VALUE STREAM MAPS
Improving Procurement of Ergonomic Office Equipment

By Marie Hayden and Diana Schwerha

SAFETY PROFESSIONALS USE USER-CENTERED APPROACHES in their everyday work to keep employees safe and healthy. Such approaches include walking the site (Gemba walks), conducting task analyses and seeking user input through formal or informal methods. While in small organizations obtaining information about processes and functions in need of improvement may be easy, large organizations pose a greater complexity because of their multiple departments and sometimes conflicting processes. In these types of organizations, a more structured approach is needed that allows for canvasing employees and understanding potentially differing methods or challenges.

Typical methods of obtaining user ideas include surveys or channels that allow anonymous suggestions. While these methods provide valuable information, a weakness is that they may consider the individual's viewpoint singularly rather than within the larger organizational context. This is not a fault, but a potential risk of using those types of input.

For many years, lean manufacturing practitioners have used value stream maps (VSMs) to understand how a product flows through the system and as a method for identifying value and non-value-added steps. A VSM provides a visual representation of a system's process by illustrating the various stages and cycle times of the process (Hofacker, Santos & Santos, 2012; Teichgraber & de Bucourt, 2011). VSMs track a product from its origin with the supplier through its arrival at the end user (Tan, 2001). Typical uses for VSMs include tracking a product through the manufacturing process or following it through the procurement process. A VSM includes processing, travel and wait times. Some VSM examples used for safety include the procurement process for endovascular stents in healthcare (Teichgraber & de Bucourt, 2011), a management process on hip procedure in healthcare (Simon & Canarcari, 2012), and construction procurement for a public building (Hofacker, et al., 2012). VSMs can be present or future; a future VSM applies possible solutions to implement waste reduction and reduce cycle time (Abdulmalek & Rajgopal, 2007; Hofacker, et al., 2012).

VSMs are easy to produce, provide multiple viewpoints and help OSH professionals speak the language of process improvement, thus integrating safety goals with process improvement metrics (Schwerha, Boudinot & Loree, 2017). The purpose of this study was to demonstrate how a VSM can be used to better understand the procurement process for ergonomic equipment at a large university. This process was specifically chosen because no standardized approach for procuring ergonomic office equipment existed and because safety professionals were interested in the various methods and outcomes to implement a better approach. Additionally, researchers were focused on ways to efficiently address the needs of hundreds of employees, since multiple one-on-one appointments for every type of ergonomic equipment purchased would not have been feasible. A better system that produced improved user outcomes was needed.

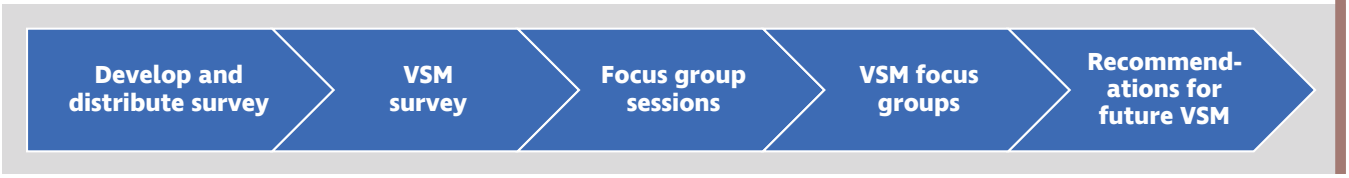
KEY TAKEAWAYS

- **This article presents research that shows how value stream maps (VSMs) were used to document the procurement process for office equipment to establish better methods of helping users obtain equipment to reduce the risk of overuse injuries in their office jobs.**
- **The research consisted of two parts: 1) a survey to employees regarding office equipment; and 2) three focus groups with employees who were active in the procurement process. VSMs of the current process were created from the survey data and improved with focus group input.**
- **The benefits of using a VSM include obtaining user input, creating better documentation and offering recommendations to streamline the process.**
- **VSMs are recommended as a structured way for OSH professionals to obtain information about user needs and ways to improve processes to reduce workplace injuries.**

Why Focus on Office Equipment?

