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Case Article

Miller Pain Treatment Center—Eastern Hospital Outpatient Center

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Abstract. Introductory courses in operations management typically introduce students to process analysis and queuing theory. We apply these tools to consider patient flows in an outpatient clinic where processes are made more complex by inclusion of the teaching mission of an Academic Medical Center. The case narrative deals with a physician who moved his practice from a setting with no teaching mission to the academic setting. This created a natural experiment because he began treating the same patients using a different process flow. Students are asked to use data collected at both settings to compare and contrast these flows. The protagonist weighs options designed to improve an appointment schedule, change patient punctuality, and introduce a type of pre-processing of patients. Evaluation of these proposals calls for a different style of analysis. Students are introduced to the use of discrete event simulation to address such questions. Simulation models are provided corresponding to the two clinic settings. This allows students to conduct and learn from virtual experiments using calibrated models. The case fills a need for material that covers issues in healthcare delivery, which the basic tools of process analysis and queuing theory are insufficient to fully address.

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Supplemental Material: The simulation tool and the teaching note are available at https://www.informs.org/Publications/Subscribe/Access-Restricted-Materials.

Keywords: process analysis • healthcare delivery • discrete event simulation • case study

Introduction

Systems involved in delivering healthcare services are both varied and complex because they accommodate a wide array of factors that increase variability along multiple dimensions (Brandeau et al. 2004). This motivates instructors to find ways to present realistic depictions of these settings, which efficiently lend themselves to analysis using both quantitative and qualitative approaches. With these factors in mind, we set out to present a realistic depiction of the measurable aspects of patient flows in an outpatient setting. The case also lays out many qualitative aspects of a world-class healthcare provider in a manner that allows instructors and students to focus on a collection of sub-problems which can be discussed one at a time, in the context of the larger system.

When teaching courses which focus on the management of care delivery processes, a variety of tools have proven to be applicable including process analysis, queueing theory, and Discrete Event Simulation (DES) (Langabeer and Helton 2015). Clearly, many insights related to resource utilization can be effectively delivered by process mapping and application of the basic tools of process analysis. These insights are key because the cost of healthcare delivery is commonly believed to be excessive. Additional insights are uncovered when queues within the delivery system are analyzed. This is key because waiting times are one of the most common sources of patient complaints (Bhattacharjee and Ray 2014). Finally, when systems and/or proposals for process improvement increase in complexity, tools like DES are highly valuable to facilitate virtual experiments, which allow students to systematically consider "what-if" questions that are not easily addressed with simpler tools (Kolker 2012).

The narrative of the case explains that in 2011 the Department of Anesthesiology and Critical Care Medicine at Eastern Hospital included a medium volume clinic on the main medical campus. This clinic was housed in a facility, known as the Eastern Hospital Outpatient Center (E-HOC) that included many other outpatient clinics on site. E-HOC was part of an Academic Medical Center (AMC) meaning that it included a teaching mission and a role for residents and fellows. The system also included several off-campus clinics including a low volume pain man-

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agement clinic operating in a suburban location. This satellite clinic allowed a single pain specialist to run a stand-alone operation, which involved a small staff to treat patients by appointment. The satellite clinics increased access to care at the cost of duplication of some activities and an increase in fixed costs. In an effort to reduce these fixed costs the satellite clinic was subsequently closed, that practice was folded into the larger on-campus location, and the managing physician was appointed as the clinic director for the larger operation. This larger practice included eight attending physicians (Attendings), several of whom were tenured faculty in the school of medicine while the director was still an assistant professor. The AMC also served a teaching mission and routinely included three residents. This resulted in delivery of the same service using a dramatically different and more complex process flow.

Our depiction of the stand-alone outpatient service is based on detailed data on patient arrival times, and activity times collected over a two-year period using paper forms. It is easy to show that the Attending was the bottleneck resource in that setting. Our depiction of the larger practice is based on detailed data collected by paid observers over a six-month period. Inclusion of the residents and teaching mission at this location complicates identification of the bottleneck resource.

It turns out that even though the process flows and scales were different across these two settings, over a 4-hour clinic session both practices employed the same levels of key resources including a single Attending, one physician's assistant (PA), and four examination rooms. To make the comparisons even stronger, data presented in the case deals with the same Attending and PA working in both environments. Thus a natural experiment is created which provides a useful teaching tool.

Proposals to Improve Patient Flow

The clinic director is considering the possible implementation of three ideas that he believes will improve flow in the larger clinic. First, he had previously implemented a lateness policy in the private practice hoping to influence patient punctuality because he believed that patient tardiness was a factor that served to degrade clinic flow. In our experience, we have found that many physicians share this belief. Data is provided on patient punctuality before and 12 months after the implementation. This leads students to consider the merits of the policy, along with elements of experimental design, and to assess the potential impact of changing customer arrival patterns.

