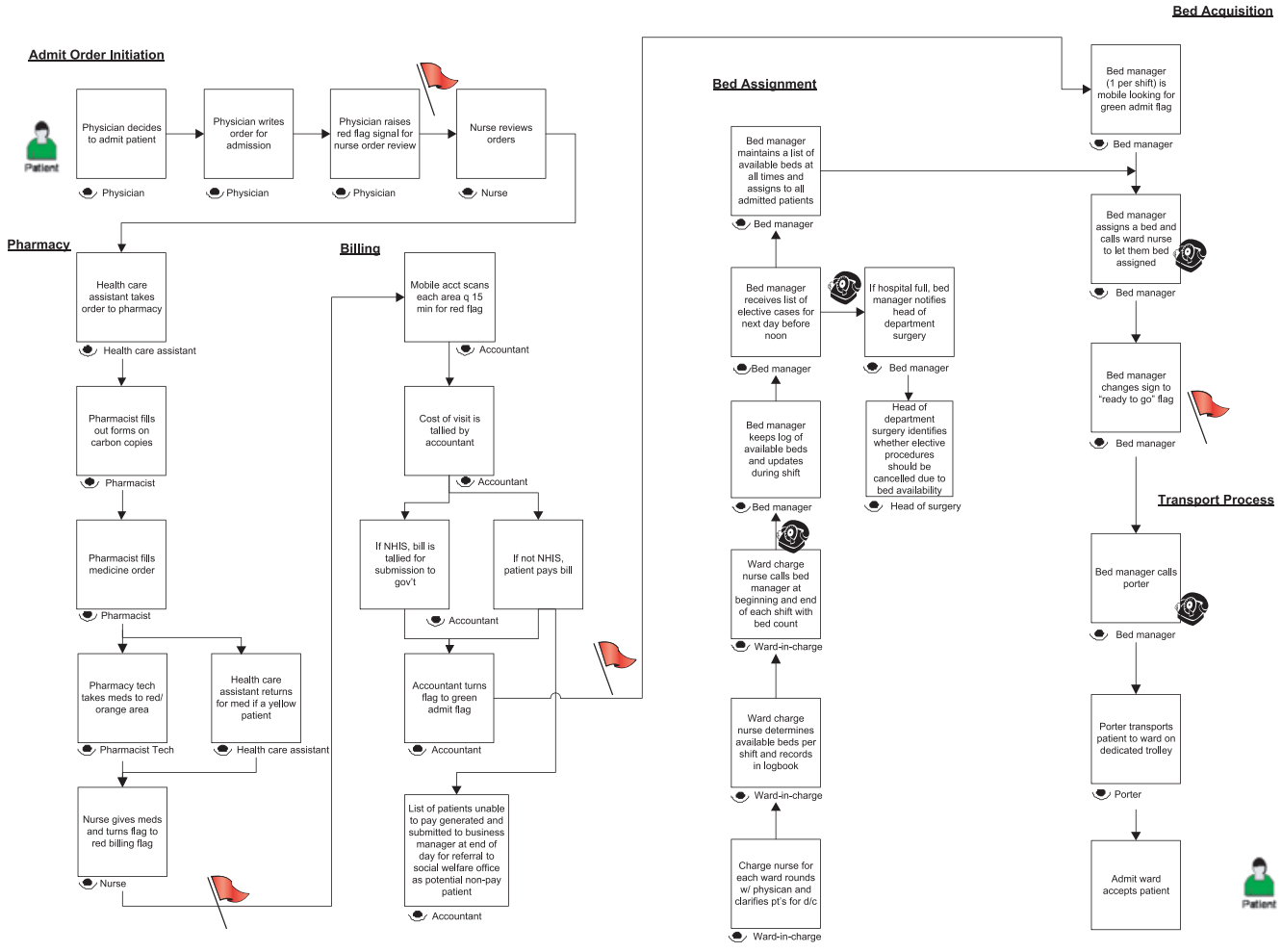


Figure 5. Future state process map suggested for admissions process at KATH. KATH = Komfo Anokye teaching Hospital.

analysis, and suboptimal development of the future state. Nurses and health care workers were noted to be less willing to make suggestions in meetings held with physician counterparts than the University of Michigan team was accustomed to in U.S. EM-based team projects. This phenomenon is also common in many U.S. Lean projects, but was more pronounced in this cultural setting. It is important, however, to recognize and counteract this problem at the outset with a clear plan to obtain unrestricted feedback from all team members. To address this problem, individual sessions were held with the nursing staff to gain input in an environment where they felt comfortable offering solutions, and these views were included in the team analysis sessions.

