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Dental Environment: Incorporating the Work Systems Approach

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The National Institutes of Health (NIH) and the Centers for Disease Control and Prevention (CDC) released a joint report in 2005 that showed the oral health status of Americans has rapidly improved during the past decade (Centers for Disease Control and Prevention [CDC], 2005). Limited public data is available, however, on errors and malpractice in the dental environment that impact patient and dental care personnel (i.e. the dentists, oral surgeons, dental assistants, and hygienists) safety. The American Dental Association (ADA) released a survey, for the first time, which attempted to capture information on trends in dental malpractice claims. Generally, the malpractice claims are a result of errors in the dental environment (Strickland, 2005). The ADA argued that the investigations of dental malpractice claims have utility beyond just being vehicles of comparison between professions and can be possible indicators of future global trends; however, the ADA asserts that information obtained from dental malpractice claims is most useful in efforts directed at risk management educational efforts focused on ameliorating the quality of patient care (ADA, 2005). While the ADA survey only provided a snapshot of the malpractice claims that exist, it reveals several malpractice claims that suggest that the dental care environment shares affinities with other healthcare settings identified in the Institute of Medicine's (IOM) 2001 review of health care systems. The Institute of Medicine (IOM) completed a review of health care systems and found that many of the systems were poorly organized; medical records were incomplete; there were an unacceptable number of medical errors; the systems were fragmented and unfriendly to many patients and lacked control over ensuring that care is completed (IOM, 2001). While all of the findings of the IOM are not applicable to the dental care systems, much is consistent with the data found in the ADA study—poor recordkeeping and communication issues were identified and were some of the leading causes of dental malpractice claims.

Dental care personnel safety is also an important component to study when reviewing the dental environment. Observational studies and surveys indicate that percutaneous or sharp injuries among general dentist and oral surgeons occur less frequently than among general and orthopedic surgeons, and that these injuries decreased in frequency during the 1990s (Siew et al., 1992; Siew et al., 1995, Cleveland et al., 1995; Gooch et al., 1998; McCarthy et al., 1999). Recent studies show, however, that needle sticks and other blood contacts continue to occur, placing health care personnel at risk of infection and experiencing emotional distress even when a serious disease is not transmitted (Cleveland et al., 2007; Armstrong, et al., 1995). The National Institute for Occupational Safety and Health issued a report that roughly estimated 600,000 to 800,000 healthcare workers annually experience needlestick and other precutaneous injuries (National Institute of Occupational Safety and Health, 1999).

When errors occur and things go wrong, it is logical for an individual and/or organization to question the dental care personnel's skill. Blaming the dental care personnel is not the best way to eliminate errors. Looking at errors from a system perspective, however, will influence an individual and/or organization to evaluate the entire work system. A system[8] is an entity that exists to carry out some purpose; it involves subsystems, hierarchies and is surrounded by an environment. Rivera and Karsh (2008) succinctly state that in the healthcare milieu, the ultimate purpose of the system is to provide safe, high-quality patient care. In this paper, the dental environment is the system investigated. A dental environment includes the procedures, policies, processes, technologies, tools and individuals that work conjunctively to provide dental care to patients. The objectives of this article is to (1) initiate the need for researchers to engage in substantial research about patient and dental care personnel safety in the dental environment, and (2) suggest a systems approach as an effective construct for evaluating the dental environment.

