ORIGINAL ARTICLE

Improving the conduct of systematic reviews: a process mining perspective

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Abstract

Objectives: To illustrate the use of process mining concepts, techniques, and tools to improve the systematic review process.

Study Design and Setting: We simulated review activities and step-specific methods in the process for systematic reviews conducted by one research team over 1 year to generate an event log of activities, with start/end dates, reviewer assignment by expertise, and person-hours worked. Process mining techniques were applied to the event log to "discover" process models, which allowed visual display, animation, or replay of the simulated review activities. Summary statistics were calculated for person-time and timelines. We also analyzed the social networks of team interactions.

Results: The 12 simulated reviews included an average of 3,831 titles/abstracts (range: 1,565−6,368) and 20 studies (6−42). The average review completion time was 463 days (range: 289−629) (881 person-hours [range: 243−1,752]). The average person-hours per activity were study selection 26%, data collection 24%, report preparation 23%, and meta-analysis 17%. Social network analyses showed the organizational interaction of team members, including how they worked together to complete review tasks and to hand over tasks upon completion.

Conclusion: Event log and process mining can be valuable tools for research teams interested in improving and modernizing the systematic review process. © 2018 Elsevier Inc. All rights reserved.

1. Introduction

Systematic reviews are essential to inform clinical and policy decision-making [1−3]. The publication of systematic reviews has increased rapidly, a 28-fold increase over 20 years from 1991 to 2014 [4], currently at about 11 reviews per day [5]. Methods for the conduct and reporting of systematic reviews have become more rigorous over time, as documented in guidance from authoritative organizations that develop methods for systematic reviews [6−8] and have further prolonged the completion of systematic reviews [9].

What is new?

Key findings
- A research team can capture process data related to the conduct of multiple reviews using an event log of review activities, with activity start and end dates, reviewer performing the activity, and hours spent on the activity.

- The number of variables needed in the event log to realistically model the review process is small. Thus, it is feasible to collect these data as part of the team's routine operation.

- Process models obtained from mining the event log illustrated the flow and characteristics of review activities and provided a framework to evaluate and improve step-specific methods of the review process.

- Social networks obtained from mining behavioral data capturing interactions among reviewers illustrated how team members worked together to complete tasks and how tasks were handed over among members.

What this adds to what was known?
- Information obtained from process mining techniques using event logs is currently not available to researchers, policy-makers, and other stakeholders interested in scoping, planning, and prioritizing reviews, making process improvements, or applying innovative computer technologies to improve or automate the systematic review process.

What is the implication and what should change now?
- Event log data can be useful for managing research teams conducting systematic reviews. Process mining tools, using such data, can provide a practical and informative approach toward improving and modernizing the systematic review process.

Allen and Olkin estimated in 1999 that a well-conducted systematic review with meta-analysis can take between 1,000 and 2,000 person-hours to complete [10]. More recently, Borah et al. (2017) estimated that on average 67 weeks and at least five reviewers are needed to complete a well-conducted systematic review [11]. Concern with the growth of primary-research studies and review, the resources they require and the long turn-around times has mobilized international efforts to improve the efficiency of systematic reviews [12,13].

Process mining offers a unique opportunity to identify and address inefficiencies in systematic reviews. Process mining is a process management technique that analyzes business processes using data related to the activities and events taking place in business conduct [14]. The data are recorded in event logs: data sets that typically record activities, employee information, time stamps, resources, and other attributes of events related to the activities. Specialized data-mining algorithms are then applied to event logs to identify trends, patterns of activities, and organizational interactions among employees [14]. In a literature review, Rojas et al. (2016) identified 74 case studies of process mining in health care, including applications to study medical treatment processes and organizational processes, with frequent applications in oncology and surgery [15]. Process mining was used to address questions, including what happened (e.g., observing a typical working day of a surgeon), why it happened (i.e., understanding the activities and circumstances characterizing the situation and action, such as long waiting lists), what will happen (i.e., identifying the circumstances of when or how a specific activity will take place, such as the likelihood of a patient deviating from expected treatments), and what is the best that can happen (i.e., identifying possible steps toward improvements, such as the sequence of activities that reduce flow time).

Figure 1 outlines a multidisciplinary research team specialized in the production of systematic reviews. The research team assembles an appropriate team for each new review, addresses the specific research question, conducts the review according to recommended methods [6], and coordinates activities within and across review teams to produce reviews on time and within budget. Reviewers routinely use literature databases, software for creating databases and data collection forms, and data analysis software for meta-analysis and qualitative synthesis, among others.

Reviewers are typically supported by an information system for the collection, organization, storage, and communication of information. They also use communication technologies for their operation. Although it may not be routinely done, it is feasible to record review activities, the identification of reviewers, start and end dates of each activity, and activity-specific person-time. This would produce an event log of activities, which represents the operation of the research team, including the conduct of multiple reviews over time.

The lower part of Figure 1 outlines how process mining can be used by review teams to gain insights into the conduct of systematic reviews using techniques and tools for process discovery, conformance checking, and process enhancement [14], among others. Process discovery allows a process model to be extracted from an event log. The process model provides a functional map of the review activities, their inter-relations and timelines, including the roles of those involved in, or affected by, the process. Process models can be used for visual display, providing a hierarchical structure that facilitates the inspection of activities at different levels of details. Typically these models can be "replayed" with animation to illustrate