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Applying Systems Engineering to Implement an Evidence-based Intervention at a Community Health Center

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Summary

Impressive results in patient care and cost reduction have increased the demand for systems-engineering methodologies in large health care systems. This Report from the Field describes the feasibility of applying systems-engineering techniques at a community health center currently lacking the dedicated expertise and resources to perform these activities.

Keywords

Systems engineering; workflow; implementation; evidence-based interventions

Community health centers (CHCs) are vanguard providers of primary care for vulnerable populations.[1-4] Located in areas where care is needed but scarce, CHCs improve access to care for Americans regardless of their insurance status or ability to pay.[5,6] With passage of health care reform, an estimated 32 million Americans will become newly insured and CHCs, the primary care safety net, will become a critical element of health care expansion through a primary care portal.[5]

Primary care practices are key to the dissemination of prevention and early detection interventions.[7,8] However, ample literature describes the challenges posed by time constraints to implement changes in these settings.[9-20] The volume of work associated with primary care delivery in the United States has increased to a greater extent than visit duration.[19,21-25] Initiatives to transform primary care have therefore emphasized the need for a team approach to delivering care.[26]

As medical care becomes more complex at every stage—diagnosis, treatment, and follow-up—experts underscore that effective health care requires a delivery system that is fully coordinated and interconnected.[27] A joint report by the Institute of Medicine and the National Academy of Engineering recommended the widespread application of systems-

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engineering approaches to deliver health care that is effective, efficient, patient-centered, and equitable.[28]

Systems engineering focuses on the coordination, synchronization, and integration of complex systems of personnel, information, materials, and financial resources.[29,30] To determine how complex systems can be improved, engineers apply analytic methods to understand how such systems operate and where changes can be made. Systems-engineering techniques can help to ensure that the increasing volume of work encompassed by primary care, especially in resource-constrained CHCs, is performed efficiently and effectively. Impressive results in patient care and cost reduction achieved through improved efficiencies at several hospitals have increased demand for these methodologies in large health care systems.[31]

Value-stream mapping is one of several systems-engineering tools that can be used to define, plan, analyze, and implement significant process changes[32] in hospitals and primary care settings. A *value stream* is the set of all actions required to take a particular good, service, or combination of the two from concept to a finished product in the hands of the customer.[33,34] A *value-stream map* depicts the flow of work;[35] the major steps in the process; the activities that take place in each step; and the time elements of the flow.[36]

Value-stream mapping facilitates the visualization and understanding of actual workflow, describing in detail how a facility should operate in order to improve flow and ensure the completion of tasks without delays.[33,34,36,37] In manufacturing, flow and value are defined in relation to the processing of products, so that value is added whenever a product advances toward completion. In health care, the definition of value depends on the objective to be achieved (e.g., decrease in patient waiting time, increase in the number of patients seen).[38] Identifying the entire value stream for a process exposes waste, so that time and resources can be invested in steps that add value to the overall process.[33]

Although conceptual frameworks emphasize the importance of compatibility between an intervention and its target setting,[39,40] limited guidance is available to determine how an intervention can strategically fit within a health care system. Systems-engineering techniques provide what-if scenarios, including the likely consequences of various alternative courses of action, to determine optimal scenarios for patient care. Such analyses, which are relatively new to health care, can predict the impact of a proposed change on workflow and patient flow.[41]

In this report we summarize a feasibility study that applied systems-engineering methodologies, specifically value-stream mapping, to examine the implementation of an evidence-based intervention (EBI) in a clinic. A search of Pubmed and Web of Science yielded no studies that applied value-stream mapping in primary care clinics. We found one qualitative study that observed workflow at six safety-net clinics.[42]

description of Project

In 2010, our partner CHC provided comprehensive primary care to 15,016 predominantly limited-English proficient patients by staff who spoke 17 different languages and dialects, at two urban clinics.[43]

We previously developed an EBI to promote colorectal cancer screening among Chinese immigrants, the largest ethnic population at the CHC, through culturally and linguistically appropriate education materials and a trilingual health educator.[44] This EBI was selected as a Research Tested Intervention Program for Cancer Control P.L.A.N.E.T., a Web site maintained by the National Cancer Institute and the Substance Abuse and Mental Health Services Administration.[45]

In a follow-up study, we investigated the adaptation of this EBI for Vietnamese immigrants, the second largest patient population at the CHC. Core elements of the adapted EBI included 1) translated educational materials for a different patient population with overlapping cultural and health beliefs, 2) delivery of these materials through a different channel—i.e., medical assistants (MAs), who are members of the primary care team with broader reach to clinic patients, and 3) presentations on colorectal cancer for the MAs.