Systems Engineering Initiative to Patient Safety (SEIPS) and Background

A systems approach suggests that human error is often caused by a combination of work system factors within an environment rather than simply the incompetence of the individual dentist (Wiegmann et al., 2007). The Systems Engineering Initiative to Patient Safety (SEIPS) model (Carayon et al., 2006) implies that in addition to dental skill and the condition of the patient, errors and patient outcomes are also impacted by such factors as the work environment (i.e. lighting, temperature, sound and etc.), tools and technology design (i.e. needle holders, probes, root elevators, visual x-rays [XDR]and etc.), organizational variables (i.e. training, policies, procedures), team member collaborations and tasks (ElBardissi et al., 2007; Carthey et al., 2001; Wiegmann et al., 2003). The SEIPS model (Figure 1) integrates Donabedian's (1988) structure-process-outcome framework and the work system model developed by Smith and Sainfort-Carayon (1989). The SEIPS model has three overarching elements: the work system, the process, and the outcomes. The structure of an organization (the work system) affects the extent to which safe care is provided (the process), and the caring for and managing of the patient (the process) affects the likelihood of the patient completing his or her experience without impairment (the outcome). The organizational structure also influences employee and organizational outcomes. As illustrated (Figure 1), the SEIPS model recognizes the mutually dependent nature of the five core elements of a work system—an individual performing various *tasks* using *tools and technology* in a given *environment* within an established *organization*.

The SEIPS model is based on the Balance Theory of Job Design and the concept of healthy organizations (Carayon et al., 2006). The Balance Theory of Job Design aims to "improve motivation and performance and reduce stress and the negative health consequences by 'balancing' the various elements of the work system to provide positive aspects to counter the negative ones and all aspects of the job are considered in developing a proper design" (Carayon and Smith, 2000; Smith and Sainfort-Carayon, 1989). The Balance Theory of Job Design posits that the various elements of the work system interact to produce a stress load that can have biological, emotional, and behavioral consequences that can lead to positive and negative outcomes on an individual's job performance (Carayon and Smith, 2000).

[8] Rivera and Karsh (2008) write, "systems can be bounded by temporal boundaries (e.g., first shift, second shift), hierarchical boundaries (e.g., a hospital unit within a hospital), spatial boundaries (e.g., a patient's room, the cafeteria), and process boundaries (e.g., scrubbing in for surgery, performing surgery)" (as cited in Karsh and Alper, 2005) (p. S174).

The SEIPS model has been used in various health care settings including outpatient surgery (Hundt, 2003; Hundt, 2004; Alvarado et al., 2004; Carayon et al., 2005; Carayon et al., 2004), pediatric hospital, home health care (Sainfort et al., 2001; Karsh et al., 2005), intensive care, and ambulatory care. It also has been instrumental in system designs associated with technology implementation like electronic health records and computerized physician order entry (COPE) (Hamilton-Escoto et al., 2003; Karsh et al., 2004; Carayon et al., 2004; Wetterneck et al., 2004).

