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# Measuring the Availability of Electronic Patient Data Across the Hospital and Throughout Selected Clinical Workflows

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**Abstract.** The workflow-oriented dissemination of electronic patient data is a central goal of IT deployment in hospitals. Against this background, the present study examines two research questions: (1.) Are there differences in the availability of electronic patient data (AEPD) between different clinical workflows and data types and (2.) which structural and organizational factors determine AEPD? Based on a Germany wide hospital survey, AEPD was assessed along six clinical workflows. While AEPD was lowest for ward rounds, discharge showed the highest AEPD with pre- and post-surgery processes ranging in between. With regard to the data types analyzed, patient demographics and observation findings obtained the highest AEPD scores. Electrophysiological results, checklists and warnings were less common electronically and received lower AEPD scores. Multiple linear regression analysis resulted in a significant model that explained 34.4% of the variance of AEPD. Large hospitals and those with a professional information management, a high health IT related innovation culture and a nursing informatics officer possess higher AEPD scores and thus have better clinical information logistics mechanisms at their command.

**Keywords.** Availability of electronic patient data, clinical information logistics, information management, innovation culture

## 1. Introduction

Patient-centred information transfer, which is oriented towards clinical workflows and thus transcends the boundaries of specialist departments and professions, has been the declared goal of IT use in hospitals for several decades [1]. On an abstract level, this goal can be described as optimal clinical information logistics [2]. This construct defines the degree to which clinical users are promptly provided with the exact information they need to make the right clinical decision [3]. Transferred to everyday hospital routine, this results in an ideal data flow. In secondary care, this data flow begins with the admission of patients by transferring patient data electronically from previous care levels. During ward rounds, admission and other types of information such as results, kardex, warnings and checklists are made available to the clinicians at the point of care. As soon as a patient is to undergo surgery, all the information collected so far is made available in electronic form to the anesthetists, surgeons and operating-room nurses. If the patients leave the operating-room, their data is also passed on electronically, regardless of whether they are transferred to - the normal or

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intensive care unit. At the end of the treatment, the collected data will eventually leave the hospital along with the patient being made available electronically via the clinical summary. The potentials that result from such a clinical information logistics are manifold and range from a pure increase in efficiency through process automation, to the creation of more transparency in the treatment process, to a more effective and safe treatment [4]. To date, there is no empirical evidence on the extent to which the hospital information systems (HIS) of German hospitals are able to provide a corresponding availability of electronic patient data (AEPD). On the one hand, a large-scale and standardised assessment of AEPD could allow a status quo analysis and thus reveal potential for optimization. In addition, it could be empirically verified which types of hospital were capable of implementing an advanced AEPD. Various studies from international HIS adoption research indicate that structural conditions such as size and ownership determine hospital digitization [e.g. 5]. More recent studies suggest that organizational conditions such as the degree of professionalization of information management (PIM), a pronounced intrapreneurship culture and participatory cooperation between IM, executive board and users can determine the initialization, implementation and institutionalization of HIS [6-8]. Against this background, the present study intends to answer two research questions: (1.) Are there differences in AEPD between different clinical workflows and data types and (2.) which structural and organizational hospital characteristics determine AEPD?

## 2. Method

A Germany-wide cross-sectional survey was carried out to answer the research questions. The following six clinical workflows were defined to reflect the care process as comprehensively as possible: admissions, ward rounds, pre-surgery, post-surgery to normal station and post-surgery to ICU and discharge. For each of the six processes, a list of patient data was compiled that is ideally provided electronically by the HIS including patient demographics, diagnosis and therapy and observation findings. Dedicated sets of information were assigned for specific processes: medical summary including medication and vital signs (admission, discharge), kardex including medication and vital parameters, warnings and checklists (ward rounds and pre- and post-operative processes)[2]. In addition, several modes of data flows were addressed: mobile availability of data for ward rounds, distinction between post-surgery data flow to ICU and normal ward, and finally data availability for writing electronic medical summaries. In order to check which structural hospital characteristics were associated with a high AEPD, ownership (private/public), size (number of beds) and teaching hospital status (yes/no) were assessed. In order to test the influence of organizational factors, the degree of professionalization of information management (PIM) was assessed by measuring the extent of planning, implementing and evaluating IM activities at the strategic, tactical and operational level with a 15 items scale that had been previously tested for reliability and validity [7]. In addition to PIM, the degree of the HIS related innovation culture (HIC) was gauged by a 25 items scale with high reliability and validity values [6, 8]. HIC consists of five sub-dimensions (CIO[3] and IT

