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Health IT Adoption in German Hospitals: Could We See Any Changes Between 2017 and 2023?

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Abstract. Introduction Increase in health IT adoption is often driven by financial support through the state. In 2020, the German Hospital Future Law passed Parliament with a schedule to see potential effects in 2023. The research question of the present study thus was if there were differences between 2017 and 2023 in selected application areas eligible for funding by the law. **Methods** Availability and percentage of use in clinical units was measured in a panel of 172 hospitals for these areas. A linear mixed model with repeated measures yielded a significant increase in "medication management" and "discharge management". **Results and Discussion** In "medication management", hospitals in a group as compared to single hospitals tripled the percentage of clinical units using IT systems for this purpose. Not-for-profit hospitals doubled their IT systems for "discharge management" when compared to for-profit hospitals. **Conclusion** Whether these changes can be attributed to the Hospital Future Law is debatable due to severe delays in various fields, particularly in making funding available. There is room for speeding up particularly the administrative funding process and finally demonstrating results that are proportional to the government money invested.

Keywords. Health IT Adoption, Hospitals, Germany, Hospital Future Law, IT Report Healthcare

1. Introduction

Increase in health IT adoption is often driven by financial support through the state. This could be observed over several years in the United States where the "Health Information Technology for Economic and Clinical Health Act" (HITECH Act) [1] had caused large increases in EHR adoption as shown by [2]. Other countries are following suit, e.g. France [3]. Germany who has not performed well with regard to international and European benchmarks in years [4] has been criticized for its lack of political engagement in the hospital sector and particularly for neglecting the needs of hospitals to modernize

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their IT infrastructure and applications. Without financial incentives a standstill - for example regarding the adoption of EHRs - was predicted [5]. Based on this notion the German Federal Government issued the "Krankenhauszukunftsgesetz (KHZG)" (Hospital Future Law) that made 4.3 billion Euros available in 11 areas of health IT applications, amongst other "patient portals", "documentation", "clinical decision support", "medication management", and "order entry" [6]. Hospitals were encouraged to apply for funding in one or more of these areas otherwise they would be sanctioned by financial penalties in later years. Initially, the time schedule provided for a period of applying for funding in 2021, implementation in 2022 with results becoming manifest in 2023 to be measured by DigitalRadar, a project consortium commissioned by the German Federal Ministry of Health [7]. This schedule was extended in 2023 so that projects could be realized even after 2024. The second DigitalRadar survey took place in Spring 2024 [7]. Several factors had impeded the implementation and roll out of the IT systems. They included a) the Covid pandemic, b) applications for financial support being slowly processed by the State and Federal Governments, c) no IT staff in the hospitals to support the implementation and d) finally delays caused by the industry and their supply chains in delivering hardware and other necessary components [8].

Despite these delays there were hopes that the Hospital Future Act would spark off a large digitalization process among German hospitals as soon as possible. It was therefore justified to ask whether any changes were visible three years after the Hospital Future Law was enacted and two years after the application phase - as initially planned. The detailed questions thus were if there were differences before and after KHZG in selected application areas from the users' perspective.

2. Methods

2.1. Data source, sample and methodology

To answer the research questions data from 2017 and 2023 were compared. The year 2017 represented a good baseline as there were not yet any discussions about potential future funding available thus clearly marking a phase "without KHZG". Data were obtained from the IT-Report Healthcare series, a national survey taking place since 2002 to measure the adoption rates of health IT in hospitals in Germany but also in other countries from the perspective of different stakeholder groups [9]. Participation is voluntary. In both years, 2017 and 2023 almost identical questionnaires were made available to nearly all hospitals in Germany (1,951 in 2017 and 1,862 in 2023) inviting the medical and nurse directors by eMail to take part online. Both questionnaires embraced a set of items on each of the following fields of interest: availability and use of IT functions, user satisfaction and alignment of IT systems with the clinical processes, IT management and hospital demographics. In total, the 2017 survey included 75 items, the 2023 survey 79 items. The survey periods were July 1st to December 14th, 2017, and July 3rd to September 14th, 2023. In 2017 492 hospitals responded, in 2023, there were 496 hospitals that answered the questionnaire. Typically, only one person from each hospital responded representing this hospital. In the rare cases where more than one person from a hospital participated, the most complete questionnaire was counted. Out of these two samples, hospitals were identified that took part in both surveys thus allowing for a panel analysis. This included a sample of 172 hospitals consisting of different types regarding size, ownership, hospital status (Fig. 1). In 2017, the mean

number of beds per hospital was 436.76 ± 549.14 (SD) and in 2023 the mean was 442.61 ± 547.04 (SD).