Medical-assistant responsibilities included measuring and recording patient vital signs; facilitating in-clinic laboratory testing; and providing coordination, information, and instructions, as needed, during and after patient interactions with medical providers.

To explore the appeal of a more systematic approach to understanding the efficient integration of new MA tasks, we sought the expertise of the Chair of the University of Washington's Industrial and Systems Engineering Department (RS), and then engaged in discussions with the CHC leadership to explore a feasibility study. We successfully obtained approval to add the feasibility study to our follow-up study, first from the CHC's Research Review Committee and subsequently from the Institutional Review Board of the University of Washington. With the available resources, we then conducted value-stream mapping of MAs, providers, and patients in order to encompass patient-centered perspectives.

time and motion studies

After training, four University of Washington engineering students conducted time and motion studies to capture the current state of MA and provider workflows, and patient flow. No observations were conducted in exam rooms, and specific details of work at the MA stations and providers' desks were not recorded since this was a feasibility study using limited resources and it was imperative to minimize disruptions in clinic services while simultaneously adhering to privacy standards required by federal law (the Health Insurance Portability and Accountability Act).

Time and motion study is a well-established technique used to evaluate the efficiency of work processes.[46,47] Originally applied to increase productivity in manufacturing, this technique systematically analyzes workflows through first-hand observation and timing.[47] Workflows in health care, like manufacturing tasks, tend to have a repetitive pattern, making time and motion studies a highly applicable tool.

We observed a total of 44 MA cycles, 40 provider cycles, and 31 patients. A cycle is defined as one complete process flow.[37] For example, a MA cycle begins when he/she leaves the MA station to pick up a patient in the clinic waiting area, and it concludes when the MA returns to the MA station in preparation to pick up the next patient. Observation of at least 30 cycles ensures stable estimates of the mean and standard deviation of the time spent at each step. Using stopwatches and data collection forms, the students spent 59.25 hours conducting observations over the course of 22 separate days, from February 22 to May 7, 2010. Distances between locations were recorded separately and assumed to be related to the time spent walking between them.

Value-stream mapping

Using the time and motion study data, we developed value-stream maps for the MAs, providers, and patients (Figures 1-3). Presenting the data in this way made it easier to recognize the overall movement patterns of these individuals throughout the clinic. Each value-stream map documents key steps in the workflow and their associated location, and identifies general activities by assigning alphabetic characters in sequential order to each step. Each map also details the mean duration in seconds of each step (μ) and the standard deviation (σ). Arrows indicate the direction of the flow, and the numbers adjacent to each arrow represent the average walking time in seconds from starting point to destination.

Within a given value-stream map, steps with the greatest variability and duration present opportunities for improvement, and are generally ideal places to introduce change. In accordance with this technique, we met with the MAs to elicit their feedback on the initial draft of the value-stream map. They noted that our value-stream map omitted less frequent workflow steps, such as vision exams and the use of extra exam rooms to accommodate providers who see more than one patient at a time. Since our observations did not include these additional steps, Figure 1 incorporates the MAs' feedback but does not report times for these activities.

Spaghetti diagrams

Spaghetti diagrams visually represent the movement of a person or product through a physical space.[36] They depict walking patterns and can 1) identify where time is wasted by traveling between locations of essential checkpoints in the flow; 2) reveal unnoticed workarounds; and 3) identify opportunities for layout improvements, such as the movement of equipment and supplies, to reflect better the ways in which people move and work.[36]

Using the time and motion study data and value-stream maps we generated spaghetti diagrams of the movements of MAs, providers, and patients. Figures 4-6 present the respective spaghetti diagrams for each group, observed in a top-down layout of the clinic.

meeting with ChC clinical leadership team

Previously, CHC clinical leaders expressed interest in a comprehensive portrayal of clinic activities. At a meeting to present the value-stream maps and spaghetti diagrams, the leaders reiterated their preference for a more comprehensive value-stream mapping with additional staff (e.g., nurses and interpreters) and all areas of the clinic. They also expressed great interest in developing the CHC's capacity to apply value-stream mapping in conjunction with Kaizen workshops. *Kaizen* is a Japanese word often translated as "continuous improvement," and Kaizen events typically follow a three-step process: observation and careful documentation of the current state using a process or value-stream map; value analysis and process redesign towards a future state with input from frontline employees; and implementation of the ideal future state.[48]

Currently, our partner CHC lacks the dedicated expertise and resources needed to conduct value-stream mapping or Kaizen workshops at their clinics. Given the CHC's interest in acquiring the expertise needed for these activities, we collaborated on another research proposal to investigate the application of systems-engineering techniques by CHC staff, with training from systems engineers, to integrate our EBI into clinic services.