The researchers specifically focused on office equipment because of the number of employees engaged in office-related

FIGURE 1
STUDY METHODOLOGY



tasks, the incidence of injuries in these tasks and potential costs in terms of employee health, especially musculoskeletal disorders (MSDs). Known to occur in office workers, MSDs are soft-tissue injuries that may affect muscles, tendons, ligaments, blood vessels and discs in the musculoskeletal system (Barr, Barbe & Clark, 2004; NIOSH, 2017). Physical risk factors for MSDs consist of awkward postures, contact stress, force and vibration. Factors that contribute to the severity of the disorders are frequency, duration and intensity. Studies indicate that the continued growth of computer use has increased concerns about work-related MSDs (Robertson, Ciriello & Garabet, 2013; Robertson, Huang & Larson, 2016; Robertson & O'Neill, 2003).

Many office employees spend more than 75% of their work hours seated at a computer in static or recurring awkward postures that cause strain on the body (Matos & Arezes, 2015). Studies report that 40% to 80% of computer users may have experienced work-related MSDs (Robertson, et al., 2013; Robertson, et al., 2016). Even more alarming is that upper extremity musculoskeletal symptoms reported by workers ranges from 63% to 86% (Dropkin, Kim, Punnett, et al., 2015; Robertson, et al., 2016), and 50% of employees experienced both upper-extremity and lower-back disorders (Robertson, Huang & Lee, 2017).

In addition to the human cost of these injuries, MSDs are costly for companies in not only direct costs of medical and insurance premiums, but also indirect costs such as productivity declines, turnover and loss of morale. MSDs financially affect individuals and organizations in terms of worker disability, lost work days (Bidassie, McGlothlin, Goh, et al., 2010; Choobineh, Motamedzade, Kazemi, et al., 2011), and decline in worker performance (Halford & Cohen, 2003).

Office equipment designed to place the employee in neutral postures reduces the risk of injury and supports employees' needs and well-being (Robertson & O'Neill, 2003). Procurement of office equipment, however, may require assistance from a trained ergonomist. Therefore, the procurement process for office equipment may be different from ordering supplies and equipment that do not require professional knowledge. While much information is available on the Internet about arranging office equipment by oneself, procurement processes that result in the wrong item or take excessive time may affect an employee's physical health because they do not provide the appropriate or required product in a timely manner. This could result in the employee purchasing equipment that does not fit the user, and it can potentially increase the risk of work-related MSDs among office workers (Mahmud, Bahari & Zainudin, 2014; Robertson, et al., 2013), and decrease the employee's task performance (Halford & Cohen, 2003).

Paquette (2016) discusses employees' knowledge of available services that impact their request to improve their work environment to reduce the risk of work-related MSDs from the large variety of equipment and tools. Studies demonstrate that assistance in providing office equipment that better fits an employee can reduce health risks (Bidassie, et al., 2010; Robertson, et al., 2013; Robertson & O'Neill, 2003).

Studies show that ergonomic office equipment and training help reduce MSDs. Amick, Robertson, DeRango, et al. (2003), collected short daily symptoms surveys on experienced pain level or discomfort scaled 0 (none) to 10 (extremely severe) "at the beginning, middle and end of the workday for 5 days during a workweek." Their study showed that the average difference in pain level or discomfort by the end of the day decreased 4.3 points with the ergonomic intervention (chair) and training, 2.2 points with only ergonomic training and 1.2 points for the controlled group. It demonstrated that the ergonomic intervention and training was twice as effective than only ergonomic training, and four times more effective than the controlled group with regular settings. Bidassie, et al. (2010), reported a significant decrease in the incident rates from 0.672 to 0.093 related to their 17 years implementing an office ergonomics program and providing knowledge and equipment to employees. Hoffmeister, Gibbons, Schwatka, et al. (2015), studied the effects of ergonomic programs on operational metrics, reporting the average impact from ergonomic interventions increased productivity by 66%, quality by 44%, safety records 82% and decreased workers' compensation costs by 71%. These studies discuss the benefits of ergonomic interventions and training (Robertson, et al., 2013; Robertson & O'Neill, 2003) but do not discuss how such equipment can be efficiently procured to ensure that employees receive the assistance they need to improve their well-being.

Methodology

This research consisted of two parts: 1) a survey to employees on procurement and office employee health; and 2) three focus groups with employees who were active in the procurement process. Figure 1 illustrates the order of the methodology used in this study. The survey established general knowledge of the procurement process and areas that affect process duration, quality and functionality. Focus groups established more detail on the VSM created from the survey data and provided suggestions for improvement. VSMs established a visual representation of the current process, knowledge of the process stages and differences that occurred between academic units. Information from the VSM established the different stages and types of waste. This research was approved by the Ohio University Institutional Review Board and individuals participated on an informed-consent basis. Both the methodology and results section were provided from Hayden's (2016) thesis, "Engaging Users Through the Application of Value Stream Mapping to Streamline the Procurement Process for Office Equipment" (pp. 28-29, 31, 33-36, 42-43).

