The Adoption Level of Electronic Health Records in Turkish Hospitals and the Relation with Hospital Sizes

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Abstract

**Background:** Considering the benefits of using electronic health records (EHR) for maintaining the overall quality of clinical care, the nationwide adoption of EHR in hospitals has become a policy priority. The electronic medical record maturity model (EMRAM) is one of the most popular survey tools developed by the Healthcare Information and Management Systems Society (HIMSS) that measures the level of adoption for EHR functions in a hospital or a secondary care setting. Turkey has accomplished many standardizations and infrastructural studies in the health IT domain as a part of the first phase of the Health Transformation Program between 2003 and 2017. The Turkish MoH applied a bottom-up approach to adopting EHR in public hospitals, as the USA did. This study aims to measure the EHR adoption level of public hospitals in Turkey and criticize the relation between adoption and hospital size.

**Methods:** EMRAM surveys were completed by 600 (68.9%) public hospitals of Turkey between 2014 and 2017. The availability and prevalence of medical information systems and EHR functions were measured. The association between hospital size and the availability/prevalence of EHR functions was also calculated.

**Results:** We found that 63.1% of all hospitals in Turkey have at least basic EHR functions, and 36% have comprehensive EHR functions, which is better than the results of Korean hospitals of 2017 but still lower than the USA hospitals of 2015 and 2017. Our findings suggest that small hospitals are better than larger hospitals at adopting certain EHR functions.

**Conclusion:** Measuring the overall adoption level of EHR functions is an emerging approach and a beneficial tool for the strategic management of countries. This study is the first one covering all public hospitals in a country by using EMRAM. It can be suggested that using a bottom-up approach as applied by the USA on adopting EHR in public hospital gives successful results also in Turkey. The results are used by MoH of Turkey to disseminate the benefits of EHR functions overall in the country.

**Background**

Electronic health records (EHR) are electronic data files that can be stored, accessed, and transferred
electronically by information systems. EHR covers the episodic health information of a patient staying in a medical facility. This information repository, when used in a meaningful manner, keeps all of the records that are useful, effective, ethical, and easily accessible within regulated boundaries (2,3). The key functions contained in EHR are computerized physician order entries (CPOE) (4–7), closed-loop medication administrations (CLMA) (8–12), clinical decision support systems (CDSS) (13–15), picture archiving and communication systems (PACS) (16), and electronic medication administration records (eMAR) (9,17,18). The hospital information systems (HIS) combine all those functions with some additional modules. As one of those modules, patient administration systems (PAS) are capable of recording identification and demographic data of patients (19), which are essential for both clinical and administrative processes. Similarly, despite its changing content and structure due to the social security system of the relevant country, electronic medical billing (EMB) systems are also another crucial component integrated with EHR and PAS (20).

1.1. Overall Electronic Health Record Capabilities of Countries
There are only a few studies evaluating the national adoption level of EHR functions in hospitals. One of the first studies was conducted in 2009 by Jha et al., which focused on hospitals in the USA (21). The survey developed by Jha et al. questioned the availability of 24 EHR functions. They classified the results according to whether the hospitals had basic or comprehensive EHR functions. The basic EHR functions indicate that clinical documentation, CPOE, CDSS, laboratory and imaging results are applicable in one clinic, while comprehensive EHR functions, means all those functions are available in all clinics of the hospital. This study showed that only 1.5% of US hospitals had comprehensive EHR functions, and 7.6% had basic EHR functions. The next study, which was also conducted by Jha et al. in 2011, indicated that the total percentage of hospitals having at least basic EHR functions had increased to 15.1% in the USA (22). The most recent studies were conducted in the US by Adler-Milstein et al. in 2014 (23), 2015 (1), and 2017 (24). These studies showed that the proportion of hospitals having comprehensive EHR functions was 25.5% in 2014, 34.1% in 2015, and 39.1% in 2017. Similarly, the proportion of hospitals having at least basic EHR functions was 58.9% in 2014, 75.2% in 2015, and 80.5% in 2017.
Studies focusing on Korean hospitals are also remarkable. The first study was conducted by Park et al. in 2005 (25). The researchers used the survey designed by Ash et al. (26), which is mostly focusing on CPOE rather than other EHR functions. This study showed that although 80.3% of hospitals have CPOE forms, only 9% have complete EHR systems. The next two studies conducted in Korean hospitals used the survey developed by Jha et al. (21), and so that they could compare their results with hospitals in the USA. The 2012 study by Yoon et al. (27) showed that the percentage of Korean hospitals having at least basic EHR functions was 37.2%, which was better than the proportion of hospitals in the USA (15.1%). The most recent study, which was published in 2017 by Kim et al. (28), showed that the percentage of Korean hospitals having at least basic EHR functions increased to 58.1%, but this figure was lower than the proportion of hospitals in the US with at least basic EHR functions (80.5%) for the same year. The rapid increase in the EHR adoption level of hospitals in the USA may be attributed to the financial and political support in line with the HITECH Act (2009).

Another remarkable study was published in 2014 by Shu et al. (29). This cross-sectional study measured the percentage of EHR adoption in tertiary hospitals in China. The authors conducted a national survey entitled the Model of EHR Grading (MEG), which gives hospitals a rating between Stage 0 and 7 based on their adoption of 37 EHR functions. This study showed that, among 848 hospitals, 30.7% were Stage 0, 12.0% were Stage 1, 31.7% were Stage 2, 22.2% were Stage 3, 2.7% were Stage 4, 0.6% were Stage 5, 0.1% were Stage 6, and 0% were Stage 7. Other studies performed in Greece (30) and Saudi Arabia (31) are not survey-based but thematic reviews and focusing on giving insights for the policymakers.