Second, the clinic director believed that a form of pre-processing of patients would improve patient flow. Upon his arrival in the AMC, residents did not consider patient records until after the patient was placed in the examination room. After seeing the patient, the resident presented information to the Attending and some teaching took place. This increased flow time, and utilization of the examination rooms. In this context preprocessing refers to having the resident and attending discuss each patient prior to the clinic session. Consideration of this notion naturally leads to a discussion of the merits of moving setups offline.

Third, he believed that the appointment schedule for the clinic had never been optimized, and could be improved. Appointment scheduling in this context is much more complex than it is in a single server system due to this clinic's teaching mission. Students are asked to consider these three proposals, make predictions about how each would or would not improve the patient experience, and present a plan to implement the ideas that they decide to adopt.

Existing Case Studies

A number of case studies are available to instructors which deal with process flows within an appointment based outpatient clinic (Blake 2016) including: University Health Services (Maister et al. 2006), West Coast Medical Center (Wylie et al. 2000), and Paediatric Orthopaedic Clinic of Western Ontario (Klassen et al. 2008). In comparison to these works this case adds three critical elements. This is the first case study designed for classroom use that explicitly incorporates the complications added by the AMC's teaching mission. This is important because it is estimated that roughly 40 million visits per year are made to such facilities in the U.S. alone (Hing et al. 2010).

Second, this work builds directly on detailed data collected on site at two clinics and explores how such data collection fits into a larger strategy of using rigorous approaches to experimentation and data analysis to improve real systems. This is important because experimental design, data collection, and hypothesis testing are all key elements of managing by fact in complex systems.

Third, this case can be used along with the DES models provided which have been calibrated in the actual clinics and used in detailed research on clinic performance (Williams et al. 2012, 2014, 2015; Chambers et al. 2016) Instructors can use the data and DES models in a variety of ways, depending on the emphasis of the course and background of the student population. This is useful because DES models are becoming increasingly common as elements of quality improvement (QI) efforts in healthcare settings (Jacobson et al. 2006). Understanding their development and use opens doors to new opportunities for graduates of our programs.

Pedagogical Value

The main teaching points of the case revolve around how to model, compare, and improve service delivery

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processes. The case introduces students to the needs for quantitative analysis of service delivery systems including:

(1) Process mapping to help understand and explain process flow;

(2) Calculation of utilization levels for multiple resources interacting in a single system to help identify bottlenecks and compare processes, and;

(3) Use of M | M | 1 approximations to estimate waiting times.

To facilitate analysis, the student is provided with simplified process flow diagrams and Activity times for both settings for three different patient types. A typical schedule includes slots for new patients, returning patients, and short follow-ups for simple issues such as a prescription refills. This makes the private practice setting deceptively complex, even though it does not include the teaching element.

Second, the natural experiment embedded in the case facilitates comparison of a process with and without the teaching mission. This is useful to introduce a variety of concepts including:

(1) The use of parallel processing to increase system capacity;

(2) Changes in utilization levels with process redesign which can result in a different resource being the bottleneck given the same set of jobs, and;

(3) Impact of shifting work from the bottleneck resource to an alternative resource that is slower than the bottleneck.

To facilitate this analysis the case gives detailed activity time data for the AMC including information about activities unique to that environment such as the Resident's review of the case, and the interaction between the Resident and the Attending while the patient waits in the examination room.

In addition to these topics, the case raises several issues that cannot be adequately explained using process maps alone. These include:

(1) Assessing the impact of altering the arrival process,

(2) The use of pre-processing to move setup times offline, and

(3) Development of a new appointment scheduling template.

Analysis of these more subtle issues requires a different type of tool. The role and use of DES adds a crucial dimension to the case analysis, which is likely to be novel for many students. Students need to think through ways to experiment with the proposals under consideration in a manner that does no harm to patients. This is one of the key motivations for the use of DES in healthcare and partially explains its popularity in the field.

Finally, in addition to the traditional operations management topics listed above, the case points out the importance of several key elements that are not purely quantitative in nature. These include:

(1) The use of incentives and policies to alter patient punctuality;

(2) Issues related to changing resource schedules to improve patient flow, and;

(3) Exercising influence over parties who outrank the unit manager.

Students are presented with a depiction of the operating environment including a bit of history of the institution along with material about the status of Eastern Hospital as one of the premier teaching hospitals in the world. This serves to give students some insights into the multi-dimensional nature of the job of physicians who are also researchers and teachers.