The Qualtrics software program was used to create an online survey, which consisted of four sections: 1) demographics; 2) current workstation equipment; 3) procurement process knowl-

Recommendations from the focus groups provided a future value stream map to improve the process. These suggestions centered on providing the user with more information about products to order and methods to simplify the process.

edge; and 4) satisfaction with purchased items. The purpose of this part of the study was to obtain generalized information on the process of procuring office equipment and the health status of those procuring equipment. The first section, demographics, included five questions establishing participants' history with the procurement process. Demographics questions also focused on the time spent using equipment and when participants experienced discomfort or pain from daily use of equipment. The second section consisted of six questions concerning current computer workstation equipment and focused on the type and features of the office equipment participants used daily. The third section focused on the procurement process and consisted of 15 questions to determine participants' awareness and involvement with equipment purchasing procedures. The fourth and last section consisted of six questions concerning requesters' satisfaction related to the length of time to receive equipment, and the quality and function of their procured office equipment. A VSM was created from the survey data. Although VSMs are usually created from documented data such as receipts or time stamps, this one was created from survey responses and information recorded from memory.

The second part of the study consisted of three focus groups that were assembled to characterize the procurement system at the university. These focus groups included representatives from an academic department, the Equal Opportunity and Accessibility Department and a combined university library/project management group. The purpose of this part of the study was to better characterize individual departments' processes and delineate challenges, barriers and benefits of the process.

The academic focus group included five individuals familiar with the request and purchase stages. The accessibility group consisted of four participants possessing an understanding of the required stages to determine, request and purchase equipment. The combined university library/project management group handled orders of 15 to 20 pieces of office equipment and the staff were familiar with the university's stages of procurement (i.e., determine, request, purchase). The campus ergonomist made recommendations for potential focus group participants, as did the participants themselves. Participants were contacted through e-mail and completed an informal consent form (Hayden, 2016, pp. 28-29).

Focus group sessions lasted approximately 1 hour and participants did not receive compensation. Each session consisted of a group introduction, slide presentation and a discussion guided by interview questions. The slide presentation explained the concepts of a VSM and flow process gathered from the survey data. The remainder of the sessions covered questions concerning the current procurement process (Hayden, 2016, pp. 28-29).

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Each group created VSMs on their process. A current VSM (created with Visio) began with participants determining the need for equipment and finished with participants receiving equipment. Recommendations made by the focus groups helped with the development of a future VSM.

Results: Survey Data

The survey was directed to participants who work at computer workstations. Of the nearly 5,000 individuals receiving the survey, 11% responded (548 out of 4,789 people started the survey). The mean respondent age was 44.7 years (*SD* = 11.9 years). Distribution for gender responses was 62.7% female, 36.9% male and 0.37% other. The average length of employment at the university was 9.9 years (*SD* = 9.1 years). The average time spent working on a computer was 30 hours per week (*SD* = 11.7 hours/week; Hayden, 2016, p. 31).

Participants provided information on pain or discomfort experienced in nine specific areas of the body. Results indicated that slightly more than half of participants experienced pain working at a computer workstation. Figure 2 (p. 56) provides a visual breakdown on participants who acknowledge pain or discomfort in the nine areas of the body listed. Participants experienced pain in the neck, shoulders, upper back and lower back with 42% experiencing pain in the entire body section, 7% on the right side, 2% on the left side and 49% experienced no pain.

To understand the participants' work environment, the researchers asked participants what type of office equipment they currently used. The most common pieces of equipment identified were wired mouse controllers (49%), wired standard-shaped keyboards (65%), and chairs with a height-adjustable seat (28%), adjustable back support (19%), armrest (26%) and casters (24%).