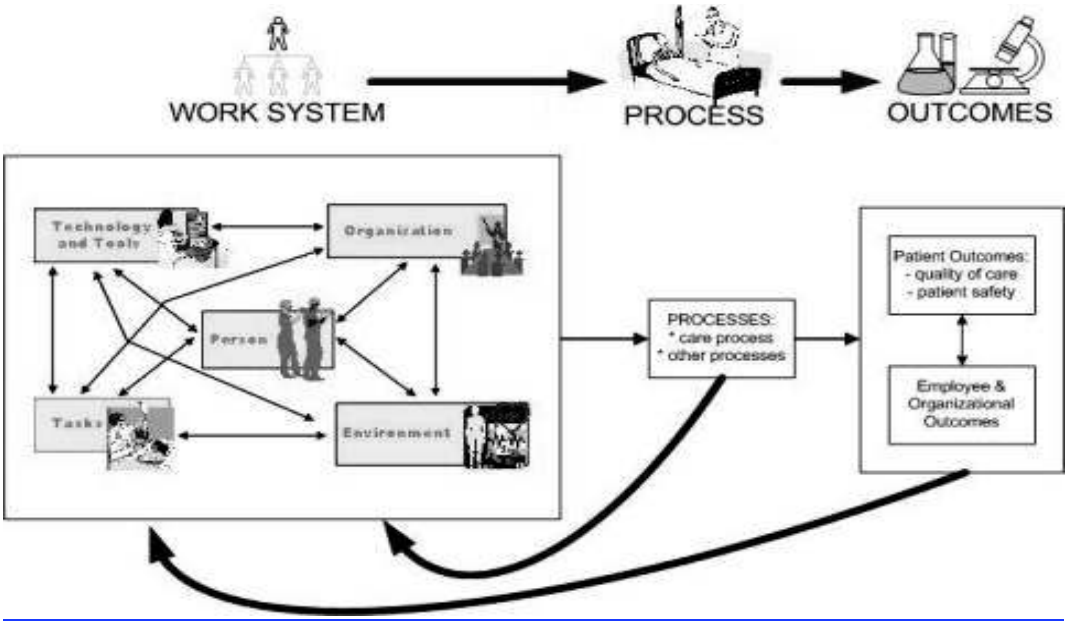

Figure 1: Systems Engineering Initiative for Patient Safety (SEIPS) Model of work system and patient safety (Carayon et al., 2006; Donabedian's 1988). Reprinted with permission from Carayon et al. 2006.

A systems approach to dental practice evaluation is a relatively new intervention and can provide a thorough understanding of outcomes associated with the dental environment. A mounting awareness of the impact that systemic factors have on shaping performances in various health care settings is evolving. Unfortunately, this growing acceptance of the systems perspective has not fully translated into a similar development of effective patient safety programs in the dental environment. Like in other health care settings, the dental literature implies that much of the dental patient safety programs have been developed without a full understanding of the underlying systemic problems that have contributed to errors. Much of the data concerning factors that impact patient safety in the dental environment has come primarily from anecdotal and sentinel event reports that often lack details concerning the specific nature of the systemic problems. These event reports often come from resources such as the Center for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), U.S. Food and Drug Administration (FDA), and the American Dental Association (ADA). For instance, the FDA released a 2007 report that warned dental care personnel about serious patient injuries, including third degree burns associated with the use of poorly maintained electric dental

handpieces (U.S. Food and Drug Administration [FDA], 2007). Although the report recommends actions to prevent or minimize the problem, it does not address systematic problems that lead to the poor maintenance of the dental handpieces. For instance, it does not address the possibility that cleaning and maintaining the equipment probably does not integrate into the workflow of the dental care personnel seamlessly. An urgent need exists for critical analyses of the dental environment to better understand how the system impacts the outcomes of dental care.

A study conducted by Irwin et al. (2009) provides a Consolidated Flow Model (Figure 2) that offers an overview of individuals, roles, tasks, artifacts and interactions in the work process of initial dental examination and treatment planning appointments. This model unveils the complex dental environment workflow and its significant vulnerabilities for error incidences. Irwin et al.'s purpose for the study was to develop a "comprehensive, empirical model for clinical work in the dental office that would provide a detailed understanding of workflow and information management during initial examination and treatment planning appointments in general dentistry" (p. 1). This study wanted to "learn how dental clinicians work together, communicate, and interact with their environment, and how technology is integrated into workflow" (p. 1). Irwin et al.'s study did not focus on patient and dental care personnel safety; however, the study reveals several breakdowns that can arguably lead to errors in dental care that can impact the safety of patients and dental care personnel. Breakdowns are described in Irwin et al.'s research as interruptions to the workflow, and interruptions to the workflow can lead to errors and unwanted outcomes (Wiegmann et al., 2007). Breakdowns that were identified were generally related to the recording or retrieval of information, technology, and procedures. Arguably, Irwin et al.'s study provides a solid validation of previous studies (Button et al., 1991; Weerakkody et al., 2003; Wotman et al., 2001), but it integrated a more systematic approach to dental practice research.