Conclusion

According to the literature, systems-engineering techniques have been available predominantly in hospitals and large health care systems that have the resources to pay for the necessary expertise.[31,49-56] Like larger health care systems,[31,57] CHCs and the patients they serve are likely to benefit from the application of systems-engineering techniques to deliver care. In order for CHCs to serve a larger segment of the U.S. population, or to expand beyond their current programs, it is imperative that the implementation of new programs not interfere with essential processes of medical care delivery.

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Our feasibility study adapted approaches from traditional applications in manufacturing. In contrast to manufacturing settings, the application of these techniques in health care may face unique challenges, including the imperative to maintain confidentiality of patient health information, limited availability of space in certain clinical settings, and disruptions in patient care.

To identify appropriate value-adding operations at a clinic, comprehensive value-stream mapping must incorporate more detailed staff activities, include additional clinic staff, and encompass all areas of the clinic. We also recommend obtaining informed consent from patients, clinic staff, and providers prior to scheduled medical visits to minimize disruptions in patient care.

Research on the efficacy and effectiveness of systems-engineering methods is necessary not only to augment the quality improvement literature but, more crucially, to guide busy CHC clinics in their mission of satisfying the complex health care needs of underserved populations.

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Notes

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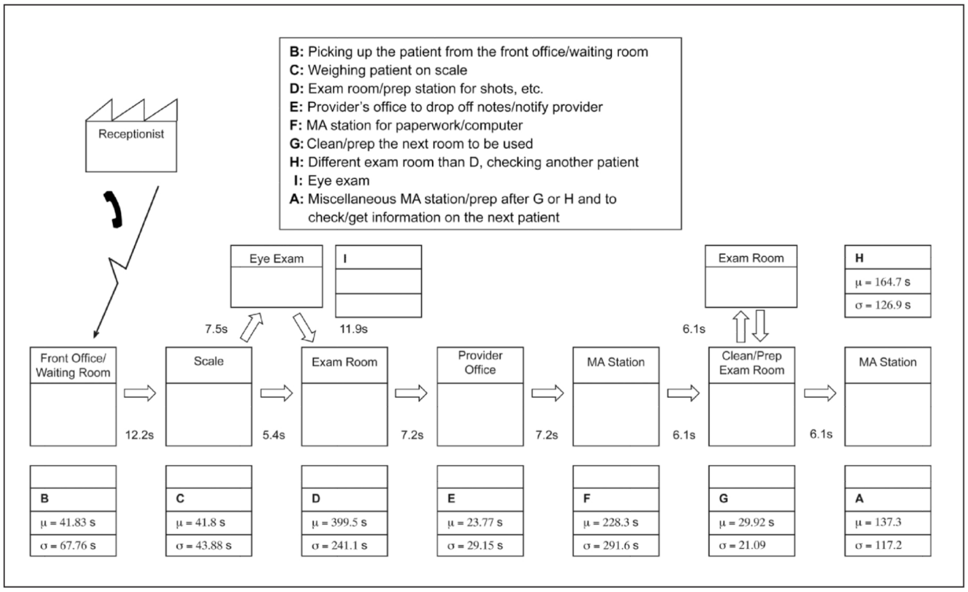

Figure 1.

Current state value-stream map of medical assistants' activities.