Data collected on the process indicated 68% (331 of 490) of respondents recently procured office equipment. A large

FIGURE 2

PARTICIPANTS WHO EXPERIENCED PAIN IN VARIOUS PARTS OF THE BODY

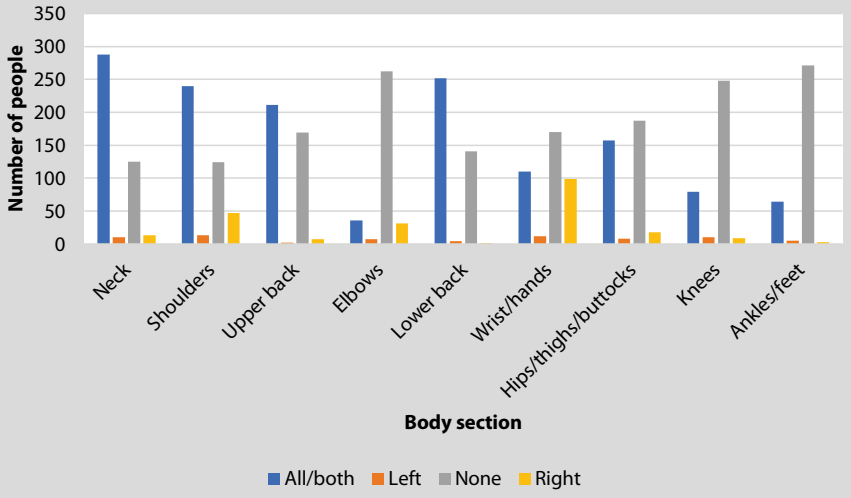


TABLE 1

SATISFACTION WITH NO ASSISTANCE VS. ERGONOMIST ASSISTANCE

Process satisfaction	Assistance	Determine	Request	Purchase	Assemble
Time	Ergo assist	62%	69%	83%	79%
	No assist	63%	55%	63%	61%
Quality	Ergo assist	85%	91%	94%	93%
	No assist	73%	67%	71%	72%
Functionality	Ergo assist	87%	94%	100%	93%
	No assist	72%	67%	72%	74%

percentage (73.8%) reported their most recently procured equipment as chairs, mouse controllers and keyboards. A small percentage reported computer desk, keyboard trays and other. The survey asked about four different stages for obtaining new equipment: 1) determining the need for the equipment; 2) requesting the equipment; 3) purchasing the equipment; and 4) assembling the equipment. Participants were actively involved in determining (36%) and requesting (36%) equipment. Results noted 40% of participants marked acquired assistance as no assistance, which means that they did not require assistance or were unaware of assistance for that procurement stage. Reports indicated 21% of assistance came from coworkers, 14% from others, 14% from supervisors and 11% from the university ergonomist. Participants reported other assistance came from administrators or vendors.

The survey asked respondents about their overall satisfaction on the length of time required to procure equipment, and the quality and functionality of the procurement process satisfaction was rated using a five-point Likert scale of 1) very dissatisfied; 2) dissatisfied; 3) neutral; 4) satisfied; and 5) very satisfied. The overall satisfaction for both somewhat and very satisfied rates for length of time, quality and functionality were in the range of 50% to 83%, even though the responses for dissatisfaction were small (10%). Of the three areas, length of time had a lower satisfaction compared to quality and function. Lower satisfaction was seen for the purchase of chairs, keyboard trays and computer desks compared to keyboards, mouse controllers and other equipment.

Table 1 compares the process satisfaction of no assistance versus ergonomist assistance in length of time, quality and functionality at each stage. There was no significant difference in satisfaction on the length of time ($df = 7, f = 5.98, p = .5$) between the ergonomist assistance and no assistance in the procurement process. Satisfaction in the length of time illustrated little differences in determine (1%), request (8%) and purchase (9%) stages but assembled equipment had 18% higher satisfaction with ergonomist assistance than no assistance. There was significant difference of satisfaction for both the quality ($df = 7, f = 69.42, p = .000$) and functionality ($df = 7, f = 58.02, p = .000$) on the procured equipment in the process. Both quality and functionality indicated higher percentage satisfaction with the ergonomist assistance than no assistance. The percentage difference in each stage of quality satisfaction was 12% to determine equipment, 23% to request, 23% to purchase and 21% to assemble. The percentage difference for each stage of functionality was 16% to determine equipment, 27% to request, 28% to purchase and 19% to assemble. Overall, assistance from the professional ergonomist resulted in higher satisfaction ratings for office equipment quality and functionality than those rating for processes with no assistance.