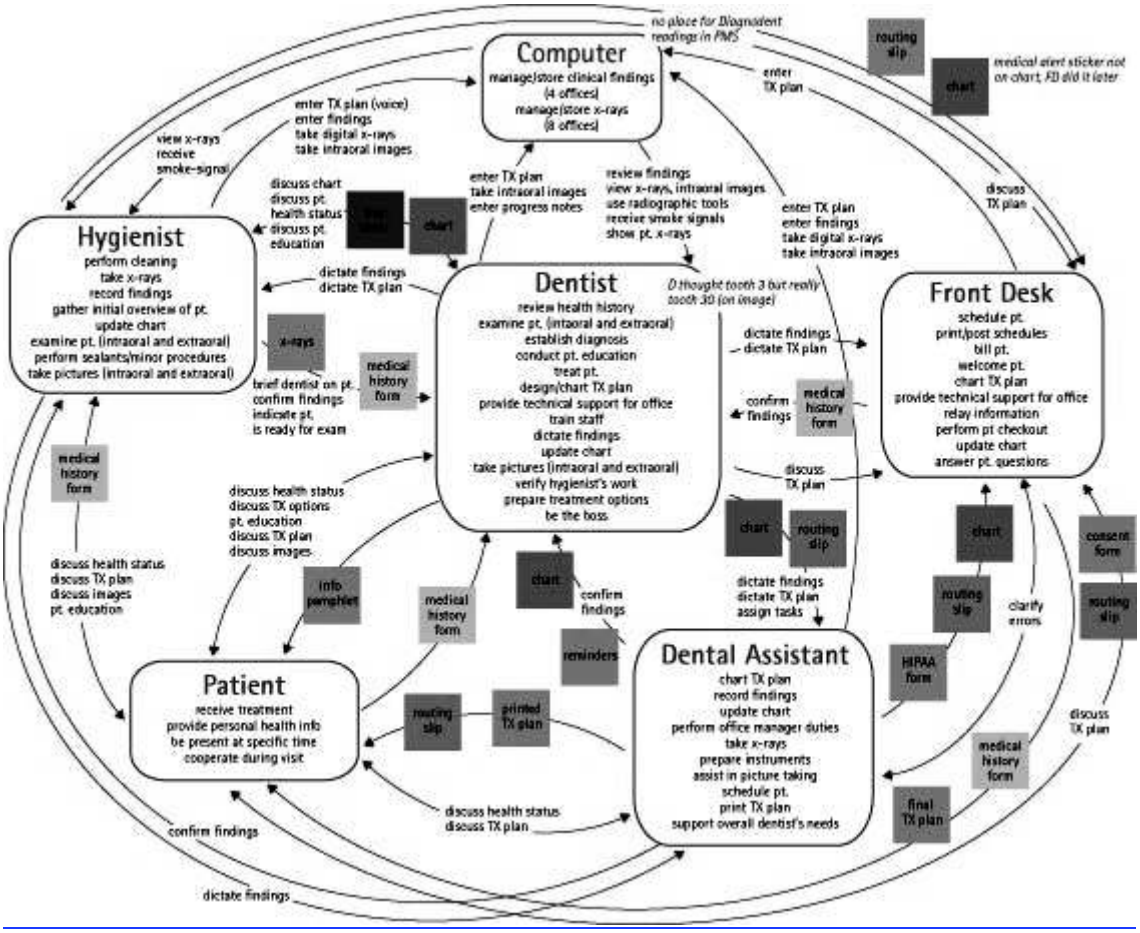

Figure 2: Consolidate Flow Model (Irwin et al., 2009). Reprinted with permission from Irwin et al. 2009.

Since Irwin et al. (2009) presents us with a complete understanding of the workflow of the dental environment, one can easily understand how the SEIPS model can be used to understand how different factors in the work system can influence care processes and affect both patient and dental care personnel outcomes. It is worth reiterating that the SEIPS model assumes that patient safety is determined by the way a work system (i.e. dental environment) and various processes, including the patient care process, are designed. The SEIPS model also assumes that work system design influences organizational and individual outcomes and that organizational and individual outcomes are related to patient safety outcomes (Carayon, 2006).