[2] The selection of workflows and data types was based on expert surveys conducted during the questionnaire development. The selection should ensure the highest possible comparability between the hospitals.

[3] Chief Information Officer (CIO) is used as umbrella term to all leaders in charge of IT.

department intrapreneurship, innovation climate, innovation-friendly hospital management and degree of communication between IM and clinical users). Finally, the existence of a medical/nursing informatics officer and the position of the CIO (board member or not) was captured by the survey. The questionnaire was pretested for content and technical plausibility by five CIOs, 11 medical informatics scientists and one clinician. The link to the online questionnaire was sent to 1349 persons in charge of IT in German hospitals (responsible for 1950 hospitals) by e-mail at the beginning of December 2016. Based on the collected data, several scores were calculated to quantify AEPD. First, we calculated the perceived data-type specific AEPD score by the relative number of workflows in which a specific data type (e. g. patient demographics) was electronically available in all workflows consistently. Second, we calculated the perceived workflow-related AEPD by the ratio of the number of data available to the maximum of data possible. If for example the CIO reported that three out of seven patient data to be electronically available in the ward round, the specific workflow-related AEPD score was 42.9%. Both score types were added up across all workflows and data types to an overall AEPD composite score per hospital. In order to identify structural and organizational hospital characteristics that are associated with the AEPD composite score, a multiple regression analysis was calculated with structural and organizational characteristics as predictors. The model requirements were tested for normal distribution, homoscedasticity and multicollinearity.

## 3. Results

A total of 224 CIOs took part in the survey. Of these, 44 cases had to be ruled out for the analyses because the corresponding institutions did not have an operation room or did not pass the data quality plausibility test. The final sample thus corresponded to a response rate of 14.7% (125 out of 1349 e-mails could not be delivered). The participating hospitals had an average of 543 beds and were, for the most part, public or non-profit institutions (85.6%, n=180). Compared to the basic population, smaller and private hospitals were thus slightly underrepresented [10]. Table 1 shows the means and standard deviations of the data-type related AEPD scores and workflow related AEPD scores. In terms of data types, the results indicate that patient demographics and diagnoses and therapy data, as well as electronic observation reports (text and images) were continuously available to a large extent (means between 65.2% and 73.2%, Tab. 1) in the facilities surveyed. Electrophysiological results, warnings and checklists were continuously available in electronic format to a lower degree ranging from 32.7% to 51,5% (Tab. 1) with the lowest values for kardex. Table 1 furthermore shows that AEPD scores varied with the workflows examined. The highest AEPD score was measured for discharge (74.4%). The lowest (26.0%) was recorded for admission in which only a quarter of the data was made available electronically on a mobile basis. The overall average AEPD composite score was 54.8% ± 19.9. Multiple linear regression analysis resulted in a significant model that explained 34.4% of the variance of the AEPD composite score. Table 2 shows the beta coefficients as well as the p-values and the variance inflation factor (VIF) of the eight predictors. Hospital size was the only structural hospital characteristics that showed a significant influence on the level of the overall AEPD composite score ($p < 0.01$). Organizational factors, in particular the degree of professionalization of the IM (PIM), the development of the innovation culture and the existence of a nursing informatics officer showed a

significant positive influence on the AEPD composite score ($p < 0.05$). Residuals were normally distributed and showed no signs of heteroscedasticity, neither did the VIF indicate multicollinearity.