The approaches to adopting EHR to hospitals is another critical point for policymakers. The approaches of the UK and the USA for adopting EHR functions are attractive to make a comparison. Aziz Sheikh et al., in 2014, criticized the approaches of the UK and the USA (32). Even though Owen et al. corresponds to them by not considering the achievements of the UK in EHR adoption in primary care (33), Aziz et al. claimed that many lessons should be learned from the USA achievements. One of the essential differences between the UK and USA to Aziz Sheik et al. is the implementation strategy. While the UK used a top-down approach, the USA pursued a bottom-up strategy. Moreover, the USA
has three distinct stages of implementing its strategy, while the UK has not clearly defined milestones in its strategy (32). In a recent study, in 2018, Wilson and Khansa also compared the EHR systems of the UK and the USA. They noted that the top-down strategy brought early success to the UK with general practitioners. However, this strategy was not successful when the UK tried to bring EHR to hospitals because of the complexity of processes among stakeholders. They suggested that even though the USA has the most extensive private healthcare system in the world, which might be more challenging to control, their bottom-up approach seems more successful than the top-down approach of the UK who has the most extensive public healthcare system in the world (34).

1.2. Electronic Health Record Capability in Turkey

The Ministry of Health (MoH) in Turkey launched the Health Transformation Program in 2003 (35) and finalized its first phase in 2017. There were many milestones achieved with this program in terms of using information and technology standards such as the National Health Data Dictionary (NHDD) (36), Health Coding Reference Server (37), ICD 10 (38), HL7 (39,40), National Health Tariffs (41), and systems such as The Family Physician Information System (42), National Health Information System (36), The Central Physician Booking System (43), Central Claim Management System (44), teleradiology system (45), and Personal Health Record (46,47). As an essential part of health IT infrastructure, the MoH initiated the e-prescription application in June of 2012 as a pilot and made it mandatory since January of 2013. Although the target is set as 95%, the percentage of e-prescription was 87% as of September of 2018 (48).

Although there are many nation-wide standards and applications, the adoption of the applications within the healthcare facilities (i.e., hospitals, health centers, etc.) is something different to be measured. Thus, the MoH of Turkey intended to measure the overall adoption level of EHR functions inside public hospitals. So, one of the objectives of the Strategic Plan of the MoH between 2013 and 2017 was to study the “digital hospital” concept and disseminate it across all public hospitals (49). In line with this strategic objective, MoH signed a collaborative agreement with the Healthcare Information and Management Systems Society (HIMSS) in 2013 (50). As readily seen, the Turkish MoH acts as just a policymaker and let the hospitals to make relevant studies in a period. Thus, Turkey is
also applying a bottom-up approach as the USA did on adopting EHR in public hospitals while the UK applied a top-down approach.

1.3. Electronic Medical Health Record Adaptation Model

HIMSS developed the electronic medical health record adaptation model (EMRAM) (51). EMRAM provides algorithms to assess inpatient services in acute hospitals based on their EHR capabilities and, like all other models (52–54) created by HIMSS, has eight stages from 0 to 7. The requirements to be met by the hospitals in our study are shown in Table 1 (51).

In order to benchmark this study with the previous ones conducted in the USA and Korean hospitals, EMRAM requirements may be aligned with the 24 functions of the survey developed by Jha et al. (21). Therefore, Stage 3 of EMRAM indicates that the hospital has basic EHR functions, and Stage 6 indicates that the hospital has comprehensive EHR functions.

Methods

This study utilizes the EMRAM survey, including five dimensions: i) Software Applications, ii) Software Usage, iii) Electronic Ordering, iv) Image Management Systems, and v) Medication Safety. The survey studies took place between 2014 and 2017. Sixteen regional workshops were organized in the same period, with 2,716 participants, including hospital managers. This study aimed to cover all 870 public hospitals (55) in Turkey. The inconsistent or having inadequate quality surveys were excluded from this study. Only the most recent one was analyzed if there is more than one survey from the same hospital.

IBM SPSS version 23 was used to perform statistical analyses. The Chi-Square test was conducted to analyze associations or differences between the categorical variables, such as hospital size and the usage/prevalence of EHR functions. The threshold for significance was set at $\alpha = 0.05$.

Results

A total of 889 surveys were collected from 870 hospitals. Two hundred four of them were excluded because they are repeated submissions. The number of distinct hospitals included in the study is 685 (78.7%). Similarly, 85 of the surveys were also excluded because of poor quality data and some severe inconsistencies. Overall, 600 verified, acceptable surveys (68.9%) were analyzed in this study. The distribution of the hospitals and their size, type, and level of healthcare are shown in Table 2.
The distribution of the number of hospitals in each EMRAM stage is shown in Figure 1. It is exciting to see that most of the hospitals (72.66%) are either Stage 2 or 6. It is logical to suggest that the barrier requirements of Stage 3, such as having PACS, eMAR, and adopting nursing documents, act as a kind of threshold. It seems, once hospitals achieve Stage 3, the remaining technologies can be adopted relatively easily and so that their adoption level regularly increases.

### 3.1. Availability of Applications and Electronic Health Record Functions

This section provides the results of the availability of information systems and EHR functions in hospitals.

#### 3.1.1. Hospital Information Systems, Laboratory Information Systems, and Patient Administration Systems

The availability of HIS, LIS, and PAS is listed in Table 3 concerning the hospital sizes. The results show that 100% of hospitals have a HIS suite. Similarly, 94% of hospitals have PAS, and 93% of hospitals have LIS integrated with HIS. It is also evident that the hospital size does not have a role in having HIS, LIS, and PAS.

#### 3.1.2. Clinical Documents and Computerized Physician Order Entry

The clinical documentation is also provided in Table 4, along with hospital sizes. The results show that 98.6% of hospitals have a CDR, and 79.7% of hospitals have a hospital-wide CDR. Recall that the CDR was one of the requirements of EMRAM Stage 2. Physician and nursing documents, as requirements of EMRAM Stage 3, have very similar availability percentage across hospital sizes. Although 86.2% of hospitals have physician documents, the nursing documents are available in 84.8% of all hospitals. Those high percentages can be explained by the national healthcare quality standard (SKS), which makes it mandatory to have clinical document infrastructure since 2009 in Turkey. However, CPOE is not functional in 13.8% of hospitals. The size of the hospital has no significant relationship with the availability of clinical documents and CPOE systems.

