In an effort to stay relevant and competitive, companies and organizations explore ways to streamline processes while continuing to deliver quality products and/or services to their customers. Two hallmarks of process improvement are the “Lean” principle, with its focus on speed, and the “Six Sigma” principle, with its focus on quality. Combining these principles, Lean Six Sigma (LSS) is a complementary process-improvement, problem-solving methodology used in the business and manufacturing industries to improve the speed, quality, and cost of products.

LSS is commonly associated with manufacturing entities and corporations such as GE, Motorola, Toyota, and Lockheed Martin. However, over the past decade, the LSS methodology has expanded into other organizational realms. LSS has been used to improve knowledge-based products from service organizations such as hospitals, government offices, and research and development organizations. This article presents an example of the use of LSS to improve knowledge-based products in the public health sector.

In July 2008, the Army Institute of Public Health Behavioral and Social Health Outcomes Program (BSHOP) was established at US Army Public Health Command. The mission of BSHOP is to maximize total Soldier health and combat readiness by identifying and assessing the relative impact of psychological and social threats using a mixed methodological approach. At inception, one of the primary missions of BSHOP involved routine reporting and surveillance of suicidal behavior among Soldiers using data from the Army Behavioral Health Integrated Data Environment (ABHIDE). The ABHIDE is one of the most comprehensive data sources for suicidal behavior and includes data from 27 disparate administrative data sources. The BSHOP created the Surveillance of Suicidal Behavior Publication (SSBP), which is disseminated to key military leaders including the Vice Chief of Staff of the Army, the Army Surgeon General, public health practitioners, and behavioral health providers at regional medical commands and military treatment facilities.

As the mission and scope of BSHOP expanded, it became apparent that preparation of the SSBP was a time- and resource-intensive process that prevented epidemiologists and analysts from exploring other behavioral health-related topics of public health significance. The SSBP production process had to be refined. Refining the process allows consistency in methods and provides
time to explore not only other negative outcomes important to public health, but also to expand what can be included in the SSBP. This article describes an LSS project completed by the BSHOP Behavioral Health Surveillance Section (BHSS). Unlike other publications related to process improvement, this article describes how an industry tool was used to enhance a public health surveillance process for the US Army.

**METHODS**

The LSS problem-solving model is known as Define-Measure-Analyze-Improve-Control (DMAIC). Using DMAIC, LSS teams confirm the nature and extent of the problem they wish to solve, identify the true cause of the problem, develop solutions based upon data, and establish procedures for maintaining the solutions.

Before initiation, the LSS team created a project charter, a 1- to 2-page iterative document that includes the problem and goal statement, a timeline, and a list of the LSS team members. The charter was updated as the project developed through each of the DMAIC phases.

The DMAIC methodology and associated tools are discussed in detail by George et al. A brief description of each phase as it pertains to the SSBP project is presented in the following sections.

**Define**

The LSS team and the Project Sponsor (the BSHOP Program Manager) first determined the scope of the project, reviewed existing data to better define the problem, and set up a communication plan. The team created a high-level (overview) map of the process and established the project scope (Figure 1). The project process begins when the team receives the data to begin producing the SSBP and ends when the BSHOP Program Manager approves the publication.

Next, the team created a detailed map of the process, describing each team member’s position and the tasks associated with each section of the publication. In doing so, project team members depicted the flow of the process, determined the value of specified tasks, and improved their understanding of each team member’s role and responsibilities. Like the project charter, the process map is an iterative document and was updated throughout the project as the process was refined.

**Measure**

During this phase, the LSS team used baseline data and determined process performance/capability using Sigma Quality Level (SQL), a measure of process performance with respect to meeting customer requirements. A 3 SQL process meets customer requirements 93.3% (yield) of the time; a 6 SQL process meets customer requirements 99.9% of the time.

The team also developed a data collection plan to assist in the Measure phase. As part of this plan, team members recorded the number of hours they spent on each section of the publication. At the end of each publication cycle, a data technician compiled the information and created a table summarizing completion time by task and section of the publication. Operational definitions were also created to ensure clarity and consistent interpretation for each task. For example, New Code was defined as “Data analyst writes SAS code for data that has not been included in previous reports. Data analyst writes code to pull the same values in Structured Query Language to validate SAS code.” (SAS v9.2 software (SAS Institute Inc, Cary, North Carolina) was used for data analysis.) Estimated financial benefits were calculated by the resource manager (RM). Estimates were based on a fully burdened labor rate (base rate +34.1% fringe benefit rate) added to overall report hours, manager review hours, and RM hours.

**Analyze**

During the Analyze phase, the LSS team analyzed the data collected during the Measure phase. A Pareto chart was used to specify the process steps that required the most labor hours and the most common source of defects. A Cause & Effect (C&E) Diagram, shown in Figure 2, and Matrix helped the team organize ideas and determine which critical factor(s) were increasing the number of hours required to produce the SSBP. Using the nominal group technique, the team identified and prioritized 3 root causes that had the most effect on publication production hours.
Improve

The Improve phase involved changes in the process that would reduce the number of labor hours spent producing the publication. Based upon the information obtained during the Analyze phase, the team conducted a pilot assessment to test their proposed improvement. The goal of the pilot was to demonstrate that changes in the critical factor identified as most influential would reduce the number of hours in the process while simultaneously maintaining the quality and integrity of the SSBP. Team members also developed potential solutions to other prioritized causes by brainstorming ideas, then evaluated those solutions using agreed-upon criteria.