Value Stream Map

Information from the survey provided a basic skeletal structure of the current procurement process (Figure 3). The three focus groups provided more detail on the current procurement process. VSMs provide different features to illustrate the process. A feature indicating suppliers and consumers was used to represent vendors, and the initial and end stages. Each of the four arrows between the stages have different meanings. The solid black arrows are used to represent information sent between stages: The straight arrow is manual information and the zig-zag is electronic information. A thick solid green arrow represents equipment transported from vendor to consumer, while the striped arrow represents equipment moved between the process. In manufacturing, the triangle represents inventory between stages but in this case study it was used to represent wait time. The bottom of the map divides the times for each process and the overall cycle time.

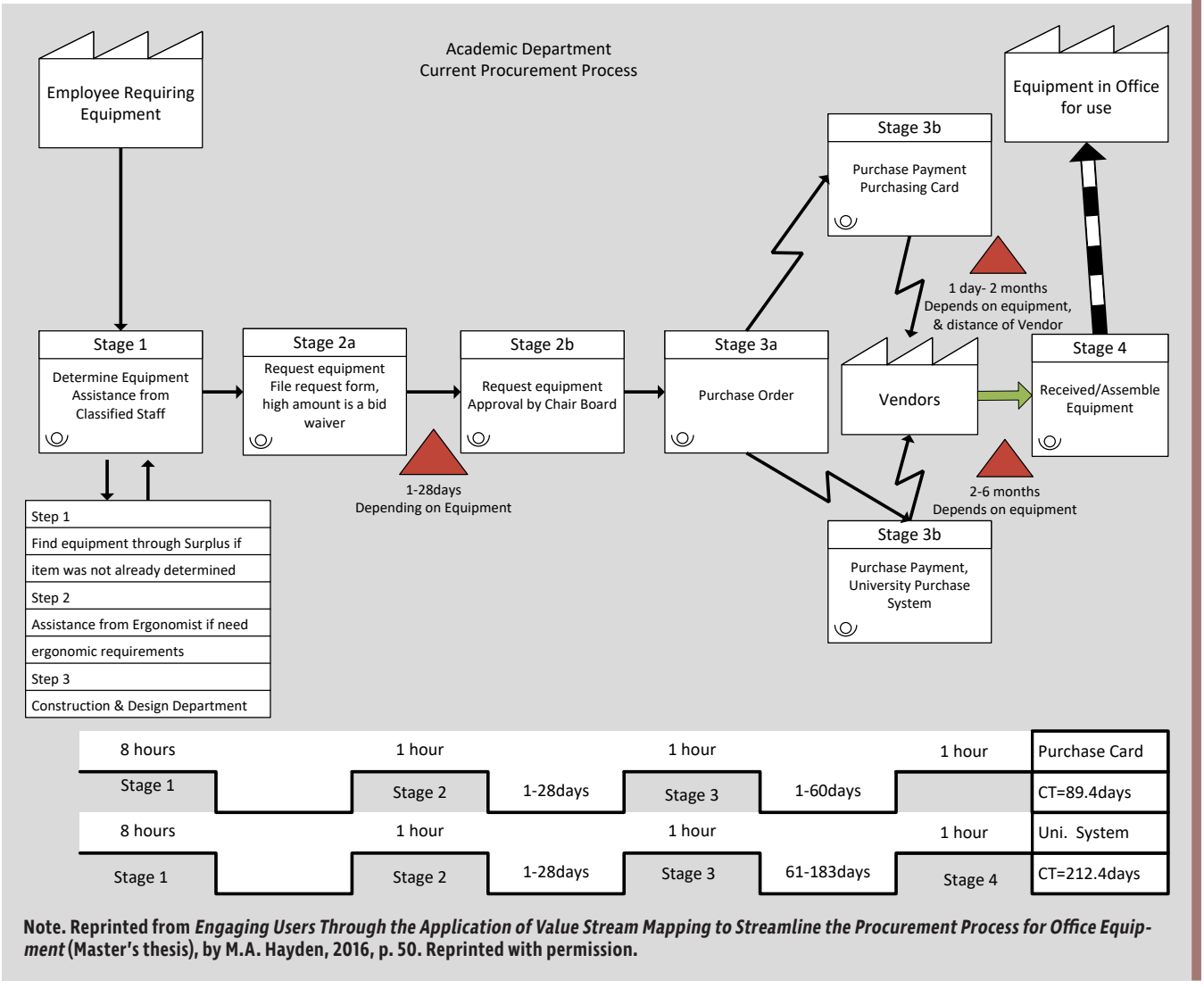
Both the survey data and the data from the three focus groups consisted of four stages between initiating the pro-