Status

single hospital

	yes	no
2017	120	52
2023	118	54

Ownership

for profit hospital

	yes	no
2017	35	137
2023	34	138

Figure 1. Hospital demographics status and ownership for 2017 and 2023

We did not use DigitalRadar data because to date they were not made available publicly for further analysis but only as aggregated pre-analysed scores in a report. Furthermore, DigitalRadar had provided a report only for one measurement point (2021) so far [7].

2.2. Statistical Model

A linear mixed model with repeated measures [10] on the availability and use of the selected systems and hospital size (number of beds), ownership (not-for profit vs. for profit), hospital status (single hospital vs. hospital in a group) as the fixed effects was calculated with IBM SPSS V29. "Availability and use in % of clinical units" were measured on a scale from "not available and not used (0%)", "in less than 25%", "used in 25% and less than 50%", "used in 50% and less than 75%" and "used in all units (100%)". Availability and use of selected systems in 2017 vs. 2023 was recoded a class-mid-points and summarized per year as an average for a defined set of IT functions in the KHZG funding areas "clinical documentation", "clinical decision support", "medication management", and "order entry". The KHZG funding area "patient portals", which comprises "digital admission and treatment management" as well as "discharge and transfer management" [11], was covered by "discharge management" only because of methodological reasons ("availability and use" had been captured as a binary variable and did not allow the grading of use in clinical units as was possible for discharge). We thus speak about "discharge management" in the following, not about "patient portals". Table 1 shows the items from which scores were computed as an average of "availability and use" in each area.

Fixed effects in linear mixed models were in a first instance computed as a so-called simple model with the year as the only predictor to identify significant changes between the years. Models that had then indicated significant changes were further refined to explain these differences by adding the other predictors, i.e. the hospital demographics size, ownership and status of the hospital together with their interaction with the year.

Table 1. IT functions supporting the different types of data, documents and processes used to calculate the scores in each area

Clinical Documentation Score	Clinical Decision Support Score
medical summary, physician notes, basic medical record	Medical guidelines and clinical pathways, reminders,
nursing documentation, surgery documentation,	alarms, supporting drug therapy,
anaesthesia documentation, intensive care documentation,	access to knowledge and publication databases,
physiotherapy documentation, wound documentation,	supporting diagnosis, therapy (apart from drug
hygiene documentation	therapy) and nursing
Medication Management Score	**Order Entry Score**
closed loop medication, medication prescription,	lab data, radiology with and without images
medication administration record	electrophysiological examinations, councils
Discharge Management Score	
updating medication record ("Medikationsplan"),	communication with health professionals in the out-patient setting
nursing summary	communication with patients

3. Results

Table 2 provides an overview of the 2017 and 2023 means for "availability and use in % of the clinical units" and the significance of their difference. "Order entry" and "clinical documentation" had the highest means which corresponds with the largest use across the hospitals. However, in both cases there were no significant differences between the six years. There was not much change either for "clinical decision support" which in addition had an availability and usage percentage of below 40% of all clinical units. While "medication management" and "discharge management" started with a low diffusion of around 20% of all clinical units in 2017, they attained a significant gain in units adopting and using these IT functions as measured in 2023.

Drilling down on the significant results (Tab. 3 and Fig. 2) showed that these gains could be attributed to the interaction between year and hospital status (single hospital) for "medication management" which was the only interaction significant. In the case of "discharge management", it was the significant interaction between year and ownership that reflected the gains best.

Furthermore, there was a significant difference between single hospitals and those in a group for "medication management" with fewer single hospitals using the respective IT functions than hospitals in a group. The same held for IT functions supporting "discharge management". "Availability and use in % in clinical units" for Medication Management was positively associated with size meaning that larger hospitals were using these IT functions more widely than smaller ones. "Discharge management" in contrast was influenced by the ownership where for-profit hospitals had less diffusion than not-for-profit hospitals. All these main effects were irrespective of the year.