Control

The Control phase ensured that solutions would be maintained after LSS project completion. To that end, the LSS team documented the solutions. A process control plan was created and the new and improved process performance and capability were compared to the old process performance and capability. Revised financial and operational benefits were also calculated.

RESULTS

Baseline

Four data points (previous SSBPs) were used to determine the average number of hours spent to complete a single publication (baseline). The LSS team and sponsor recognized that a larger sample size would be ideal. However, given that the section produces surveillance publications for a rare event (suicidal behavior), 4 data points were appropriate and scientifically sound. On average, each of the previous publications took 448 (95% confidence interval, 373-523) hours to complete. This exceeded the expected standard of 308 hours which was established based on comparison with the time another organization takes to produce a similar document.

At baseline, the process was stable over time (in statistical control). However, process SQL was less than one. This indicated that the process was not capable of consistently producing the SSBP within the determined specification limits (308 hours).

Using a Pareto chart, the team determined that preparing SAS code and running statistical analyses accounted for 75% of the labor hours. Based on analysis of the C&E Diagram and Matrix, the team identified 3 root causes that needed solutions: (1) lack of personnel, (2) lack of analytic datasets and methodology, and (3) lack of standardization in SAS coding. The team agreed that focusing efforts on the SAS coding process would have the greatest effect on reducing the number of labor hours. Therefore, this part of the process was used as the pilot for the Improve phase.

For the pilot, SAS and Structured Query Language labor hours for the 1st Quarter 2012 Surveillance of Suicidal Behavior Update and the 2012 Semiannual SSBP were used as the “before” period, while SAS and Structured
Query Language labor hours for the 3rd Quarter 2012 Update and the 2012 Annual SSBP were used as the “after” period. Results from the pilot demonstrated that the team spent 223 hours on SAS coding and Structured Query Language verification (combined) in the “before” period and 90 hours in the “after” period. Notably, the majority of the time in the “after” period was spent on code for new analyses not included in previous publications. The reduction in hours (178) during the pilot assessment demonstrated that SAS coding and Structured Query Language verification were correlated with overall production hours, resulting in a significant reduction in SSBP production hours.

Final Improvements

Project improvements resulted in a significant reduction in labor hours (-249 hours) and a significant increase in yield (+89.4%) and SQL (+3.25) as shown in the Table. The projected 7-year cost avoidance for US Army Public Health Command was $707,045. Control measures were implemented to ensure improvements would be maintained after project completion. The team created 8 Business Rules and standard operating procedure (SOP) documents. Chief among these is the Technical Notes, which describe, in detail, epidemiologic methodologies (data sources, variables, coding decisions) used for SSBP production. The Technical Notes are updated with each iteration of the SSBP.

COMMENT

The LSS team exceeded the project goal and significantly reduced the SSBP production hours by 42% (199 hours). The results of this project are important because, to our knowledge, this is one of only a few LSS projects that applied this industry tool to the improvement of a public health surveillance system. These results demonstrate that LSS can inform the public health process and provides a viable method of improving knowledge-based processes and products.

As determined during the Analyze phase, SAS coding and Structure Query Language verification accounted for the majority of the time during the production process. The verification acted as a fail-safe to ensure coding and analysis were consistent and correct. When the SAS code became standardized and error-free, the LSS team determined this practice no longer added value. However, this verification process continues to be used for new SAS code. When discrepancies have been addressed and accounted for, that step is removed from the production process.

As a result of the LSS process, the team maintained the quality of the SSBP and reduced production time, while at the same time adding valuable information. This included measures from 4 datasets in the ABHIDE pertaining to deployment, drug testing, screening for the Army Substance Abuse Program, and medical problems related to sleep and to pain. These indicators are now routinely included in the SSBP.

In addition to revising and standardizing SAS coding, the format and design of the SSBP was reconfigured to better align with the overall process of analysis and reproduction. Prior to the redesign, project team members were rewriting the entire document every quarter. The new design is not only aesthetically pleasing and more appealing to the customer, it also allows easy duplication and transfer of the data from SAS outputs to the table and text. To maintain consistency, the team developed a detailed SOP describing all aspects of document design and format, such as text specification, table and figure configuration, color scheme, and font size and style.