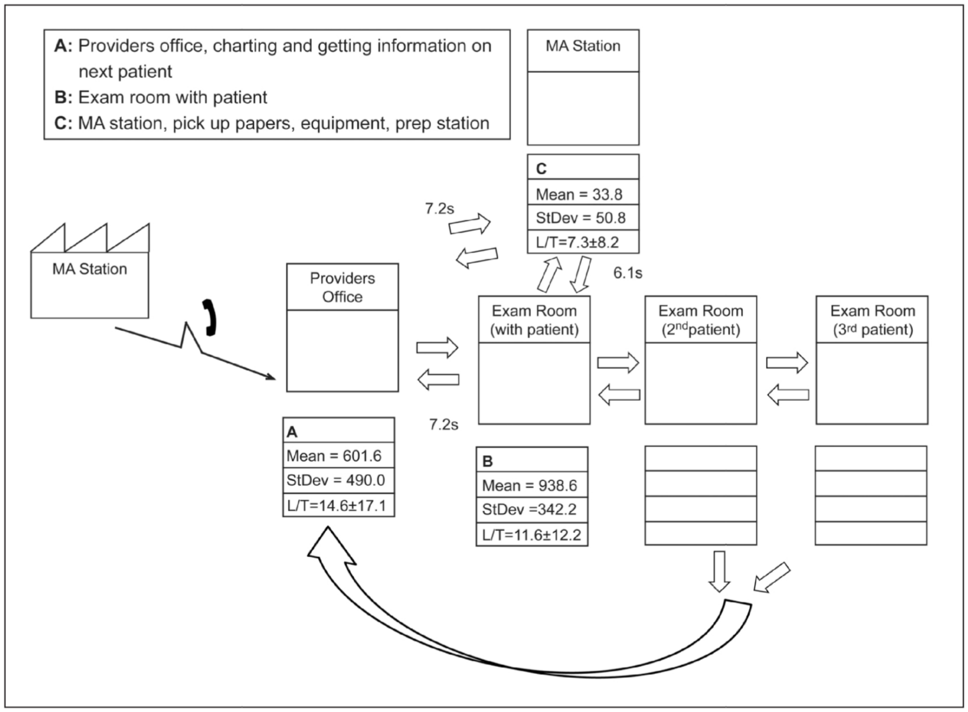

Figure 2.
Current state value-stream map of providers' activities.

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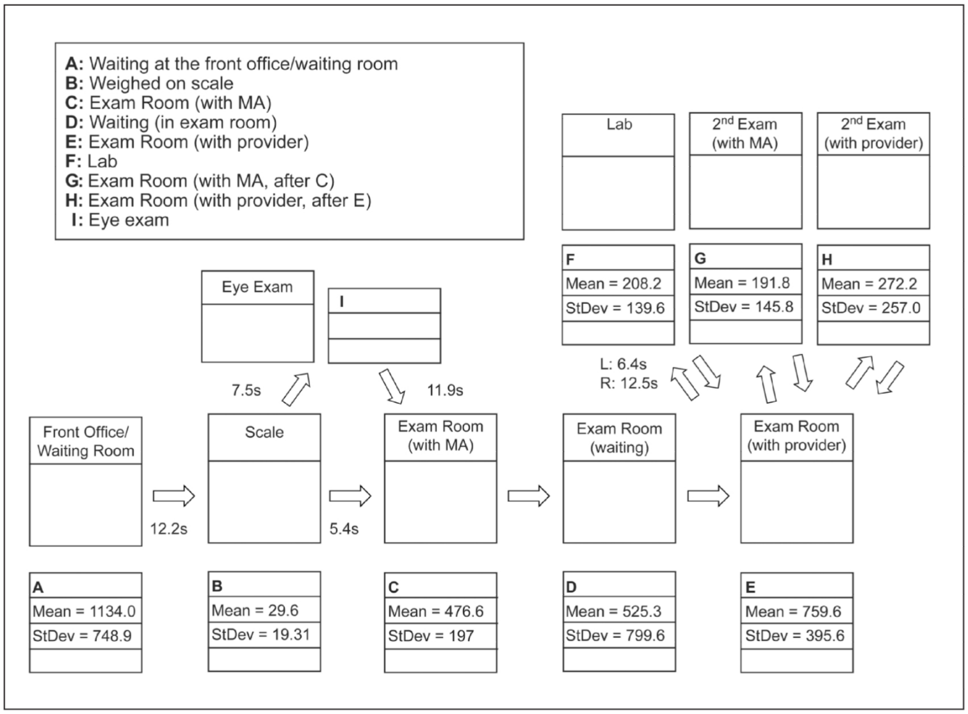

Figure 3.
Current state value-stream map of patients' activities.