4. Choosing a Manageable Size Project Is Critical

Although Lean is designed to improve large complex systemic issues that traverse multiple organizational boundaries, the initial Lean introduction in a new system should be limited in scope to provide examples of success that will encourage enthusiasm for future projects. During this program hospital administration, staff, and EM residents identified the admissions process as the most significant challenge to current clinical operations and were eager to use this as an initial test of Lean methodology. However, the intricacy of the current process, the various levels of medical providers involved, and the multiple departmental interactions have delayed the implementation of Lean team findings. Using a different approach focused on a simple process within a single department, and subsequently demonstrating multiple successes would have been a better initial approach. This would also allow team members to use various Lean tools and build momentum and enthusiasm for subsequent projects. Ultimately, this would foster interest among other medical specialties to adopt Lean, resulting in the desired catalytic effect within the entire organization. This approach would make it easier to address more complex, interdepartmental system challenges.

5. Identification of Lean Tools Requiring Modification for a Low-resource Health System

We found that Lean tools requiring complex operational data for analysis of system problems were inappropriate for Ghana, given the lack of an adequate research infrastructure and patient tracking system. Traditional value stream mapping is one example of a technique that required modification for the low-resource setting in Ghana. Value stream mapping relies on generating a process map with operational data such as process time, wait time, and first time

Table 2
Types of Waste in Health Care Processes

Types of Health Care Waste	Example
Extra processing	Multiple unnecessary patient forms
Defects	Incorrect surgical procedure, medication error
Overproduction	Antibiotics given for viral infection
Waiting	ED patient waiting for inpatient bed availability
Unnecessary motion	Lengthy distance between administrative process steps
Excessive inventory	Excessive stock supply to ensure availability
Unnecessary transport	Moving ED patients to separate areas for admit holding
Underutilized employee creativity	Limited engagement of employees in process redesign

Adapted from Hoeft.[21]

process quality. These data aid in the identification of waste in the process. While lack of complex data limited the sophistication of the value stream analysis, we found that value stream mapping was still a powerful tool. Lean methodology has several countermeasures that can be modified and used in low-resource environments, including techniques such as small nonstatistical data collection projects and ''Gemba waste walks.'' Gemba waste walks are a classic Lean tool employed to identify process waste that is not commonly identified by complex data analysis alone. We used these tools with varying levels of medical providers over several days to visually identify waste within the admissions process. Gemba waste walks helped identify system bottlenecks, steps with prolonged waiting times, duplicated process steps, inefficient worker activities, and nonstandard work processes (Figure 3). The types of waste identified in the process are summarized in Table 2.[21] Instead of analyzing system data to identify waste, we used icons on the value stream map to indicate the waste within the process identified during the Gemba waste walks. Using this modified approach still allowed for identification of waste within the process without the need for a data system.

We also found that while data are critical to understanding and following changes over time, the value of precise data to guide identification of system inefficiencies is less critical at the initial stages in developing systems. In early development stages, the room for improvement is substantial and problems can be clearly identified by visually observing the current functional state of the process. For example, observing the current bed assignment process, where ED nurses call hospital wards once a shift to find available patient beds, clearly demonstrated that this step delayed patient care, led to lengthy patient boarding, and needed revision to increase nursing efficiency and ED bed availability. As health systems improve in developing countries, more precise operations data will become a more important driver of systems changes. Incorporating this data collection into the daily process of tasks will provide a continuous measure of system performance. Use of these data for process redesign and improved efficiency will demonstrate the positive effect that data-driven decisions can have on clinical operations. An ancillary benefit of the Lean project was the value that members of the Lean team placed on the need to implement these types of operational data collection systems to make future improvements.

6. Identification of Lean Tools That Worked Well in a Low-resource System

In contrast to value stream mapping, we found that several Lean tools, including the supplies-inputs-process-outputs-customers (SIPOC) scope of work tool, and Lean problem-solving tools were easily transported to the Ghana Lean project. SIPOC is a commonly used Lean tool to define the scope of the Lean project by defining the individual characteristics of the high-level process (Figure 2). The SIPOC tool was essential at KATH due to a lack of standard terminology among health care workers. SIPOC created a standard definition for the process steps and identified additional team members to include from pharmacy and billing departments. In addition, the large volume of complex processes that needed to be addressed at KATH, and the eagerness of team members to fix all system problems once they were engaged in process improvement, led many team members to attempt to include additional problems within the project. SIPOC helped to limit scope creep. We also found that both Lean problem-solving tools (Five-Why and Ishikawa fishbone diagrams) demonstrated in Figure 4 and employed in the Lean admissions project were easily transferrable and effective methods of stimulating team discussion.