The development of business rules also led to gains in consistency in epidemiologic methodologies and analytic processes, thereby enhancing the scientific integrity of the SSBP. These included Business Rules for Data Set Exploration and 3 Business Rules for Statistics: US Population Data Sources (US Census Data and Web-based Injury Statistics Query and Reporting System (WISQARS)), Crude and Stratified Rates, and Standardized Mortality Ratios. Other methodological advances included the following: (1) use of Health Care Effectiveness Data and Information Set rules to determine what constitutes a behavioral health diagnosis; (2) internal review of behavioral health diagnoses and their International Classification of Diseases-9 (ICD-9) codes (by the BSHOP Strategic and Clinical Integration and Evaluation Section) and external review by clinicians (colleagues and subject matter experts); (3) alignment of race/ethnicity categories with Office of Management and Budget guidelines; (4) creation of a process to resolve discrepancies in static demographic variables (gender, date of birth, race/ethnicity). The team also created a welcome packet that is used as a training tool to systematically introduce new personnel to section processes and products.

The LSS team developed and distributed a stakeholder SSBP feedback survey. Based on team discussion of feedback from the survey, the SSBP is now released.

<table>
<thead>
<tr>
<th>Process improvements realized as a result of the Lean Six Sigma project</th>
<th>Metric</th>
<th>Before</th>
<th>After</th>
<th>+/-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced number of Labor Hours</td>
<td>448</td>
<td>199</td>
<td>-249</td>
<td></td>
</tr>
<tr>
<td>Increased Sigma Quality Level</td>
<td>&lt;0</td>
<td>3.25</td>
<td>+3.25</td>
<td></td>
</tr>
<tr>
<td>Increased Yield</td>
<td>&lt;6.6%</td>
<td>96%</td>
<td>+89.4%</td>
<td></td>
</tr>
</tbody>
</table>
annually rather than quarterly. Data on cases of suicidal behavior that occurred during the first 3 quarters of each calendar year are analyzed but disseminated only if trends change significantly. The decrease in the frequency of reporting also enhanced interpretation of the data. In particular, the variability in the proportions from quarter to quarter resulting from the small numbers of suicidal events suggested changes that appear large but are unimportant in the context of a longer period.

In addition to the successes described above, the team realized substantial gains in team building and enhanced workplace morale. Project participation turned LSS skeptics into champions of the process and fundamentally changed the way team members conceptualized tasks and projects. As a whole, individuals now think in terms of process improvement. Statements such as “from an LSS perspective we should…” or “is this the most efficient way to…” or “what does our customer want?” are now commonplace in the work environment. The involvement of BHSS in the project also piqued interest in LSS tools and methodologies among other sections within BSHOP and resulted in 15 employees obtaining their Yellow Belt certification. There has also been an increase in cross-section collaboration, and the sharing of ideas has aided in the scholastic enrichment of individuals and teams. Support from the BSHOP Program Manager and excellent mentorship and guidance from the LSS expert from the USAPHC Strategy & Innovation Office were also integral to the success of the project.

CONCLUSION

There are 3 reasons why service-oriented organizations should consider LSS tools and methodologies when trying to improve a process, all stemming from the fact that service processes are typically slow. First, slow processes are subject to poor quality, which increases cost and drives down customer satisfaction. Second, service processes are often slow because too much work is in progress, which results in unnecessary complexity in the service or product. Third, in any slow process, 80% of the delay is caused by less than 20% of the activities. Individuals who work in service functions typically find that most of the steps in the process add no value to the product they are producing. Use of LSS to identify and quantify the steps in the process that are not of value will result in improvements as demonstrated by the BSHOP LSS project described here. The time and knowledge gained from this project have enabled the exploration of other behavioral health-related topics of significance, such as those added to the SSBP during the course of the project. In addition, the team has begun applying LSS tools and methodologies to other surveillance publications, including those on all-cause mortality in the US Army, risk assessment, and sexual assault. Other programs and organizations within the Army and, more specifically, the US Army Medical Command, could use LSS tools to improve relatively simple (organization and structure of public access drives, version control for document review staffing of documents), and complex processes (patient intake process or routine medical procedures) in need of refinement. Interested parties should contact their organization’s Strategy & Innovation Office for guidance to determine feasibility of a proposed project.

ACKNOWLEDGMENTS

The project was supported in part by an appointment to the Research Participation Program for the US Army Public Health Command (USAPHC) administered by The Oak Ridge Institute for Science and Education through an agreement between the US Department of Energy and the USAPHC. We thank the following individuals for their support and/or contribution to this work: Christopher Watts, MPH; Sara Parker, Director, Strategy and Innovation Office, USAPHC; Dr Bradley Nindl, Science Advisor, Army Institute of Public Health; John Resta, Director, Army Institute of Public Health; MG Dean Sienko, Commander, USAPHC.

REFERENCES


AUTHORS

Dr Watkins, Ms Spiess, Mr Wills, Dr Mancha, Ms Nichols, and Dr Bell are with the Behavioral and Social Health Outcomes Program, Army Institute of Public Health, US Army Public Health Command, Aberdeen Proving Ground, Maryland.

Mr Kemerer is with the Stategy & Innovation Office, US Army Public Health Command, Aberdeen Proving Ground, Maryland.

Ms Corrigan and Ms Kately are with the Batelle Eastern Science and Technology Center, Aberdeen, Maryland.