Use of Case in Our Curriculum

This case has been used for 4 years in an MS/MBA level elective on Managing Health Care Processes. Core courses in operations management, decision models, and statistics, are pre-requisites for the elective, but our students have had no formal exposure within our school to DES before this course. The case has been used with both full time and part time students seeking an MS in Healthcare Management or an MBA with a concentration in healthcare. The MS audience typically includes physicians who prove particularly useful in discussing the managerial issues embedded in the case. The full time MBA audience typically includes several students with some experience in healthcare consulting who often provide anecdotes about the ability of DES models to influence decision makers or clients in the HC industry.

Over the years, the reception to the case has been highly positive. Some students have seen DES models in other settings and wondered how they were created and how they could be used. It is common for students to ask how they can get additional training on the creation of such models. We are routinely surprised by the ingenuity of students to adapt models and to propose process changes that the instructors did not anticipate. Students have a particularly strong, and positive response to the ability to experiment with a process in a virtual way. The ability to interact with a virtual system can present many of the same benefits derived from other business simulations or games, which mimic service delivery systems (Lewis and Maylor 2007).

The case has been assigned as preparation for the opening session of the course. When used in this context, one major message of the case is that many process analysis tools are highly valuable in service settings, but they are also limited in what they can do when process complexity is increased. If used in this fashion the simulation models can be used to debrief students on case outcomes and to test suggestions that arise during the case discussion.

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On two instances, this case was treated twice in the same semester. In session 1, students apply lessons from the core course on operations management. Then we re-visit the same case near the end of the term after conducting several one-hour tutorials on the use of DES. This approach facilitates a discussion on the value added by creating the DES models. This is particularly useful because many different appointment schedules will produce the same levels of expected resource utilization even though they produce different distributions of waiting times and session completion times. This makes it difficult to explain why one schedule is better than another unless the DES is used. Simulating a variety of scenarios also allows students to link a rough sensitivity analysis to their recommendations.

The case has also been assigned as a group project serving as a capstone for the course. If students have little to no experience with such models they can quickly be instructed on how to change only a few parameters selected by the instructor and asked to discuss the results. A similar approach has been described by Ernst and Schmidt (2005) involving a case depicting the Benihana restaurant chain (Sasser 2004). On the other hand, if the students have more experience with such models from this or prior courses, they can be given free reign to simulate much more dramatic changes to the process and/or appointment schedules.

In other instances, students are not given the DES models at all but are allowed to analyze the case in small groups. When used in this way students can make decisions about how to apply technology to address the issues at hand. If this approach is taken, some students will create ingenious models on their own using spreadsheets, or other simulation packages. If the instructor chooses this path, the DES models can be used in class for demonstration purposes and to give the instructor a nice way to summarize results or compare recommendations from different student teams.

Use of Simulation

The DES models used with this case were created using ExtendSim although they are easily replicated using other packages if the instructor sees fit. A demonstration version of the software is available that can run the models. Discounted versions of the software are available for academic use from Imagine That, Inc. that allow students to save altered versions of the models. Interested parties should contact the vendor directly for details about academic pricing. Versions of this particular package are also provided with over 25 different textbooks including the extensive coverage offered in Laguna and Markland (2013). We have found that a single one-hour session on the topic and software were sufficient to prepare students to make simple model changes and interpret results. If students are allowed to create dramatically different process flows we have found that two or three one-hour sessions are needed to prepare them adequately for this more extensive use.

Closing Comments

The key elements that determine the instructor's best use of this case are the emphasis of the course, and the background of the students. If the introduction of DES models is a point of emphasis or students have prior exposure to the technique, the case can serve either as an introduction or as a capstone. For programs in industrial engineering or in programs that seek to train managers as consultants, this approach may be the best fit. We also believe that undergraduates with prior exposure to the tools applied here can perform as well as our MS/MBA audience on the quantitative analysis.

On the other hand, if time does not permit such a deep dive into the topic of DES, the case lends itself well to more common tools of process analysis including process mapping, and analysis of queues. When used in this way, the instructor may also choose to emphasize how to experiment with process changes in healthcare systems, and how to influence physician behavior to improve process flows.

Additionally, the case provides instructors with many options to take hybrid approaches. Students can be presented with system simulations and asked to do as much or as little with this tool as the instructor sees fit. The use of this case provides opportunities to build understanding of commonly used tools of process analysis. It also introduces the use of DES as a tool of growing prominence in healthcare in general and Quality Improvement projects in particular. All of this is done in an unusual context that helps students recognize and wrestle with issues of experimental design, evaluation of interventions, and ways to influence key stakeholders.

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