7. Using Lean Highlighted That Important Changes Do Not Require an Influx of Resources

The project counteracted the perception that all improvements would require major monetary investments. Instead, the process stressed that many underlying system inefficiencies can be counteracted with inexpensive, low-tech solutions. For example, we identified an improved visual process with colored flags for communication between various providers that patients were ready for transport from the ED to the ward. In addition, we developed a plan for training a bed manager who had previously been identified but had not received any training or description of responsibilities. The solutions helped address the problems of poor communication between medical providers and substandard worker training. The result was creative solutions that were inexpensive, but will ultimately reduce the delays in transferring admitted patients to inpatient beds. The solutions within developed health systems typically use high-tech interventions, but we found that the same root

causes can be addressed with low-tech solutions that are inexpensive, but effective in improving the process.

8. Despite Different Levels of Resources, Root Causes of System Inefficiencies Are Similar Across Health Care Systems, but Require Solutions Unique to the Clinical Setting

We also identified that despite clear differences between the health care system in Ghana and in more developed countries like the United States, the root causes of many system inefficiencies are similar. Within the Lean admissions project, the root causes of many system inefficiencies were due to inadequate health care worker training, poorly defined job responsibilities, substandard communication, and absence of standardized workflow among various workers completing similar tasks. These are commonly identified root causes of problems within developed health care systems that conduct process improvement projects. The added problem of significant human capacity deficits in the health care sector magnifies these inefficiencies and adds additional delay to processes. Due to differences in available resources and technology, countermeasures will differ from those commonly employed in developed settings. However, the Lean process proved effective at demonstrating to team members that system inefficiencies can be countered with improved process redesign that recognizes the unique nature of the clinical setting and resources available.

DISCUSSION

Global EM development programs continue to increase in number and scope. Many developing countries have formed partnerships with academic institutions with EM to promote health systems improvements and to provide efficient and effective emergency care. A key challenge for global health partnerships is the need to concurrently introduce a new medical specialty and improve the underlying health system while avoiding potential pitfalls, including limited understanding of available health system resources, unfamiliarity with the local political and clinical environment, and cultural differences in both the medical care and the worker relationships. The literature contains very little information on methods of accomplishing these system improvements, although it has been previously recognized that successful implementation of EM in developing countries requires a broader health systems and operational focus.[17–19] This was recently confirmed in the report on Africa's first EM training program at Cape Town, where integrating EM into the health system was recognized as a significant barrier to success.[22]

We have examined the use of Lean to address the admissions process at KATH and highlighted several significant lessons learned about the application and modification of Lean for use in developing health systems. Overall, we found that Lean was a successful means of engaging team members to examine the health system and effectively avoid the common pitfalls identified for development projects. In addition, we identified new challenges not previously recognized prior to starting our process improvement program that will aid future investigators wishing to use Lean for health systems improvements. The project was successfully received by our international partners, and the KATH leadership has expressed interest in using Lean methodology to examine other potential system challenges, including the current use of the operating theatres to be more effective at managing unscheduled emergency cases.

While Lean has been extensively implemented to improve ED care in developed countries such as the United States and Australia, this is the first report in the literature to our knowledge where Lean was used to improve the emergency care delivered in lower- to middle-income countries. In developed countries, Lean has been effective improving patient satisfaction scores as well as decreasing important ED metrics of care.[10–13] More study is necessary to determine if Lean can have the same impact on emergency care processes in developing countries. The application of Lean in developing systems requires modification and it is our intention that the lessons learned through our use of Lean can aid future investigators as they examine the effectiveness of Lean in global health development.

Our review of Lean methodology to improve the health system and admissions process at KATH has several limitations. Quantitative data are not currently available to determine if the recommendations improved the admissions process at KATH. Although we found that the process of using Lean was successful in engaging health care workers to identify the problems and potential solutions within their own system, this limits our ability to comment on the use of Lean techniques to positively affect current patient care processes. Furthermore, the observations and lessons learned are qualitative in nature, gathered during team debriefing sessions by U.S. and Ghanaian Lean facilitators, thus representing a possible source of bias. Finally, this represents one example of the use of Lean at a single site in Ghana. More study of the use of Lean as a part of global health development programs is necessary to determine if the observations and findings are generalizable to other specialties, other aspects of the health system, and other international sites.

CONCLUSIONS

Despite these limitations, Lean is an active part of many U.S. EDs and is increasingly familiar to western EM faculty. Using Lean methods to optimize operational care delivery in synergy with improved medical education has the potential to increase long-term sustainable results as well as ultimately to improve care and patient outcomes. This type of implementation of operations principles may ultimately be as critical to the future of developing health systems as the transfer of basic medical knowledge. We hope that the lessons learned through our application of Lean will aid other partnerships between U.S./Western nations and lower- to middle-income nations as they work to improve emergency care and optimize their health system delivery.

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