The subsequent sections highlight the *tools and technology* and *individual* elements of the SEIPS models relevant to the leading causes of dental malpractice claims, poor recordkeeping and communication issues, identified by the ADA 2005 report. For simplification, poor recordkeeping is categorized under the SEIPS model's *tools and technology* element, since most of the recordkeeping in the dental environment is done using a patient chart or computer technology (Irwin et. al, 2009). Communication is coupled into the SEIPS model's *individual* element simply because verbal communication among dental care personnel is essential in the dental environment. Irwin et al.'s (2009) study found that dental software supported few, if any, communication requirements in the dental environment and therefore much of the communication among dental care personnel was verbal. The goal of the following sections is to

highlight the importance of understanding each element (tools and technology and individual) in the context of the SEIPS model.

Tools and Technology Implementation

Using the SEIPS model, one can better understand how to implement changes in a system and how those changes can affect the workflow. For instance, the use of the SEIPS model can assist in implementing new technologies in the dental environment to minimize disruptions to the workflow that can possibly lead to unwanted errors in patient care. Technology is only one of five elements of the work system model (Carayon & Smith, 2000; Smith & Carayon-Sainfort, 1989). Understanding how the different elements in the work system model interact with existing technologies can provide an unyielding amount of information for improving the workflow of the dental environment with the use of new technology. A few studies (Thomas et al., 2003; Schleyer et al., 2006; Irwin et al., 2009) show that the majority of dentists use computers only for administrative purposes, but not in the clinical environment. Irwin et al. (2009) proved computers interrupted and/or hindered individuals from performing common tasks. Computers tended to interrupt the workflow, caused individuals to have to redo computer-aided work, and increased the number of steps in a work process. Overall, Irwin et al. state that technology did not integrate well with existing equipment and required workarounds because some technologies did not have all the functions needed to complete various tasks. If the dental environment was assessed prior to the design of such technologies, integrating the technologies within the system would be seamless. Technology that is well integrated can possibly reduce interruptions in the workflow that can lead to unwanted outcomes. Carayon et al. (2008) explain that the SEIPS model focuses on the system factors that need to be redesigned to foster effective performances from healthcare providers and promote and buttress patient safety.

Carayon et al. (2008) further highlight that technologies are being introduced at an increased pace in healthcare, primarily to enhance the quality and safety of patient care (Bates & Gawande, 2003). Carayon et al. (2008) noted that considerable pressure has been placed on healthcare organizations to use technologies to prevent medical errors and improve patient safety. For instance, bar coding medication administration technology that matches patients with the right medication and IV (intravenous) infusion pump technology that can set drug dosing limits have been proposed as solutions to reduce medication administration errors (Institute of Medicine Committee on Quality of Health Care in America, 2001). According to the SEIPS Model (Carayon et al., 2006), it is important to understand the systemic impact (i.e. the possible positive and negative impact) of technology on the rest of the work system. Understanding the systemic impact of technology on the entire system will assist with the technology design and provide a seamless implementation process for new technologies. Designing the technology to fit the system can reduce errors and competently improve patient and dental care personnel safety. For instance, designing electronic patient charting software to be used by dental care personnel should take into account the various tasks the dental care personnel will be possibly engaged in prior to using the electronic patient charting software and after its use. Understanding the prior and sequence tasks of dental care personnel will ensure that the electronic patient charting software fits within the workflow of the system, thus eliminating possible errors. The process by which technology is implemented, and the actual use of the technology, needs to be examined to better understand the full impact of technology and its effectiveness in ameliorating patient safety (Carayon et al., 2008).