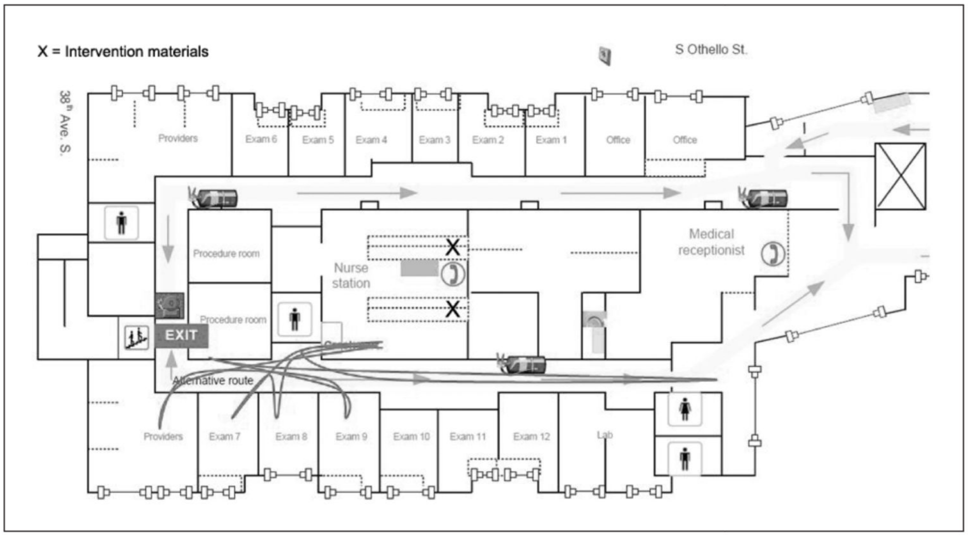

Figure 4.
Spaghetti diagram of medical assistants' activities.

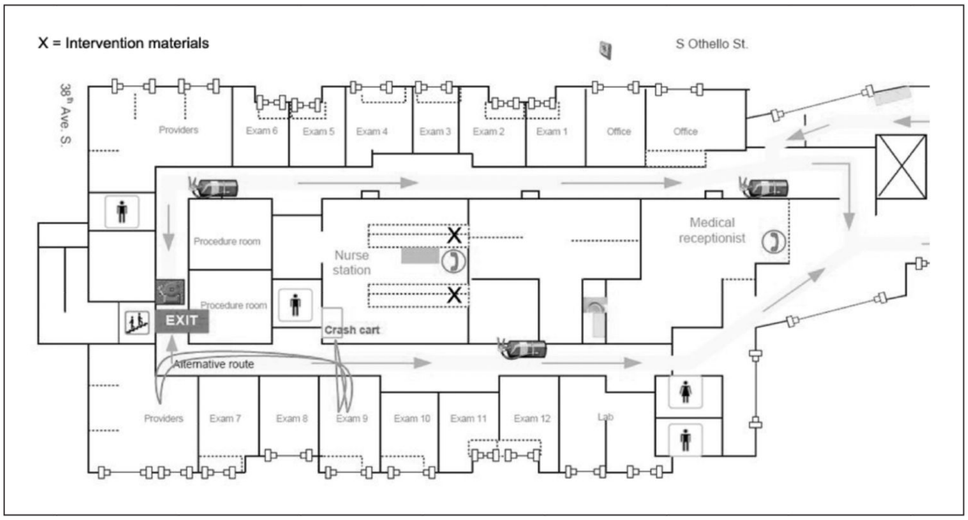

Figure 5.
Spaghetti diagram of providers' activities.

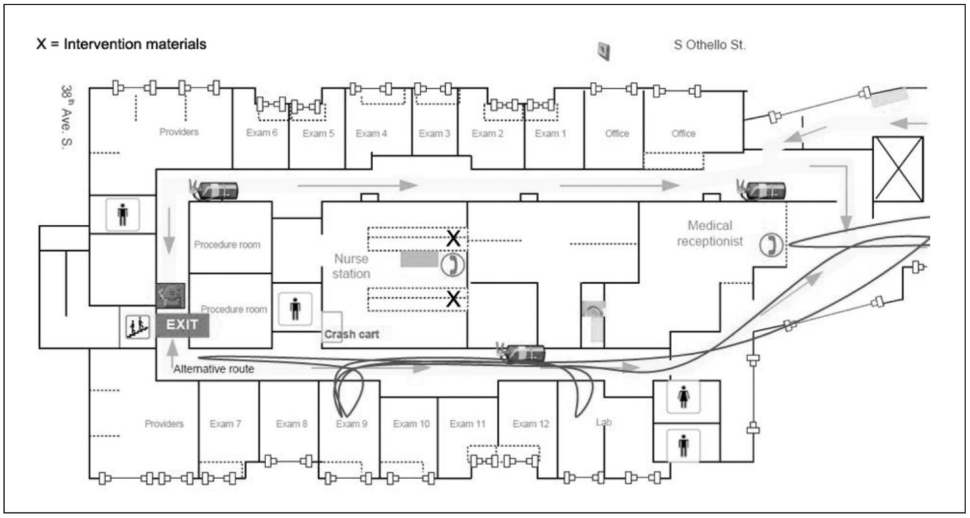

Figure 6.
Spaghetti diagram of patients' activities.