#### 3.1.4. Medication Administration
Pharmacy and medication administration are essential functions of HIS. As depicted in Table 5, the surveys indicate that 99.5% of all hospitals have a pharmacy management system, even though three (0.5%) of them receive this service from an external source. The medications applied to the patient are recorded during the time of application in 66% of the hospitals, but 29.2% of them do not record those applications. The high availability of pharmacy management systems can be explained by the MoH regulations about stock management and efficiency criteria in the pharmacies of public hospitals since 2013. Despite the high availability of the information systems, the lack of recording the medication application shows that the information systems still focus the institutional purposes more than the clinical services.

3.1.5. Image Management

As depicted in Table 6, the surveys show that 89% of hospitals have a PACS system; however, the PACS systems in 14.5% of hospitals are not integrated with HIS and may only the by the radiology department. On the other hand, 9.5% of hospitals have a dictation and speech recognition system, which helps the radiologists write their reports more efficiently. That is to say that technology has not penetrated to the reporting process.

Electronic ordering also has a similar prevalence. The usage of CPOE is 72.5% for medication and 62.7% for non-medication orders, respectively. However, orders for nurses in inpatient care facilities have a slightly higher proportion of 79%. By considering the prevalence of CPOE, Table 9 shows that the percentage of CPOE usage for inpatient medication orders is 66.6% and 70.5% for non-medication orders in more than 50% of the hospital.

Although there is no significant relationship between hospital size and the usage of electronic
ordering (Table 8), the prevalence of electronic ordering has a significant relationship with hospital size (Table 9). The results show that small hospitals are better than medium-sized and larger hospitals in adopting electronic ordering capabilities. The verbal order is not allowed by regulations in Turkish public hospitals. However, it seems that the managers can apply this rule better in smaller hospitals.

3.2.2. Clinical Decision Support

As shown in Table 10, the hospitals have access to clinical decision support systems (CDSS). Correctly, CDSS was used in 69% of physician/nursing documents, 71.7% of medication orders, and 57.3% of non-medication orders. Additionally, although there is no significant relationship between hospital size and the usage of CDSS in clinical documents and non-medication orders, the usage of CDSS in medication orders has a significant relationship with hospital size. Small hospitals are better than medium-sized and larger hospitals in adopting CDSS for medication orders. Considering Tables 5, 9, and 10 together, we can claim that despite nearly all hospitals have pharmacy management systems and drug databases; the small hospitals are quickly adopting e-order and CDSS for medications to larger hospitals.

Table 12 shows the items or persons (i.e., patient and nurse) to be identified using technology (RFID and barcode) during the application of medication at the bedside. The results show that the
technology is used more frequently to identify medications and patients than identifying nurses. However, although those percentages are high in large and medium hospitals, the percentages are significantly lower in small hospitals. Moreover, the p-value indicates that there is a significant relationship between the auto-identified target (medication, nurse, and patient) and usage of technology. This result can be evaluated that the nurses do not consider a necessity to validate themselves and patients since they believe that they can do it well enough even manually, but they validate the drugs at the bedside by using technology.

3.2.4. Image Management

Image management systems (IMS) are stand-alone applications that are required to be integrated with EHR or HIS for practical usage. Table 13 shows that 74.7% of hospitals integrated their IMS with EHR. When we consider the prevalence of IMS in hospitals, we can see that 37.3% of hospitals are using IMS in greater than 50% of the entire facility. There is no significant relationship between hospital size and the percentage of IMS integration with EHR nor the prevalence of IMS. This situation can be explained by a nation-wide teleradiology system of Turkish MoH, which has been applicable since 2008 (45).

Discussion

This study shows that HIS and main ancillaries, such as laboratory, radiology, and pharmacy information systems, are present in all hospitals in Turkey. The availability of LIS, PAS, PACS, BI, and MIS varies between 63.6% and 94%. The prevalence of EHR functions such as CPOE, CDSS, clinical documents, and drug management also ranges from 70% to 99.5%. The size of the hospital has no significant relationship with the availability of those applications.

On the other hand, it is measured that not all hospitals having those applications adopted them. The proportion of hospitals adopted those applications and functions in at least half of the hospital varies between 57.3% and 79.3%. Despite the relationship between hospital size and availability of the applications, there is a significant relationship between the hospital size and the adoption of some EHR applications or functions. For example, the adoption of clinical documents, medication, and non-medication orders is higher among small hospitals compared to larger hospitals. Similarly, the use of
CDSS during drug orders is more frequently adopted by small hospitals. The only point that the larger hospitals are better than smaller hospitals is the 2\textsuperscript{nd} line verification of ordered medications at the bedside, which can be achieved through having enough resources, i.e., nurses.

On the other hand, Jha et al. (22), DesRoches et al. (60), and Hikmet et al. (61) showed that the small hospitals in the USA are significantly slow to adopt EHR functions to larger hospitals. One reason that may be extracted from the study of Thakkar and Davis, as their study concluded that the perception of the hospital managers in the USA is saying that the benefits of EHR adoption are more in larger hospitals concerning the smaller ones (62). Additional to this perception, the large hospitals in the USA can be suggested that they have high financial capabilities so that they can make investments to adopt EHR functions better than the smaller hospitals. However, Turkey, as a unitary state, is smaller than the USA, and the MoH can actively regulate all public hospitals. Thus, the small hospitals in Turkey can be suggested that they can use their size as an advantage to change quicker than large hospitals. Nevertheless, when we consider the 2\textsuperscript{nd} line validation for medication at the bedside, the larger hospitals are better, most probably due to the same reasons as suggested by Thakkar and Davis (62), such as having enough resources and financial capabilities.

When we consider the concepts of basic and comprehensive EHR functions as defined by Jha et al. (21) by comparing them with EMRAM stages (as expressed in Table 1), we found that 63.1\% of all hospitals in Turkey have at least basic EHR functions, and 36\% have comprehensive EHR functions. This result is better than the results of Korean hospitals of 2017 (28) but still lower than that of hospitals in the USA of 2015 (1) and 2017 (24), as depicted in Table 15.

Additionally, the Turkish experience summarized in this study strengthens the claims (32–34) that following a bottom-up approach on adopting EHR in public hospitals, as applied in the USA, is better than a top-down approach as applied in the UK.