Individual and Communication

In the dental care environment, efficient communication among members in the work team is important to patient outcomes. The ADA cited communication to be one of the reasons for malpractices claims; therefore, communication among the dentistry team is essential to preventing errors and upholding patient safety. Suboptimal communication was the most frequently cited cause of medication errors reported to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) between 1995 and 2003, accounting for more than 60 percent of reports (Patterson et al., 2004; Walker et al., 2009). Walker et al. (2009) noted that "communication problems have been shown to be the leading cause of in-hospital death—twice as frequent as errors resulting from lack of clinical skills—and have been associated with 50 percent of detected adverse events in general practice" (Wilson et al., 1998; Walker et al., 2009, p. 470). In addition, Walker et al. (2009) notes that "another study found that a computerized physician order entry (CPOE) system that complicated the communication and work-coordination needs of physicians and nurses led to delays in medication administration" (Beuscart-Zéphir et al., 2005; Walker et al., 2009, p. 470).

Effective communication among team members is a vital component of value-added care processes and has demonstrated potential to improve care quality (Baker et al., 1999; Clegg et al., 2000; Gittell et al., 2000). A national study of intensive care units (ICUs) found that "the culture, leadership, coordination, communication, and conflict management abilities of the unit" are significantly associated with shorter lengths-of-stay and higher-quality care (Shortell et al., 1994, p. 508). The SEIPS model can help one fully understand the individual's role in a system. In understanding the individual's role in the system, it will be evident that communication in an organization and environment is essential, as implied by Irwin et al.'s 2009 study. For instance, in a collaborative atmosphere such as the dental environment, effective communication among dental care personnel is essential to carrying out tasks such as preparing a patient for root canal treatment. Without dental care personnel communicating and assisting each other with the various required tasks in dental care treatments, patients could experience harmful delays that can lead to unwanted outcomes.

Brief Discussion

This paper reveals some of the salient reasons why the SEIPS model of work and patient safety is essential for the dental environment. The SEIPS model provides a framework for focusing on the system factors that need to be redesigned to foster effective performances from dental care providers and promote and improve patient safety. When applied to the dental environment outlined in Irwin et al.'s (2009) Consolidated Flow Model (Figure. 2), the understanding of how the different elements in the SEIPS model impact the workflow can offer a much more informed rationale for the design or redesigning of a clinical computing environment.

Recordkeeping and communication issues were two critical issues highlighted in the ADA report on malpractice claims that lead to unwanted patient outcomes. Those two issues can be grouped into two of the elements of the SEIPS model: recordkeeping can be grouped into the tools and technology component and communication issues can be grouped into the individual component. With the SEIPS model framework, one can understand how those issues that arise from dental malpractice claims can be impacted by other elements in the SEIPS model to

produce those unwanted outcomes. For instance, the physical workplace (the environment) and the policy (the organization) and procedures (the task) play an important role in the dental care personnel's (the individual) ability to devote extensive amount of time to accurately recording patient information (tools and technology) that can jeopardize patient and physician safety. With the use of the SEIPS model, one can understand how dental errors in general are not solely based on the incompetence of the dental care personnel, and can evaluate how the entire system plays a vital role in patient safety.

Although this paper focuses much of its discussion on patient safety, the safety of physicians is also important. As mentioned in the introduction of this paper, Cleveland's (2007) study highlights percutaneous injuries among dental health care personnel. Cleveland's study provided a discussion on how the injuries could have been prevented, indicating that the use of safety features could have been activated or a safer work practice used. Cleveland et al.'s perspective almost entirely placed the blame on the individual (i.e the dentists, oral surgeons, dental assistants, and hygienists). With the SEIPS model framework, one can understand how elements within the system (the dental environment) impact the safety of the dental care personnel. Additionally, one can redesign the system to create a safe environment to prevent the percutaneous injuries dental care personnel have incurred.

Conclusion

Dental schools and clinics as well as human factors engineers must engage in more substantial patient and physician safety research about the dental environment. The literature indicates that other areas of healthcare have explored the work system approach in their various settings, and the dental care setting can tremendously benefit from this interdisciplinary approach to research. At a time when the dental profession is moving towards integrating technology more fully, the recommendation of the SEIPS Model will prove beneficial to the evolution of novel technology implementation in the dental environment. This paper should serve as an important vehicle for change in the dental environment, promoting the amelioration of dental care.

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