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Towards an evaluation framework for Laboratory Information Systems

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Summary
Introduction: Laboratory testing and reporting are error-prone and redundant due to repeated, unnecessary requests and delayed or missed reactions to laboratory reports. Occurring errors may negatively affect the patient treatment process and clinical decision making. Evaluation on laboratory testing and Laboratory Information System (LIS) may explain the root cause to improve the testing process and enhance LIS in supporting the process. This paper discusses a new evaluation framework for LIS that encompasses the laboratory testing cycle and the socio-technical part of LIS.
Methodology: Literature review on discourses, dimensions and evaluation methods of laboratory testing and LIS. A critical appraisal of the Total Testing Process (TTP) and the human, organization, technology-fit factors (HOT-fit) evaluation frameworks was undertaken in order to identify error incident, its contributing factors and preventive action pertinent to laboratory testing process and LIS.
Result: A new evaluation framework for LIS using a comprehensive and socio-technical approach is outlined. Positive relationship between laboratory and clinical staff resulted in a smooth laboratory testing process, reduced errors and increased process efficiency whilst effective use of LIS streamlined the testing processes.
Conclusion: The TTP-LIS framework could serve as an assessment as well as a problem-solving tool for the laboratory testing process and system.

Introduction

Laboratory testing errors can happen at any stage of the testing process, from the pre-analytic

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steps (for example, test selection and ordering, specimen collection) to post-analytic steps (for example, reporting and interpreting results, notifying patients) [1]. Errors in laboratory testing generally include unreasonable testing order (e.g.: additional test copy, duplicate test); wrong patient identification/specimen/labelling; unidentified failure in quality control; problems in handling, storing and transporting test sample; wrong validation of data analysis; and data entry error [1—5]. Various strategies have been used to reduce error and monitor workflow performance in laboratory including quality control programme and Information Systems/Technology [2,3]. The use of Health Information Systems (HIS), particularly Laboratory Information Systems (LIS) to validate, manage, deliver, process, and store data should reduce problems and ease process implementation in the laboratory testing workflow [6]. LIS facilitate smooth and fast interaction between medical practitioners and laboratory staff, specifically in ordering tests and delivering test reports [7—9]. However, numerous error factors related to LIS have also been reported including wrong data entry and access; poor system interface and reporting; limited system functionality; and incompetent users [1,10,11]. The involvement of multiple units in a workflow requires effective methods to monitor the task performance as the method would ensure process smoothness and ease error detection.

The paper aims to discuss influencing factors for errors in laboratory testing processes and LIS as well as to present our proposed framework known as TTP-LIS which combined laboratory process and socio-technical factors. The framework makes use of the original Total Testing Process (TTP) framework and combines it with Human, Organization, Technology-fit (HOT-fit) framework [12]. Laboratory related errors are briefly described in this introduction section. Section two discusses the theoretical background of TTP and HOT-fit frameworks; the basis of our proposed framework. The third section illustrates the new framework whilst the discussion and conclusion are included in the last section.

Theoretical background

LIS supports laboratory requirements [13] and integrates multiple laboratories [8]. However, the LIS role in preventing recurring error in laboratory testing process is still a work in progress. Platform heterogeneity in lab-clinical settings [14,15] which involve system development, software use, discrepancy in technology management and information systems used in both settings, contribute to error incidents. In order to identify root causes, error incident in laboratory testing processes needs to be evaluated rigorously. Laboratory testing generally consists of nine steps: (1) test request; (2) sample collection; (3) sample labelling; (4) transportation of labelled sample to the lab; (5) preparation of raw specimen; (6) analysis of specimen testing; (7) interpretation of test results; (8) reporting of test interpretation; and (9) archiving of test results [16]. These steps are represented in a framework known as Total Testing Process (TTP); it can be used to evaluate laboratory process while the socio-technical aspects of LIS require another evaluation framework called the HOT-fit framework which takes a socio-technical approach to represent the interaction of social and technical in IS. The following section elaborates TTP and HOT-fit framework and their relationship that formed TTP-LIS.

Total Testing Process (TTP) framework

TTP is used as a basic guideline in the testing process of medical laboratories. It is a unique framework for analysing and minimising error risk not only in laboratory test centre but also in other clinical units [17]. TTP encompasses internal and external laboratory activities that comprise of one or more procedures and require interaction between internal and external laboratory staff. Failure in any TTP activity can affect patient care as doctors make decisions based on clinical results obtained from laboratory [18].

The original TTP framework was introduced by Lundberg [19], known as *brain-to-brain loop* concept (Fig. 1). The concept has been used by medical practitioners in conducting lab testing processes; from a triggered idea to testing patient samples to taking action in treating a patient. The simplified Lundberg concept in Fig. 1 illustrates the thoroughness of laboratory processes, from ordering tests to generating and utilising laboratory test results. The evidence of implementation effectiveness in each step indicates error reduction in patient care and treatment. TTP workflow in medical laboratories also focuses on process smoothness as smooth and systematic process yield to effective quality control. Process thoroughness based on productive and ethical work culture is critical in maintaining and improving workflow quality as it contributes to minimising error and subsequently ensuring patient safety [20].

The testing steps in Fig. 1 can be aggregated into five phases namely pre-pre-analytic, pre-analytic, analytic, post-analytic and post-post-analytic, as