cess and receiving the equipment: 1) determine equipment; 2) request equipment; 3) purchase equipment; and 4) assemble equipment. Survey and focus group data collected participants' estimated cycle time used to complete the task at each stage. Figure 3 shows one of the current VSMs created from the collected data. Between the survey data and focus groups, the decision to replace equipment occurred for reasons including broken or worn down, causing discomfort or ergonomic support. The information from the survey data and focus groups showed a difference in the knowledge of the current procurement process. The main differences were assistance acquired at the stages, purchasing process and time length. The creation of the VSMs demonstrated that procurement processes differed between the departments. This was not evident from the survey and thus justified the use of the focus groups to collect more detailed data.

Recommendations from the focus groups provided a future VSM to improve the process. These suggestions centered on providing the user with more information about products to order and methods to simplify the process. For example, participants recommended that a catalog with a simple interface and details on price with listed benefits could reduce time on approval in the request stage. Preapproved resources in a catalog could reduce the time spent for approval in procurement services. An inventory list of ergonomic equipment already on campus or in company stock could decrease the time to purchase equipment. Improving communication between the ergonomist and procurement services to help employees procure equipment to fit their needs would also be beneficial. Another solution was to create a decision tree that would direct an employee on which steps to take to procure equipment and the type of assistance needed. In some cases, depending on the established procurement policy, it may limit the changes to reduce the time frame. During the wait time it may benefit employees by providing ergonomic training. This could avoid instances of employees not knowing how to adjust equipment to a neutral posture.

FIGURE 3

CURRENT VALUE STREAM MAP



Note. Reprinted from *Engaging Users Through the Application of Value Stream Mapping to Streamline the Procurement Process for Office Equipment* (Master's thesis), by M.A. Hayden, 2016, p. 50. Reprinted with permission.

Conclusion

This study successfully applied the lean manufacturing VSM to understand the procurement process for office equipment. A two-part methodology was utilized to obtain generalized information from university employees as well as more specific data from three different departments. A review from the survey and focus group VSMs provided the difference between the known process and the employee's belief about the procurement process. The survey and the focus groups demonstrated the importance of assistance and communication acquired in the procurement process. The survey also demonstrated that procurement done with the assistance of a professional ergonomist led to better procurement decisions. Individuals rated both quality and functionality with a significantly higher percentage satisfaction when they had ergonomist assistance. These results are important because poor procurement decisions can lead to not only waste (in the form of unused equipment), but also poor working conditions and increased risk for injury.

In addition to outlining the process, the study showed that using a VSM can point to differences that can then be used to develop suggestions for improvement. In today's world of changing technology, products and processes, the ability to identify problems and correct them in a timely manner is extremely important. OSH professionals are evaluated on different metrics, and being able to obtain input is important in accomplishing their goals (Minnick & Wachter, 2019). The VSM gives the user the ability to do this quickly without the need for a large sample size. The tool can be easily learned and applied to procurement and safety applications. As a fundamental tool for lean processes, its use for safety applications produces results and metrics that are understandable to the business world and, as such, places the improvement and worth of safety interventions at the table with business processes and metrics. **PSJ**

References

Abdulmalek, F.A. & Rajgopal, J. (2007). Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. *International Journal of Production Economics, 107*(1), 223-236. doi:10.1016/j.ijpe.2006.09.009

Amick, B.C., Robertson, M.M., DeRango, K., et al. (2003). Effect of office ergonomics intervention on reducing musculoskeletal symptoms. *Spine, 28*(24), 2706-2711.

Barr, A., Barbe, M. & Clark, B. (2004). Work-related musculoskeletal disorders of the hand and wrist: Epidemiology, pathophysiology and sensorimotor changes. *Journal of Orthopaedic and Sports Physical Therapy, 34*(10), 610-627. doi:10.2519/jospt.2004.34.10.610

Bidassie, B., McGlothlin, J., Goh, A., et al. (2010). Limited economic evaluation to assess the effectiveness of a university-wide office ergonomics program. *Applied Ergonomics, 41*(3), 417-427. doi:10.1016/j.apergo.2009.09.005

Choobineh, A., Motamedzade, M., Kazemi, M., et al. (2011). The impact of ergonomics intervention on psychosocial factors and musculoskeletal symptoms among office workers. *International Journal of Industrial Ergonomics, 41*(6), 671-676. doi:10.1016/j.ergon.2011.08.007

Dropkin, J., Kim, H., Punnett, L., et al. (2015). Effect of an office ergonomic randomized controlled trial among workers with neck and upper extremity pain. *Occupational and Environmental Medicine, 72*(1), 6-14.