Conclusions
The adoption level of EHR functions in a country is very critical information since it can provide insights for healthcare policy establishment. Despite all practical difficulties, the studies measuring the overall adoption level of EHR are increasing. This study is the first one covering all public hospitals
in a country by using EMRAM. As the first nation-wide study in Turkey, it is one of the studies like in the USA, Korea, and China, etc. which can enable the researchers to make benchmarking among countries. On the contrary of the suggestions of the previous studies (22), (60), (61), this study explores that smaller hospitals are better in adopting most of the EHR functions, except the 2nd line validation for medication at the bedside.

Additionally, as in the USA (32–34), this study also suggests that after all required standardization and infrastructural studies, applying a bottom-up approach to adopting EHR functions in public hospitals gives successful results also in Turkey.

The results of this study are used by the MoH of Turkey to disseminate the benefits of EHR functions overall in the country. Considering studies showing the effect of using EHR functions on increasing healthcare quality, the Turkish MoH’s experience of using EMRAM may suggest that measure the adoption level of EHR functions can be a good starting point for a healthcare authority and set some targets to increase the healthcare quality.

For further studies, it may be interesting to focus on measuring the correlation of EHR adoption level and healthcare quality scores measured by international standards, such as Joint Commission International, etc.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to the MoH regulations but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

IK generated the survey database and made relevant analyses, did a literature review, and was a major contributor in writing the manuscript. JR helped in designing the survey and the quality control mechanism and contributed to writing the manuscript. SG enhanced the literature review and constructed the tables in the manuscript. SB, MMU, and IY planned the regional workshops of public hospitals, trained the hospital delegates, and contributed to gathering the surveys from hospitals, and reviewed the manuscript.

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Table 1. HIMSS EMRAM Requirements (until the 1st of January 2018)

| Stage     | Cumulative Capabilities                                                                 |
|-----------|----------------------------------------------------------------------------------------|
| Stage 7   | Complete Electronic Medical Record (EMR), Continuity of Care Document transactions to share data warehousing; Data Continuity with Emergency Department, ambulatory, OP |
| Stage 6   | Physician documentation (structured templates), full Clinical Decision Support System (CDSS) (variety & compliance), full Remote-PACS |
| Stage 5   | Closed-loop medication administration                                                    |
| Stage 4   | Computerized Physician Order Entry (CPOE), CDSS (clinical protocols)                     |
| Stage 3   | Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology |
| Stage 2   | Clinical Data Repository (CDR), Controlled Medical Vocabulary, CDSS, may have Document Imaging Information Exchange (HIE) capable |
| Stage 1   | Ancillaries - Lab, Rad, Pharmacy - All Installed                                         |
| Stage 0   | All Three Ancillaries not Installed                                                     |

Table 2. Basic characteristics of responding hospitals

| Characteristic                        | Number | Percent |
|---------------------------------------|--------|---------|
| Region                                | 7      | 100     |
| Province                              | 79     | 98      |
| Hospital                              | 600    | 68.3    |
| Size                                  |        |         |
| Small (0-99 beds)                     | 295    | 49.2    |
| Medium (100-399 beds)                 | 205    | 34.1    |
| Large (≥400 beds)                     | 100    | 16.7    |
| Teaching Status                       |        |         |
| Public Hospital                       | 531    | 88.5    |
| Training Hospital (including affiliated university hospitals) | 69 | 11.5 |
| Hospital Type                         |        |         |
| Secondary Hospital                    | 489    | 81.5    |
| Tertiary Hospital                     | 54     | 9       |
| Branch Hospital                       | 57     | 9.5     |

Table 3. Availability of HIS, LIS and PAS
| Applications                      | Hospital Size            | Live    | Live - hospital-wide | Live - departmental | Not Automated | Not Reported |
|----------------------------------|--------------------------|---------|----------------------|---------------------|--------------|--------------|
| **EMR / Hospital Information System (Suite)** | Large (>=400 beds)       | 100     | 0                     | 0                   | 0            | 0            |
|                                  | Medium (100-399 beds)    | 205     | 0                     | 0                   | 0            | 0            |
|                                  | Small (6-99 beds)        | 294     | 1                     | 0                   | 0            | 0            |
| **Percentage**                   |                          | 99.8%   | 0.2%                 | 0.0%                | 0.0%         | 0.0%         |
| **Total**                        |                          | 599     | (99.8%)              | 0.16%               | 0            | 0            |
| **Patient Administrative System** | Large (>=400 beds)       | 1       | 98                   | 0                   | 1            | 0            |
|                                  | Medium (100-399 beds)    | 2       | 189                  | 3                   | 8            | 3            |
|                                  | Small (6-99 beds)        | 5       | 269                  | 9                   | 10           | 2            |
| **Percentage**                   |                          | 1.3%    | 92.7%                | 2.0%                | 3.2%         | 0.8%         |
| **Total**                        |                          | 8       | 556                  | 12                  | 19           | 5            |
| **Laboratory Information System** | Large (>=400 beds)       | 41      | 57                   | 2                   | 0            | 0            |
|                                  | Medium (100-399 beds)    | 43      | 153                  | 7                   | 1            | 1            |
|                                  | Small (6-99 beds)        | 7       | 257                  | 29                  | 2            | 0            |
| **Percentage**                   |                          | 15.2%   | 77.8%                | 6.3%                | 0.5%         | 0.2%         |
| **Total**                        |                          | 91      | 467                  | 38                  | 3            | 1            |