Figure 2 highlights the interactions described above. It is only the hospitals in a group that more than tripled their availability and use of IT functions supporting "medication management" over time while single hospitals made only small progress. A similar picture emerged for "discharge management" where also only one type of hospitals made a big leap forward. Here it was the not-for-profit hospitals that doubled

the percentage of clinical units where "discharge management" is digitally enabled. For-profit hospitals even witnessed a small decline.

Table 2. Statistics of the "availability and use in % of clinical units" score based on Mixed Linear Models (simple model with "year" as only fixed predictor) for selected funding areas. SEM: standard error of mean; CI: confidence interval

Funding Area	mean	SEM	n	95% CI	
				lower	upper
Clinical Documentation estimate "year": -3.54; df = 263; p = 0.266			166		
2017	64.85	1.98		60.92	68.79
2023	68.40	2.47		63.53	73.26
Clinical Decision Support estimate "year": -0.96; df = 208;p = 0.82			145		
2017	38.23	2.64		33.04	43.42
2023	39.19	3.33		32.61	45.75
Medication Management estimate "year": -20.14; df = 186; **p < 0.001**			134		
2017	21.09	3.13		14.90	27.27
2023	41.23	3.99		33.36	49.09
Order Entry estimate "year": 0.297; df = 234; p = 0.94			158		
2017	70.36	2.40		65.63	75.09
2023	70.06	3.15		63.86	76.26
Discharge Management estimate "year": -14.61; df = 181; **p < 0.001**			130		
2017	20.54	2.72		15.17	25.92
2023	35.32	3.32		28.60	41.70

Table 3. Results of a refined Mixed Linear Model with fixed effects on the "availability and use in % of clinical units" score for Medication Management and Discharge Management. SEM: standard error of mean. Significant predictors are bolded.

	Medication Management (n = 134)			Discharge Management (n = 130)		
parameter	**estimate**	**SEM**	**p**	**estimate**	**SEM**	**p**
constant	13.83	10.08	0.17	4.37	8.36	0.60
year	14.13	13.23	0.29	7.19	10.91	0.51
status (single hospital)	**21.55**	**8.57**	**0.01**	**15.96**	**6.92**	**0.02**
ownership (for profit)	12.44	9.95	0.21	**27.45**	**8.17**	**<0.001**
size	**0.027**	**0.01**	**0.02**	0.009	0.009	0.32
year * single hospital	**-31.31**	**11.15**	**0.01**	-8.67	9.06	0.34
year * ownership	-22.25	13.01	0.09	**-25.34**	**10.74**	**0.02**
year * size	-0.018	0.012	0.15	0.001	0.010	0.90

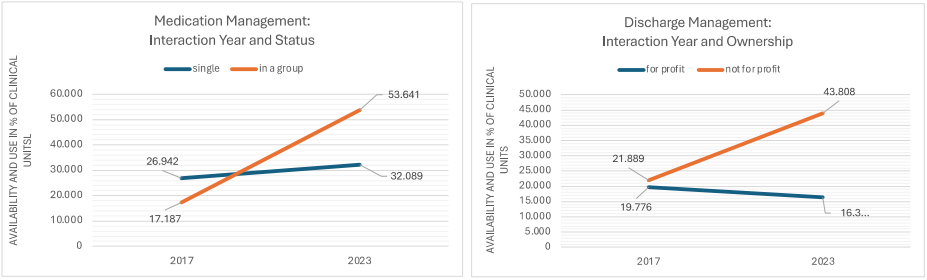

Figure 2. Interaction with the year in 2017 and 2023 for Medication Management and Discharge Management

4. Discussion

4.1. Summary and Interpretation

This is the first panel study to investigate potential changes from before to the late phase of the Hospital Future Law (KHZG) in the adoption and use of selected health IT functions that are eligible for KHZG funding. Out of the five major areas studied only two exhibited a significant increase in the diffusion throughout the hospital. They are "medication management" and "discharge management". The other three either showed a standstill ("order entry") or had so small increases that they did not become significant ("clinical documentation" and "clinical decision support"). This finding cannot be attributed to a ceiling effect because all in all the diffusion rates reached a maximum of only around 70%. However, "medication management" and "discharge management" are examples of health IT supported applications that started rather low in 2017 and caught up until 2023. Obviously, they were given high priority by the hospitals. In contrast, "clinical decision support" still lingered below 40% over a period of six years. In summary, this study revealed only single areas of major gains in several years and a general moderate diffusion rate of the systems.

