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# Contained nomadic information environments: Technology, organization, and environment influences on adoption of hospital RFID patient tracking

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ABSTRACT

This paper reports on a case study of adoption of a contained nomadic information environment, exemplified by the use of Radio Frequency Identification (RFID) to keep track of hospital patients. The technology, organization, and environment (TOE) framework is applied to gain insights concerning contextual influences on the adoption of patient tracking RFID, including some RFID-specific issues. The results of this study provide insights to health care organizations embarking on RFID. The resultant model is a step towards developing a theory of adoption of contained nomadic information environments, of which RFID is one instance.



## 1. Introduction

In this paper, we investigate a particular type of computing which we refer to as a *contained nomadic information environment.* In general, a nomadic information environment "is a heterogeneous assemblage of interconnected technological, and social, and organizational elements that enable the physical and social mobility of computing and communication services between organizational actors both within and across organizational borders" [28]. We add the adjective "contained" to describe an environment that has physical boundaries and to highlight that inside these boundaries a manager or owner can hold some elements to more specialized purposes or to higher standards than are normally found in the world at large. Examples of places where contained nomadic information environments could be implemented include hospitals, museums, and residential homes. In such environments users, as well as other people and things, are mobile.

The focus of our study is the adoption of Radio Frequency Identification (RFID) patient tracking in hospitals. Hospitals are special environments in which both patients and providers may frequently change locations but remain within the confines of a building or campus, including areas where the RFID tracking technology can be installed. This makes patient tracking RFID in hospitals an important element in hospitals' role as contained nomadic information environments. Keeping track of the location of patients is a critical hospital function and a survey conducted on more than 300 health care organizations indicated that the key potential benefit of RFID is its contribution to patient safety [11]. Indeed, health care is a significant growing sector for RFID applications with a global market of US $1.7 billion by 2018 [17]. On the other hand, the healthcare industry includes special barriers to technology adoption. Some of these barriers include concern by administrators about the costs of new technology, fear of physicians that the technology will be disruptive and can add risks to patient safety, concern for security and privacy of patient data, general lack of knowledge about IT applications by health

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care professionals, concerns by employees about being monitored and the possible impact on their job performance and even potential lawsuits, and the need for buy-in from various stakeholders including patients, physicians, nurses, and administrators who may not all have identical agendas [23]. An additional barrier to RFID adoption is the somewhat hostile condition in which the technology must operate, such as the need for devices to be frequently cleaned and disinfected. Widespread adoption and implementation of RFID technology has not yet occurred in health care [26] and current use of RFID in the healthcare supply chain is not only limited due to the high cost but also the unknowns associated with full implementation of a system based on this technology [25]. Nonetheless, research based on multiple case studies has found that RFID technology has the potential to transform the healthcare sector and help healthcare organizations to achieve business values [1].

One important emerging research question in contained nomadic information environments is to study how nomadic services are adopted and used by organizations and how the contained nomadic information environments influence organizational operations, structure, performance, and effectiveness. Furthermore, little academic research in the health care-specific application of RFID exists, let alone research that systematically investigates the factors influencing health care organizations' adoption of RFID applications. The health care industry is an appropriate choice for study because billions of dollars are currently being spent on IT adoption of relatively new applications and because of the relatively unexplored status of factors giving challenges to IT adoption inherent in the health care industry.

The research reported herein fills these voids by studying adoption and implications of an RFID patient tracking application in a hospital environment with the aim of contributing toward a theory in this emerging research area. The central research question is: "How do health care organizations adopt and implement RFID applications?" To answer this question, we need to understand the important constructs identified by nomadic RFID stakeholders related to RFID adoption as part of a contained nomadic information environment. To guide our case analysis, we begin with the technology-organization-environment (TOE) framework, and consider the influence of its elements on the adoption process. The outcome of this study is a model that identifies the main constructs of adopting nomadic RFID applications in hospitals. The results of this study not only contribute to our understanding of the emerging phenomenon of RFID applications in the health care field, but also provide guidelines and suggestions to practitioners who are considering the adoption of contained nomadic information environments.

## 2. Background

### 2.1. IT adoption in the health care industry

The health care industry is facing increased pressure to function more efficiently and one solution to meet the new demands has been the introduction of information technology [34]. Using both primary and secondary data, Menachemi et al. [29] examined the relationship between information technology (IT) utilization and hospital financial performance in Florida hospitals. Their findings suggest a significant and positive relationship between increased levels of IT use and various measures of financial performance. Nevertheless, the late and sparse adoption of new technology in the health care sector is both well known and documented [19,36,41,55]. The majority of academic research in IT adoption in health care has focused on the individual level. For instance, Chau and Hu [8] examined physicians' acceptance of telemedicine technology. They suggested that in a typical professional setting, the essential characteristics of user, technology, and context may differ considerably from those in ordinary business settings. Bandyopadhyay and Schkade [3] asserted that there was no known published empirical research addressing the understanding of IT adoption within the health care industry. More recently, Khoumbati et al. [22] proposed a conceptual framework for enterprise application integration (EAI) adoption in health care. Using a fuzzy cognitive mapping approach, they tried to evaluate the factors that influence EAI adoption in the health care sector. Because the data were collected from a public health care organization in the United Kingdom, according to the authors (p. 105) it is difficult to generalize the results to other parts of the world because the organizational structures for the delivery of health care services vary from country to country. In summary, little research in the health care-specific IT adoption at the firm level exists, let alone research that systematically investigates the factors influencing health care organizations' adoption of RFID applications [26].

### 2.2. RFID applications

Radio Frequency Identification (RFID) refers to the use of radio frequency wireless communications for labeling and identifying objects [52]. Although RFID technology has existed for 50 years, recent advancements in RFID technology, significant declines in RFID costs, and improvements in Electronic Product Code (EPC) standards have made RFID practical for wide adoption [7]. RFID has become so popular nowadays that we are "witnessing the forward progress of an unstoppable technology adoption" [35]. RFID can be an important component of a contained nomadic information environment, in which an RFID tag is attached to a roaming object or. RFID has potential to add value in situations where an infrastructure to support RFID can be established and the objects or people to which RFID tags are attached are not permanently site-bound.

RFID can provide a very high level of information accuracy and real-time visibility across the supply chain; RFID increases the reliability by eliminating the error caused by paper-based systems [30]. RFID, once established, can institute significant cost savings. Still, RFID adoption is not without its challenges. Sometimes the data generation from RFID is not perfect and also results in what is called "dirty data" and noise [21]. These problems can be addressed by the application of middleware to process the data to filter out redundant and unneeded data elements. RFID tag reliability can also be problematic. RFID tags are not immune to attacks from hackers or competitors, which result in loss and misuse of important and confidential data [53], but the security of a hospital or other important place can be improved by controlling the facility access using an RFID system. There is the concern that RFID may increase infringement on consumers' privacy due to its perpetual tracking ability [42]. Finally, it is possible for any third party equipped with an RFID scanner to determine what medicines patients are taking by scanning their tagged pill bottles [54].

Although companies benefit from RFID applications by cost savings gained through information accuracy, the initial investment of setting up the RFID system is very high. Therefore, the support of the organization's financial committee is essential in RFID adoption. According to Premkumar and Ramamurhy [33], *top management support has been consistently found to be important in IS adoption cases and RFID literature also supports their notion.* Organizational variables unique to the health care industry include specialization, functional differentiation, physician and administrator relationships, and telemedicine [22].

According to Fadlalla and Wickramasinghe [15], the Health Insurance Portability and Accountability Act (HIPAA) deals with ensuring the privacy of health care information. The purpose of HIPAA is to maintain strong protections for the privacy of