Table 4. Availability of clinical documents and CPOE systems
| Applications                              | Hospital Size   | Live     | Live - departmental | Not Automated | Not Reported |
|------------------------------------------|-----------------|----------|---------------------|---------------|--------------|
| Clinical Data Repository (CDR)           | Large (>=400 beds) | 42 (42%) | 56 (56%)            | 1 (1%)        | 1 (1%)       |
|                                          | Medium (100-399 beds) | 44 (21.5%) | 154 (75.1%)       | 4 (2%)        | 3 (1.5%)     |
|                                          | Small (6-99 beds)    | 7 (2.4%)  | 268 (91.2%)        | 16 (5.4%)     | 3 (1%)       |
|                                          | Percentage          | 15.5%    | 79.7%               | 3.5%          | 1.2%         |
|                                          | Total               | 93       | 478                 | 21            | 7            |
| Nursing Documentation                    | Large (>=400 beds) | 24 (24%)  | 55 (55%)            | 2 (2%)        | 19 (19%)     |
|                                          | Medium (100-399 beds) | 25 (12.3%) | 131 (64.5%)     | 10 (4.9%)     | 37 (18.2%)   |
|                                          | Small (6-99 beds)    | 6 (2%)    | 230 (78.2%)        | 26 (8.8%)     | 32 (10.9%)   |
|                                          | Percentage          | 9.2%     | 69.3%               | 6.3%          | 14.7%        |
|                                          | Total               | 55       | 416                 | 38            | 88           |
| Physician Documentation                  | Large (>=400 beds) | 28 (28%)  | 53 (53%)            | 3 (3%)        | 16 (16%)     |
|                                          | Medium (100-399 beds) | 32 (15.8%) | 128 (63.1%)     | 11 (5.4%)     | 32 (15.8%)   |
|                                          | Small (6-99 beds)    | 6 (2.0%)  | 234 (79.6%)        | 22 (7.5%)     | 32 (10.9%)   |
|                                          | Percentage          | 11.0%    | 69.2%               | 6.0%          | 13.3%        |
|                                          | Total               | 66       | 415                 | 36            | 80           |
| CPOE                                     | Large (>=400 beds) | 25 (25%)  | 55 (55%)            | 2 (2%)        | 18 (18%)     |
|                                          | Medium (100-399 beds) | 31 (15.1%) | 132 (64.4%)     | 8 (3.9%)      | 34 (16.6%)   |
|                                          | Small (6-99 beds)    | 3 (1%)    | 234 (79.6%)        | 26 (8.8%)     | 31 (10.5%)   |
|                                          | Percentage          | 9.8%     | 70.2%               | 6.0%          | 13.8%        |
|                                          | Total               | 59       | 421                 | 36            | 83           |

Table 5. Availability of medication administration systems
| Applications                              | Hospital Size          | Live | Live - hospita l-wide | Live - departmen tal | Installa tion in Proces s | Not Autom ated | ESP attach ed | Not Repor ted | Total |
|------------------------------------------|------------------------|------|-----------------------|----------------------|----------------------------|----------------|---------------|---------------|-------|
| Pharmacy Management System               | Large (>=400 beds)     | 41 (41%) | 55 (55%)       | 4 (4%)               | 0 (0%)                    | 0 (0%)         | 0 (0%)        | 0 (0%)        | 100   |
|                                          | Medium (100-399 beds)  | 43 (20.97%) | 144 (70.24%) | 15 (7.3%)            | 0 (0%)                    | 2 (0.97%)      | 1 (0.48%)     | 0 (0%)        | 205   |
|                                          | Small (6-99 beds)      | 8 (2.71%)   | 247 (83.72%) | 37 (12.54%)          | 0 (0%)                    | 1 (0.33%)      | 2 (0.67%)     | 0 (0%)        | 295   |
|                                          | Percentage             | 15.3% | 74.3%               | 9.3%                 | 0.0%                      | 0.5%           | 0.5%          | 0.0%          | 100%  |
|                                          | Total                  | 92    | 446                  | 56                   | 0                         | 3              | 3             | 0 (0%)        | 600   |
| Electronic Medication Administration Record | Large (>=400 beds)  | 30 (30%)  | 46 (46%)       | 4 (4%)               | 1 (1%)                    | 19 (19%)       | 0 (0%)        | 0 (0%)        | 100   |
|                                          | Medium (100-399 beds) | 29 (14.28%) | 110 (54.18%) | 3 (1.47%)            | 0 (0%)                    | 61 (30.04%)    | 0 (0%)        | 2 (0%)        | 205   |
|                                          | Small (6-99 beds)      | 5 (1.70%)   | 176 (60.06%) | 17 (5.80%)           | 0 (0%)                    | 95 (32.42%)    | 0 (0%)        | 2 (0%)        | 295   |
|                                          | Percentage             | 10.7% | 55.3%               | 4.0%                 | 0.2%                      | 29.2%          | 0.0%          | 0.7%          | 100%  |
|                                          | Total                  | 64    | 332                  | 24                   | 1                         | 175            | 0             | 4 (0%)        | 600   |

Table 6. Availability of image management systems

| Applications                              | Hospital Size          | Live | Live - hospita l-wide | Live - departmen tal | Installa tion in Proces s | Servic e Not Provid ed | Not Autom ated | Not Repor ted | Total |
|------------------------------------------|------------------------|------|-----------------------|----------------------|----------------------------|------------------------|---------------|---------------|-------|
| Dictation with Speech Recognition        | Large (>=400 beds)     | 1 (1%)   | 6 (6%)             | 6 (6%)               | 0 (0.0%)                   | 0 (0.0%)               | 46 (46%)       | 41 (100%)     | 100   |
|                                          | Medium (100-399 beds)  | 1 (0.64%) | 15 (9.61%)  | 5 (3.20%)            | 0 (0.0%)                   | 0 (0.0%)               | 135 (86.53%)  | 49 (205%)     | 205   |
|                                          | Small (6-99 beds)      | 1 (0.35%) | 16 (5.65%)  | 6 (2.12%)            | 0 (0.0%)                   | 0 (0.0%)               | 260 (91.87%)  | 12 (295%)     | 295   |
|                                          | Percentage             | 0.5%  | 6.2%                 | 2.8%                 | 0.0%                      | 0.0%                   | 73.5%         | 17.0%         | 100%  |
|                                          | Total                  | 3     | 37                   | 17                   | 0                         | 0                      | 441           | 102 (600)     | 600   |
| Radiology - Central PACS                 | Large (>=400 beds)     | 31 (31%)  | 56 (56%)       | 1 (1%)               | 1 (1%)                    | 1 (1%)                 | 9 (9%)         | 1 (100%)      | 100   |
|                                          | Medium (100-399 beds)  | 34 (16.58%) | 137 (66.8%) | 24 (11.70%)          | 0 (0.0%)                   | 1 (0.48%)              | 9 (4.39%)      | 0 (205%)      | 205   |
|                                          | Small (6-99 beds)      | 4 (1.36%)   | 185 (63.13%) | 62 (21.16%)          | 0 (0.0%)                   | 1 (0.34%)              | 41 (13.99%)    | 2 (295%)      | 295   |
|                                          | Percentage             | 11.5% | 63.0%                | 14.5%                | 0.2%                      | 0.5%                   | 9.8%          | 0.5%          | 100%  |
|                                          | Total                  | 69    | 378                  | 87                   | 1                         | 3                      | 59            | 3 (600)       | 600   |
Table 7. Prevalence of physician documents