Halford, V. & Cohen, H.H. (2003). Technology use and psychosocial factors in the self-reporting of musculoskeletal disorder symptoms in call center workers. *Journal of Safety Research, 34*(2), 167-173. doi:10.1016/S0022-4375(03)00012-4

Hayden, M.A. (2016). *Engaging users through the application of value stream mapping to streamline the procurement process for office equipment* (Master's thesis). Retrieved from https://etd.ohiolink.edu

Hofacker, A., Santos, A. & Santos, A.P.L. (2012). A critical view of the German procurement process in the sector. *Ambiente Construído, 12*(3), 45-56. doi:10.1590/S1678-86212012000300004

Hoffmeister, K., Gibbons, A., Schwatka, N., et al. (2015). Ergonomics climate assessment: A measure of operational performance and employee well-being. *Applied Ergonomics, 50*, 160-169. doi:10.1016/j.apergo.2015.03.011

Mahmud, N., Bahari, S.F. & Zainudin, N.F. (2014). Psychosocial and ergonomics risk factors related to neck, shoulder and back complaints among Malaysia office workers. *International Journal of Social Science and Humanity, 4*(4), 260-263.

Matos, M. & Arezes, P.M. (2015). Ergonomic evaluation of office workplaces with rapid office strain assessment (ROSA). *Procedia Manufacturing, 3*, 4689-4694. doi:10.1016/j.promfg.2015.07.562

Minnick, W.D. & Wachter, J.K. (2019, Jan.). The role of leading and lagging indicators in evaluating OSH professionals' performance. *Professional Safety, 64*(1), 32-36.

NIOSH. (2017). Elements of ergonomics programs. Retrieved from www.cdc.gov/niosh/topics/ergonomics/ergoprimer/step1.html

Paquette, S. (2016). Ergonomic accommodation in return to work. In I.Z. Schultz & R.J. Gatchel (Eds.), *Handbook of return to work: From research to practice* (pp. 307-326). New York, NY: Springer Science+Business Media.

Robertson, M.M., Ciriello, V.M. & Garabet, A.M. (2013). Office ergonomics training and a sit-stand workstation: Effects on musculoskeletal and visual symptoms and performance of office workers. *Applied Ergonomics 44*(1), 73-85. doi:10.1016/j.apergo.2012.05.001

Robertson, M.M., Huang, Y.H. & Larson, N. (2016). The relationship among computer work, environmental design, and musculoskeletal and visual discomfort: Examining the moderating role of supervisory relations and coworker support. *International Archives of Occupational and Environmental Health, 89*(1), 7-22.

Robertson, M.M., Huang, Y.H. & Lee, J. (2017). Improvements in musculoskeletal health and computing behaviors: Effects of a macroergonomics office workplace and training intervention. *Applied Ergonomics, 62*, 182-196. doi:10.1016/j.apergo.2017.02.017

Robertson, M.M. & O'Neill, M.J. (2003). Reducing musculoskeletal discomfort: Effects of an office ergonomics workplace and training intervention. *International Journal of Occupational Safety and Ergonomics, 9*(4), 491-502. doi:10.1080/10803548.2003.11076585

Schwerha, D.J., Boudinot, A. & Loree, N. (2017). Integrating safety with process improvement for sustainable manufacturing. *Proceedings of the 2017 IISE Annual Conference, Pittsburgh, PA*.

Simon, R.W. & Canacari, E.G. (2012). A practical guide to applying lean tools and management principles to health care improvement projects. *AORN Journal, 95*(1), 85-103.

Tan, K.C. (2001). A framework of supply chain management literature. *European Journal of Purchasing and Supply Management, 7*(1), 39-48.

Teichgraber, U.K. & de Bucourt, M. (2011). Applying value stream mapping techniques to eliminate non-value-added waste for the procurement of endovascular stents. *European Journal of Radiology, 81*(1), e47-52. doi:10.1016/j.ejrad.2010.12.045

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