**Table 1.** Data type and workflow related AEPD scores (in %; n=180).

| Data type related AEPD | x̄ | SD | Workflow related AEPD | x̄ | SD |
|---|---|---|---|---|---|
| Patient demographics | 73.2 | 23.6 | Admission | 26.0 | 35.4 |
| Diagnoses and therapies | 72.2 | 21.8 | Ward round (mobile availability) | 49.0 | 41.7 |
| Observation reports (text) | 69.9 | 27.4 | Pre-surgery | 72.8 | 28.2 |
| Observation reports (images) | 65.2 | 26.6 | Post-surgery (to normal station) | 68.5 | 29.4 |
| Electrophysiological findings | 49.3 | 35.0 | Post-surgery (to ICU) | 64.1 | 33.9 |
| Kardex | 32.7 | 39.2 | Discharge | 74.4 | 21.0 |
| Warnings | 51,5 | 42.5 | | | |
| Checklists | 48.3 | 42.7 | | | |

**Table 2.** Beta-coefficients, p-values and VIF of the multiple linear regression model (n=160).

| Predictors | Beta | p-value | VIF |
|---|---|---|---|
| **Structural hospital characteristics** | | | |
| Size (number of hospital beds) | 0.220 | 0.009 | 1.713 |
| Teaching hospital | 0.108 | 0.146 | 1.346 |
| Private ownership | -0.032 | 0,631 | 1.082 |
| **Organizational hospital characteristics** | | | |
| Professionalism of information management (PIM) | 0.186 | 0.044 | 2.053 |
| HIS related innovation culture (HIC) | 0.190 | 0.017 | 1.506 |
| Nursing informatics officer | 0.252 | 0.002 | 1.582 |
| Medical informatics officer | -0.052 | 0.521 | 1.566 |
| CIO member of the executive board | 0.038 | 0.563 | 1.042 |

## 4. Discussion

This study investigated whether there are differences in the continuous availability of electronic patient data (AEPD) with respect to different clinical workflows and data types. Furthermore, it was examined which structural and organizational hospital characteristics determine AEPD. In four out of the six workflows studied, clinicians are receiving a higher percentage of electronic than of paper-based patient data. Potential for development could be identified for admission and ward rounds, where less than half of the patient data is made available electronically. With regard to data type-related AEPD, it can be seen that on the average patient demographics, diagnoses and therapy data as well as observation findings are continuously available. More complex information types, which in particular can facilitate clinical decision-making (i.e. kardex, warnings, checklists), are less available electronically. The study also identified structural and organizational determinants of AEPD. First of all, AEPD is more pronounced in larger hospitals. These results confirm the findings of previous studies [e.g. 5]. However, the results also provide evidence of controllable conditions for a high AEPD regardless of the size of the hospital. In especially, professional information management (PIM) seems to have a positive effect on AEPD. Thus, a continuous execution of IM activities that is aligned to the hospital strategy can foster the implementation of HIS innovations that ultimately are reflected in a high AEPD scores [7]. An advanced HIS related innovation culture was also found to have a

positive impact on AEPD. However, it can be assumed that the influence identified could be partly due to indirect effects, since a pronounced intrapreneurship at the level of the CIOs and the IT department can evidently support the professionalization of IM [7]. The same applies to a visionary and transformable hospital organization, an IT-related hospital board members and established communication channels between IM, clinical users and hospital board [6-8]. This study is limited with regard to the response rate of 14.7% that might have caused a non-response bias in our sample. The results therefore require further validation. Future research approaches could enrich the operationalization of AEPD by including further factors, in particular the degree of implementation of HIS functions, the depth of integration and the capability to distribute patient data electronically within and outside the hospital.

## 5. Conclusion

This study provides initial empirical results on the continuous availability of electronic patient data in German hospitals and thus offers a starting point for further insights into the maturity of clinical information logistics in the hospital sector.

## 6. Acknowledgements

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## 7. Conflict of Interest

The authors declare no competing interests.

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