| SW Usage | Hospital Size | 51-100% | 1-50% | Not Applicable | Total | Not Reported | P   |
|----------|---------------|---------|-------|----------------|-------|--------------|-----|
|          | Large (>=400 beds) | 59 (59%) | 0 (0.0%) | 0 (0.0%) | 100 | 41 | 0.017* |
|          | Medium (100-399 beds) | 152 (74.14%) | 9 (4.39%) | 0 (0.0%) | 205 | 44 |
|          | Small (6-99 beds) | 265 (89.83%) | 29 (9.83%) | 0 (0.0%) | 295 | 1 |
| Percentage | | 79.3% | 6.3% | 0.0% | 100.0% | 14.3% |
| Total | | 476 | 38 | 0 | 600 | 86 |
|          | Large (>=400 beds) | 71 (71%) | 6 (6%) | 16 (16%) | 100 | 7 | 0.321 |
|          | Medium (100-399 beds) | 150 (73.17%) | 13 (6.34%) | 34 (16.58%) | 205 | 8 |
|          | Small (6-99 beds) | 230 (77.96%) | 24 (82.75%) | 32 (93.60%) | 295 | 9 |
| Percentage | | 75.2% | 7.2% | 13.7% | 100.0% | 4.0% |
| Total | | 451 | 43 | 82 | 600 | 24 |
|          | Large (>=400 beds) | 73 (73%) | 6 (6%) | 16 (16%) | 100 | 5 | 0.826 |
|          | Medium (100-399 beds) | 149 (72.68%) | 16 (7.80%) | 34 (16.58%) | 205 | 6 |
|          | Small (6-99 beds) | 225 (92.8%) | 26 (8.81%) | 41 (43.15%) | 295 | 3 |
| Percentage | | 74.5% | 8.0% | 15.2% | 100.0% | 2.3% |
| Total | | 447 | 48 | 91 | 600 | 14 |

*p<0.05, **p<0.01

Table 8. Availability of electronic ordering
| Questions                              | Hospital Size          | Yes    | No     | Not Applicable | Not Reported | P     |
|---------------------------------------|------------------------|--------|--------|----------------|--------------|-------|
| Electronic ordering for medication    | Large (>=400 beds)     | 54     | 5      | 1              | 40           | 0.004* |
|                                       | (90.0%)                | (90.0%)| (90.0%)| (90.0%)        | (90.0%)      |       |
|                                       | Medium (100-399 beds)  | 140    | 11     | 12             | 42           |       |
|                                       | (85.9%)                | (85.9%)| (85.9%)| (85.9%)        | (85.9%)      |       |
|                                       | Small (6-99 beds)      | 241    | 41     | 5              | 8            |       |
|                                       | (7.4%)                 | (7.4%) | (7.4%) | (7.4%)         | (7.4%)       |       |
|                                       | Percentage             | 72.5%  | 9.5%   | 3.0%           | 15.0%        |       |
|                                       | Total                  | 435    | 57     | 18             | 90           |       |
|                                       | Electronic ordering for non-medication | Total | 578            | 114           | 27            | 33.2% |
|                                       | Large (>=400 beds)     | 41     | 1      | 0              | 58           | 0.016* |
|                                       | (97.6%)                | (97.6%)| (97.6%)| (97.6%)        | (97.6%)      |       |
|                                       | Medium (100-399 beds)  | 90     | 1      | 0              | 114          |       |
|                                       | (98.9%)                | (98.9%)| (98.9%)| (98.9%)        | (98.9%)      |       |
|                                       | Small (6-99 beds)      | 245    | 23     | 0              | 27           |       |
|                                       | (91.4%)                | (91.4%)| (91.4%)| (91.4%)        | (91.4%)      |       |
|                                       | Percentage             | 62.7%  | 4.2%   | 0.0%           | 33.2%        |       |
|                                       | Total                  | 376    | 25     | 0              | 199          |       |
|                                       | Electronic ordering for nursing and/or physician services | Total | 474            | 63            | 4             | 0.001* |
|                                       | Large (>=400 beds)     | 75     | 5      | 18             | 2            |       |
|                                       | (76.5%)                | (76.5%)| (76.5%)| (76.5%)        | (76.5%)      |       |
|                                       | Medium (100-399 beds)  | 160    | 17     | 27             | 1            |       |
|                                       | (78.4%)                | (78.4%)| (78.4%)| (78.4%)        | (78.4%)      |       |
|                                       | Small (6-99 beds)      | 239    | 37     | 18             | 1            |       |
|                                       | (81.3%)                | (81.3%)| (81.3%)| (81.3%)        | (81.3%)      |       |
|                                       | Percentage             | 79.0%  | 9.8%   | 10.5%          | 0.7%         |       |
|                                       | Total                  | 474    | 59     | 63             | 4            |       |

