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Impact of electronic medical records (EMRs) on hospital productivity in Japan

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ABSTRACT

Introduction: Consistent with the global trend, Japanese hospitals have increasingly adopted electronic medical record (EMR) systems in the last 20 years. Although improved productivity is emphasized as one of the benefits of information technology (IT), there is a paucity of data regarding how the use of EMR systems influences the productivity of Japanese hospitals.

Methods: This retrospective study focused on 658 municipal hospitals. The study period was from 2006 to 2015. We analyzed the labor productivity and multi-factor productivity (MFP) of the hospitals and their average rate of change during the study period. Logistic regression models were used to assess how EMR implementation influenced labor productivity and MFP growth. We considered the duration of EMR operation, and hospitals using EMRs were divided into three groups based on tertiles of time elapsed since the implementation of the EMR system: "early adopters", "followers", and "late adopters".

Results: We found that the implementation of an EMR system had a significantly negative impact on MFP growth for the 'late adopters' (OR 0.51; 95%CI 0.31–0.82; p = 0.006). No significant association was found between EMR implementation and labor productivity growth.

Conclusion: EMR implementation has an adverse effect on the productivity of municipal hospitals in Japan. This finding should be considered when developing future healthcare policies promoting the implementation of IT.

1. Introduction

The implementation of medical information systems in hospitals is progressing steadily throughout the world [1,2]. In Japan, the implementation of electronic medical record (EMR) systems began in earnest in 2000. Following legislation to facilitate the introduction of EMRs, the 2001 "Grand Plan" released by the Ministry of Health, Labor and Welfare (MHLW) set a goal to implement EMR systems in 60% of the hospitals housing over 400 beds [3]. Consequently, there was a rapid development of structural support, such as subsidies, medical reimbursement fee incentives, and vendor product development [4]. Since then, the number of medical institutions implementing an EMR system has increased steadily. In Japan, EMR systems implemented in hospital settings typically interface with systems related to clinical documentation, computerized provider-order entry, access to test and imaging results, and billing [13]. Alongside the use of such basic systems [3], hospitals varied in their use of clinical decision support systems [13]. Whereas the vast majority of the EMR market was comprised of products offered by a few vendors (e.g., 76% of the systems active in 2015 were offered by four vendors: Fujitsu, NEC, Software Service, and CSI) [12], the degree of standardization or interoperability among medical institutions has been very low because of the substantial customization at each hospital [4,56].

Such widespread expansion of EMR implementation might be due to the various benefits expected from the introduction of information technology (IT). Specifically, in addition to improved care, enhanced patient services, and increased safety for medical treatments, increased productivity has been consistently emphasized [1]. In particular, a reduced burden of work for healthcare professionals and the use of more efficient medical treatments due to a reduction in unproductive practices are supposed to lead to the suppression of medical costs by way of increased productivity [5,6]. Current moves to advance the further use of EMRs, which can presumably solve various problems in healthcare, are based on a consensus about the increased productivity and efficiency attributable to EMRs.

Previous studies on EMRs vary in methodology and topic, such as

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the work efficiency of doctors and nurses, the flow of patients and medical tests, and the financial trends in hospital revenues and costs [7–9]. As the impact of IT solutions on productivity is reported to be both positive and negative, it is difficult to derive a comprehensive outlook from these previous studies [10,49]. Although a variety of studies on the implementation of EMR systems, and a wide range of profiles of institutions in Japan using such systems, have been published [4,11–13,44,57], we do not know how EMR implementation contributes to the increased productivity of hospitals in Japan.

Thus, we conducted a multi-center study and analyzed the impact of the introduction of EMRs on participating hospitals' mid- to long-term measures of productivity. In particular, we focused on municipal public hospitals. Our research on the effects of the implementation of EMR systems is one of the few such studies in Japan. Examination of the impact of EMRs in public hospitals, which play an important role in the Japanese healthcare system, will produce useful findings relevant to the direction of future healthcare policies in this domain. The present study on Japanese cases will add much to the extant literature focused on other countries [8,9,18,21,23,24].

2. Method

2.1. Research design and sample

We conducted a retrospective, multi-center study treating municipal public hospitals as the units of analysis. The research was performed from the beginning of the 2006 Japanese fiscal year to the end of the 2015 Japanese fiscal year. (In Japan, fiscal years begin on April 1 and end on March 31.) Our research utilized two databases: the fiscal data of municipal hospitals, and data relating to status of EMR implementation. For the fiscal data, we relied on the 2006–2015 "Handbook of Regional Public Corporations" [14], which includes hospital profiles (year opened, number of hospital beds) for each hospital in each fiscal year as well as detailed statistical and financial data (e.g., numbers of staff and patients and financial records). For EMR implementation and its timing, we utilized the "White paper on electronic health records and picture archiving and communication systems", which was published by "New Healthcare" in conjunction with the Japan Association for the Healthcare Information Systems Industry (JAHIS) [15].