When significant changes occurred, they took place either in hospitals affiliated with a group of hospitals (regional group or large health systems), which was the case for "medication management", or they happened in not-for-profit hospitals in the case of "discharge management". A trend for the role of ownership could also be seen for "medication management". These details were not surprising as previous own work and studies from other groups are backing the findings that hospital status (single vs. hospital in a group) [12, 13] and ownership (not-for-profit vs. for-profit hospitals) [13, 14] are drivers of health IT adoption and diffusion. The present study adds that this finding cannot only be revealed in cross-sectional studies but also be demonstrated over a period where the driving force becomes visible. In contrast to previous studies [15] where the size of the hospital had played a role, this relationship could only be detected for "medication management" and here as a general predictor not as a determinant of the gains over the six years. Literature shows that also small hospitals have a chance to prosper health IT wise given a good infrastructure [16].

4.2. Effect or No Effect of the Hospital Future Law?

As with all longitudinal studies that do not follow the interrupted timeseries design or do not have any control group any causal statement is hard to make. Therefore, it is impossible to say the change is caused by this law for three reasons. The first reason is that there might be a trend over the years (not observed) that would continue with or without the law. Second, in these six years many other events took place not the least the Covid pandemic and other developments in the Health Telematics Infrastructure in Germany. The third reason is that the impact of the law is likely to spread rather fuzzily than sharply. Hospitals could apply for funding during one whole year (2021) but the approval was delayed in many Federal States so that some hospitals were only able to start their projects in 2023. The selection and implementation process could take between one and two years - depending on the various funding areas, the complexity of the related health IT systems and the readiness of the IT vendors to fulfil the requirements. So that in the second half of 2023, when the data were captured in this study, the implementation was still ongoing. Clinical users at the board level of the hospitals, the target group of this study, could have known this timeline, but it is unclear whether they would have had any chance to use the technology in one of the funding areas.

Apart from these methodological concerns about causality, it can be summarised that the break-through three years after the Hospital Future Act had passed Parliament, which politicians had promised, was not observable. The area where most applications were submitted was Clinical Documentation with 1533 applications [17]. This number is disproportional compared with the lack of a significant increase of availability and use in this area. However, Patient Portals including "discharge management" (ranking second with 1130 applications) and Medication Management (ranking third with 937 applications) [17] exhibited significant diffusion gains from 2017 to 2023 in this study. Albeit significant, these changes were no landslide effect. In a comparable timespan, i.e. three years after the HITECH act was adopted, major changes in EHR adoption had become visible in the US [14].

4.3. Limitations

The main limitation of this study is its sample being not representative of all hospitals in Germany. However, we had a good mix of different types of ownership and of the hospital status. With a mean of around 440 beds per hospital and year the distribution in this panel sample is leaning towards larger hospitals. This is a phenomenon often observed in studies with voluntary participation as only the larger ones have the resources to answer the questionnaire [9]. Due to the size of the sample we cannot make any statements on the differences in the Federal States of Germany.

5. Conclusion

This panel study covering the period 2017 and 2023 hints at significant changes and lack of changes in five major funding areas of the Hospital Future Law. A mixed picture emerged which indicates only slow progress in health IT adoption and diffusion. Given the 4.3 billion Euros provided by the Federal and State Governments end of 2020, there is room for speeding up particularly the administrative funding process and finally demonstrating results that are proportional to the government money invested.

Declarations

Ethical vote: An ethical approval was obtained from the Ethical Committee of the Osnabrück University of Applied Sciences (no. WiSo_MA_HELPP_SoSe23_1_5) on June 29th, 2023.

Conflict of interest: We declare that none of the authors have any conflicts of interest related to this study.

Author contributions: JS and LB designed and conducted the study; UH and JL supervised JS and LB; UH, JS, LB, LN and JT pre-processed and analysed the data; UH, JL and ME discussed the findings and prepared the manuscript with contributions from all other authors.

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