*p<0.05, **p<0.01

Table 9. Prevalence of electronic ordering
| Questions                                                                 | Hospital Size               | 100% (all) | 76-100% | 51-75% | 26-50% | 1-25% | Not Applicable | Not Reported | P   |
|---------------------------------------------------------------------------|----------------------------|------------|---------|--------|--------|-------|----------------|--------------|-----|
| What % of all inpatient medication orders are processed electronically?    | Large (>=400 beds)         | 0          | 48 (81.35%) | 3 (5.08%) | 1 (1.69%) | 2 (3.38%) | 5 (8.47%) | 41            | 0.856       |
|                                                                           | Medium (100-399 beds)      | 0          | 123 (81.45%) | 9 (5.96%)  | 2 (1.32%)  | 4 (2.64%) | 13 (8.6%)  | 54            |              |
|                                                                           | Small (6-99 beds)          | 0          | 203 (71.22%) | 14 (4.91%) | 9 (3.15%)  | 12 (4.21%) | 47 (16.49%) | 10            |              |
|                                                                           | Percentage                 | 0.0%       | 62.3%     | 4.3%     | 2.0%     | 3.0%     | 10.8%      | 17.5%         |              |
|                                                                           | Total                      | 0          | 374       | 26       | 12       | 18       | 65          | 105           |              |
| What % of all inpatient non-medications orders are processed electronically?| Large (>=400 beds)         | 0          | 63 (66.31%) | 5 (5.26%)  | 4 (4.21%)  | 4 (4.21%) | 19 (20%)   | 5             | 0.5166      |
|                                                                           | Medium (100-399 beds)      | 0          | 125 (62.18%) | 17 (8.45%) | 10 (4.97%) | 11 (5.47%) | 38 (18.90%) | 4             |              |
|                                                                           | Small (6-99 beds)          | 0          | 180 (61.22%) | 33 (11.22%) | 19 (6.46%) | 20 (6.80%) | 42 (14.28%) | 1             |              |
|                                                                           | Percentage                 | 0.0%       | 61.3%     | 9.2%     | 5.5%     | 5.8%     | 16.5%      | 1.7%          |              |
|                                                                           | Total                      | 0          | 368       | 55       | 33       | 35       | 99          | 10            |              |

Table 10. Usage of CDSS
| Questions                                                                 | Hospital Size (>=400 beds) | Yes     | No      | Not Applicable | Not Reported |
|--------------------------------------------------------------------------|----------------------------|---------|---------|----------------|--------------|
| Clinical Documentation (Physician / Nursing Documentation)               | Large                      | 63      | 6       | 27             | 4            |
|                                                                          | (65.6%)                    | (6.3%)  | (28.1%) |                |              |
|                                                                          | Medium                     | 131     | 23      | 49             | 2            |
|                                                                          | (64.5%)                    | (11.3%) | (24.1%) |                |              |
|                                                                          | Small                      | 220     | 37      | 33             | 5            |
|                                                                          | (75.9%)                    | (12.8%) | (11.4%) |                |              |
|                                                                          | Percentage                 | 69.0%   | 11.0%   | 18.2%          | 1.8%         |
|                                                                          | Total                      | 414     | 66      | 109            | 11           |
| Medication Orders                                                        | Large                      | 64      | 4       | 29             | 6            |
|                                                                          | (66.0%)                    | (4.1%)  | (29.9%) |                |              |
|                                                                          | Medium                     | 144     | 9       | 48             | 4            |
|                                                                          | (71.6%)                    | (4.5%)  | (23.8%) |                |              |
|                                                                          | Small                      | 225     | 18      | 51             | 1            |
|                                                                          | (76.5%)                    | (6.1%)  | (17.3%) |                |              |
|                                                                          | Percentage                 | 71.7%   | 5.2%    | 21.3%          | 1.8%         |
|                                                                          | Total                      | 430     | 31      | 128            | 11           |
| Non-Medication Orders                                                    | Large                      | 48      | 7       | 1              | 44           |
|                                                                          | (85.7%)                    | (12.5%) | (1.8%)  |                |              |
|                                                                          | Medium                     | 114     | 43      | 1              | 47           |
|                                                                          | (72.2%)                    | (27.2%) | (0.6%)  |                |              |
|                                                                          | Small                      | 182     | 71      | 24             | 18           |
|                                                                          | (65.7%)                    | (25.6%) | (8.7%)  |                |              |
|                                                                          | Percentage                 | 57.3%   | 20.2%   | 4.3%           | 18.2%        |
|                                                                          | Total                      | 344     | 121     | 26             | 109          |

Table 11. Usage of CLMA
| Questions                                                                 | Hospital Size     | Yes     | No     | Not Applicable | Not Reported | P   |
|--------------------------------------------------------------------------|-------------------|---------|--------|----------------|--------------|-----|
| 2nd line of validation for medication prescriptions which is documented electronically | Large (>=400 beds) | 53 (88.3%) | 7 (11.7%) | 0              | 40           | 0.271 |
|                                                                          | Medium (100-399 beds) | 132 (80.5%) | 32 (19.5%) | 0              | 41           |     |
|                                                                          | Small (6-99 beds)   | 230 (79.3%) | 60 (20.7%) | 0              | 5            |     |
|                                                                          | Percentage          | 69.2%     | 16.5%   | 0.0%           | 14.3%        |     |
|                                                                          | Total               | 415       | 99      | 0              | 86           |     |
| Automated Dispensing of medication is available                           | Large (>=400 beds) | 3 (5.0%)  | 57 (95.0%) | 0              | 40           | 0.022* |
|                                                                          | Medium (100-399 beds) | 1 (0.6%)  | 160 (99.4%) | 0              | 44           |     |
|                                                                          | Small (6-99 beds)   | 1 (0.3%)  | 291 (99.7%) | 0              | 3            |     |
|                                                                          | Percentage          | 0.8%      | 84.7%   | 0.0%           | 14.5%        |     |
|                                                                          | Total               | 5         | 508     | 0              | 87           |     |
| Closed-loop medication administration at the point of care                | Large (>=400 beds) | 60 (75.9%) | 19 (24.1%) | 0              | 21           | p<0.001 |
|                                                                          | Medium (100-399 beds) | 117 (62.9%) | 69 (37.1%) | 0              | 19           |     |
|                                                                          | Small (6-99 beds)   | 93 (31.8%) | 199 (68.2%) | 0              | 2            |     |
|                                                                          | Percentage          | 45.0%     | 47.8%   | 0.0%           | 7.0%         |     |
|                                                                          | Total               | 270       | 287     | 0              | 42           |     |
| Electronic Medication Administration Record (EMAR) available at point of care/bedside? | Large (>=400 beds) | 44 (44.0%) | 18 (18.0%) | 38 (38.0%) | 0 | p<0.001 |
|                                                                          | Medium (100-399 beds) | 99 (48.8%) | 65 (32.0%) | 39 (19.2%) | 2 |     |
|                                                                          | Small (6-99 beds)   | 105 (36.6%) | 181 (63.1%) | 1 (0.3%)   | 7 |     |
|                                                                          | Percentage          | 41.3%     | 44.0%   | 13.0%          | 1.5%         |     |
|                                                                          | Total               | 248       | 264     | 78             | 9            |     |