There were 943 municipal hospitals in Japan during the 2015 fiscal year. To focus on changes in long-term productivity markers between 2006 and 2015, we examined only those institutions with data that could be continuously, retrospectively traced to 2006 for the current study. Therefore, institutions that experienced mergers, division, reorganization andso forth during the study period, as well as institutions that began operating during that time, were excluded from the sample. Hospitals with missing data for the 10-year study period and psychiatric hospitals were also excluded.

2.2. Variables

2.2.1. Dependent variables

Productivity is typically calculated by dividing the amount produced by the amount of labor input [16]. However, there are various definitions of, and methods for, calculating productivity [16], and there is no single established method. However, "labor productivity" and "multi-factor productivity" (MFP) are regarded as generic markers indicating the organizational productivity of hospitals [17]. Thus, we utilized these two markers, which were calculated as follows:

$$\text{Labor productivity} = \frac{\text{Value added}}{\text{Number of staff}}$$

The "labor productivity" of a hospital is calculated by dividing its output by its labor input [16]. In this study, "added value", defined as revenue minus expenses, was used for output [18]. We calculated the labor productivity for each year by dividing this added value by the average number of staff members in each fiscal year. This method of calculation was used in previous studies regarding labor productivity [19] and is also consistent with the US Bureau of Labor Statistics' (BLS) definition of labor productivity [20]. Although some research uses total labor hours [17,19], others use number of employees as a proxy variable for the amount of labor invested [21]. In this study, due to limitations in our data, we utilized the latter.

$$MFP = \frac{\text{(Deflated net revenues of the year)}/\text{(Deflated net revenues of the previous year)}}{\text{(Deflated net expenses for the year)}/\text{(Deflated net expenses of the previous year)}}$$

"Multi-factor productivity" (MFP) is also a marker of the productivity of a business. The US BLS and other studies have defined this as a change in the level of outputs relative to a change in the level of two or more inputs [22]. This index of productivity considers not only labor but also capital investment and other inputs. Recent research examining hospital productivity has found MFP to be a useful indicator [23–28], and a number of methods of MFP prediction and calculation have been reported. We calculated MFP according to the method advocated by Cylus et al. [27,28], who defined it as follows: "the ratio of the change in the real quantity of outputs to the change in the real quantity of inputs provides an estimate of hospital MFP in a given year" [27,28]. Following this method, we calculated output and input from the revenue and expense items by deflating price changes, based on the relevant deflators, and then estimated MFP. Although Cyrus et al. used several price indices specific to the hospital sector [27,28], several of these indexes were not available in Japan. Thus, in such cases, we utilized more generic price indices, such as the corporate goods price index and the real wage index (we set 2015 for the base year). Finally, because the first available MFP data were for 2007, the labor productivity and MFP growth between 2007 and 2015 were analyzed in the study. These two productivity indicators were calculated based on data on revenues and expenses related to medical activities, payroll costs, materials costs, depreciation, external subcontracting costs, and employee numbers, which are included in the "Handbook of Regional Public Corporations" [14,15].

2.2.2. Independent variables

The JAHIS and the Japan Society for Instruction Systems in Healthcare (JSISH) [29] have suggested factors that are relevant to EMR, and a consensus has emerged with respect to the definition of EMR [4]. We assumed that the "White Paper" survey was aligned with such a conceptual definition. Indeed, the decision to implement EMR systems in hospitals was based on the information in the "White paper". Specifically, the month and year during the research period that each facility introduced EMRs were indicated. Using this information, we determined the presence or absence of EMRs and the time elapsed since their introduction. We defined the time of introduction as the time of initial EMR implementation at a facility; thus, we excluded other events, such as serial system updates and upgrades.

We also controlled for the following variables in the analysis. (1) Number of licensed beds: in accordance with the MHLW periodic reports on EMR implementation in the healthcare sector [30], we classified this variable into three categories (199 or fewer, between 200 and 399 beds, and 400 or more beds). (2) Government-designated emergency hospitals: this variable has two categories, yes and no [31]. (3) Facilities housing critical care emergency centers: this variable has two categories, yes and no [32]. (4) Training and educational facilities: this variable has two categories, yes and no [33]. (5) Hospitals in designated remote areas: this variable was defined by the Ministry of Internal Affairs and has two categories, yes and no [34]. Additionally, the annual averages for inpatient bed occupancy rates and number of outpatients were also added as independent variables. While these factors were