*p<0.05, **p<0.01

Table 12. Usage of five right rules at the bedside
| Questions                                                                 | Hospital Size       | Auto-identified | Yes     | No     | Not Reported | P     |
|--------------------------------------------------------------------------|---------------------|-----------------|---------|--------|-------------|-------|
| Which of the following is auto-identified during bedside medication administration? | Large (>=400 beds) | Medication      | 58 (69.0%) | 26 (31.0%) | 16 | 0.028* |
|                                                                          | Nurse              | 43 (51.2%)      | 41 (48.8%) | 16     |              |       |
|                                                                          | Patient            | 57 (67.9%)      | 27 (31.1%) | 16     |              |       |
|                                                                          | Percentage         | 52.7%           | 31.3%     | 16.0%  |              |       |
|                                                                          | Total              | 158             | 94       | 48     |              |       |
|                                                                          | Medium (100-399 beds) | Medication | 124 (61.7%) | 77 (38.3%) | 4 | 0.003** |
|                                                                          | Nurse              | 95 (47.3%)      | 106 (52.7%) | 4     |              |       |
|                                                                          | Patient            | 125 (62.2%)     | 76 (37.8%) | 4     |              |       |
|                                                                          | Percentage         | 55.9%           | 42.1%     | 2.0%   |              |       |
|                                                                          | Total              | 344             | 259      | 12     |              |       |
|                                                                          | Small (6-99 beds)  | Medication      | 104 (35.5%) | 189 (64.5%) | 2 | 0.422 |
|                                                                          | Nurse              | 99 (33.8%)      | 194 (66.2%) | 2     |              |       |
|                                                                          | Patient            | 114 (38.9%)     | 179 (61.1%) | 2     |              |       |
|                                                                          | Percentage         | 35.8%           | 63.5%     | 0.7%   |              |       |
|                                                                          | Total              | 317             | 562      | 6      |              |       |

*p<0.05, **p<0.01

Table 13. IMS Integration with EMR

| Question                                                                 | Hospital Size       | Yes        | No        | Not Applicable | Not Reported | P     |
|--------------------------------------------------------------------------|---------------------|------------|-----------|----------------|--------------|-------|
| Is your IMS solution integrated with your Electronic Medical Record (EMR)? | Large (>=400 beds) | 57 (95.0%) | 1 (1.7%)  | 2 (3.3%)       | 40           | p<0.00 |
|                                                                          | Medium (100-399 beds) | 155 (95.7%) | 4 (2.5%)  | 3 (1.9%)       | 43           |       |
|                                                                          | Small (6-99 beds)  | 236 (81.7%) | 10 (3.5%) | 43 (14.9%)     | 6            |       |
|                                                                          | Percentage         | 74.7%       | 2.5%      | 8.0%           | 14.8%        |       |
|                                                                          | Total              | 448         | 15        | 48             | 89           |       |

Table 14. Prevalence of IMS
| Question                                                                 | Hospital Size       | 100% (all) | 76-100%  | 51-75%  | 26-50%  | 1-25%  | Not Applicable | Not Reported | p       |
|-------------------------------------------------------------------------|---------------------|------------|----------|---------|---------|--------|----------------|--------------|---------|
| What % of medical images in all other departments are managed by your IMS? | Large (>=400 beds) | 12 (20.7%) | 19 (32.8%) | 9 (15.5%) | 3 (5.2%) | 7 (12.1%) | 8 (13.8%) | 42          | p<0.001 |
|                                                                        | Medium (100-399 beds) | 24 (14.8%) | 46 (28.4%) | 20 (12.3%) | 11 (6.8%) | 15 (9.3%) | 46 (28.4%) | 43          |         |
|                                                                        | Small (6-99 beds)   | 35 (12.3%) | 40 (14.0%) | 19 (6.7%)  | 21 (7.4%) | 23 (8.1%) | 147 (51.6%)| 10          |         |
| Percentage                                                              |                     | 11.8%      | 17.5%     | 8.0%     | 5.8%     | 7.5%     | 33.5%      | 15.8%       |         |
| Total                                                                   |                     | 71         | 105       | 48       | 35       | 45       | 201         | 95          |         |

| Question                                                                 | Hospital Size       | 100% (all) | 76-100%  | 51-75%  | 26-50%  | 1-25%  | Not Applicable | Not Reported | p       |
|-------------------------------------------------------------------------|---------------------|------------|----------|---------|---------|--------|----------------|--------------|---------|
| What % of medical images in Radiology are managed by your IMS?           | Large (>=400 beds) | 29 (48.3%) | 26 (43.3%) | 2 (3.3%)  | 1 (1.7%) | 0 (0.0%) | 2 (3.3%) | 40          | p<0.001 |
|                                                                        | Medium (100-399 beds) | 57 (34.8%) | 89 (54.3%) | 11 (6.7%) | 1 (0.6%) | 3 (1.8%) | 3 (1.8%) | 41          |         |
|                                                                        | Small (6-99 beds)   | 133 (45.5%)| 71 (24.3%) | 24 (8.2%) | 10 (3.4%)| 11 (3.8%)| 43 (14.7%)| 3           |         |
| Percentage                                                              |                     | 36.5%      | 31.0%     | 6.2%     | 2.0%     | 2.3%    | 8.0%      | 14.0%       |         |
| Total                                                                   |                     | 219        | 186       | 37       | 12       | 14      | 48         | 84          |         |

Table 15. Comparison EHR adoption of the USA (in 2017), Korea (in 2017) and Turkey (in 2014-17)

| Hospital Size | USA    | Korea | Turkey |
|---------------|--------|-------|--------|
| Basic EHR functions | 41.4% | NA    | 27.1%  |
| Comprehensive EHR functions | 39.1% | NA    | 36%    |
| Hospitals having at least basic EHR functions | 80.5% | 58.1% | 63.1%  |

Figures
Figure 1

Distributions of hospitals concerning EMRAM Stages