

# Diffusion of Electronic Health Records and electronic communication in Norway

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## Keywords

Electronic health records, primary care, hospitals, general practice, nursing home, diffusion

## Summary

**Objective:** To assess the diffusion of Electronic Health Record (EHR) systems over time in Norwegian health care.

**Methods:** This study was based on a retrospective cross-sectional questionnaire survey. Questionnaires for three groups of responders were based on two validated questionnaires from prior studies, which were further customized through workshops. The questionnaires were sent to a random sample of 180 municipalities and 150 general practices in all 26 hospitals in Norway.

**Results:** The diffusion curves for EHR systems from 1980 to 2008 were established and analyzed. The most striking finding was the length of time from the availability of the first adequate EHR systems until full coverage was achieved in general practice and in hospitals. Diffusion of EHRs into nursing homes and maternal and child health centers started ten years later, and the diffusion for these centers has also been slow. In general practice the diffusion seems to follow the classical s-curve of diffusion. Costs and the increasing complexity of EHR systems were regarded by respondents as the most important challenges and concerns for the future. Resistance among health personnel was seen only as a small problem.

**Conclusion:** National strategic processes account for the slow diffusion and complexity of EHR systems in the health sector.

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## Introduction

The Electronic Health Record (EHR) has been characterized as a hub of information in health care. The use and diffusion of Information and Communications Technologies (ICT) in health care has thus been dependent on the diffusion and adoption of EHR systems.

Most studies on the diffusion of EHR systems have been based on cross-sectional data [1–5]. Some studies have looked into differences that could explain variances between countries, e.g., national ICT strategies or incentives [6–7]. Other studies have investigated the attitudes among health personnel and the characteristics of organizations and services, often focusing on barriers to adoption [8–10]. These studies have not been longitudinal, although an important exception is Denmark, where diffusion has been followed continuously from 2000 to 2006. Nøhr describes [6–7] how the Danish EHR-Observatory monitored the development, implementation, and diffusion of EHR systems.

Hospitals in Norway are primarily operated and financed by the government. Public hospitals are organized into four regional health authorities and account for 43 % of total health expenditures. Another 5% are allocated to private specialist health services. The local municipalities are responsible for providing primary care services, including health surveillance and prevention, home care and nursing homes, and general practice. Primary care accounts for 45% of the Norwegian health budget. Most general practitioners (GPs) work on contracts for local municipalities and earn a combination of per capita and fee-for-service income.

The objective of this study [8] was to survey the diffusion of EHR in health care in Norway. This study covers a cross-section of Norwegian health care services, including hospitals, general practice physicians, nursing homes, and maternal and child health centers. We also asked various stakeholders about their expected challenges and concerns regarding the further development and diffusion of EHR systems.

## Material and methods

This study is based on a cross-sectional, retrospective study. A random sample of 180 municipalities was selected from Norway's 420 municipalities.

In this sample, 130 GP practices were randomly selected. In addition, 20 GP practices were selected from the four largest cities in Norway to ensure an adequately large sample of GPs from these cities. The questionnaire was sent to the GP responsible for ICT management in each selected practice.

Two questionnaires were sent to municipality health administrations; one questionnaire focused on the use of EHR in maternal and child centers, and the other questionnaire focused on the use of EHR in nursing homes.

All 26 public hospitals in Norway were asked to complete the questionnaire.

After an initial reminder by mail, those who had not responded were contacted directly by phone. The GPs who responded received compensation for loss of income equivalent to a patient encounter.

The questionnaires were based on questions from two formerly validated surveys. The first questionnaire has been used regularly over several years in Denmark [6]. The other questionnaire has been used in Norway [1], albeit under slightly different settings. These questionnaires were further developed through a series of workshops with a reference group that included members from the Directorate of Health, the Norwegian Medical Association, the Norwegian Nursing Association, the National ICT Organization for Hospitals, and the National ICT Organization for the Municipalities. Quality assurance and final adjustments to each questionnaire were based on expert feedback.

The questionnaire was designed so that the number of questions was low enough to ensure a high response rate, but at the same time, the questions were comprehensive enough to provide a sufficient basis for the research. The questionnaires were also intended to provide comparisons between different settings and subsequent surveys over time. The main themes in the questionnaire were related to the procurement of EHR, clinical use, electronic communication, and the management of EHR systems. The answers were scanned and read electronically. SPSS statistics software was used to analyze the data.

## Results

The final response rate was 43% from municipal health administrations, 62% from GP practices and 83% from hospitals.

### Diffusion of EHR systems over time

The diffusion of EHR systems into different health services is illustrated in ► Figure 1. This figure shows the proportion of different health services that had implemented or were in the process of implementing EHR systems at the time of the survey. Implementation in hospitals is slow, and approximately 20% of hospitals reported that implementation was still incomplete in 2008. The adoption of EHR systems in general practice takes the shape of an s-curve. The diffusion curve for the hospitals is more step-shaped than the other curves. EHR adoption started at the beginning of the 1980s for both hospitals and general practices. While nearly all GPs had acquired EHR systems by the turn of the millennium, it took 20 years from when the first systems arrived to reach this level of adoption. The diffusion in hospitals has taken even longer.

The use of EHR systems in nursing homes and maternal and child health centers started about 10 years after their use in general practice, but the rate of adoption seems to follow the same slope. By 2008, EHR systems were in use in nursing homes (82%), homecare services (56%), school health services (39%), community mental health clinics (66%), community services for mentally retarded (34%) and maternal and child health centers (65%). The data also show that there is a strong relationship between the size of the municipality and the implementation of EHR systems. Smaller municipalities were usually far behind the larger ones, but EHR implementation seemed slowest in school health centers, community mental health centers and community service centers for the mentally retarded.

The GPs were asked when they had purchased their first EHR system as well as when they had purchased the system they currently use. ► Figure 2 shows that the purchase of the first system peaked around 1992 and 1993, which coincides with the most rapid growth in the number of users shown in ► Figure 1. At approximately the same time, another group of GPs started replacing their earlier systems with the systems that they currently use. The substitution of systems reached its peak approximately in 2000. Altogether, 48% of the GPs had substituted their first EHR system with another system by 2008, and two-thirds of them made this substitution between 1999 and 2003. By 2002, EHR installations approached almost full coverage (95%), with only a few remaining GPs purchasing their first system in the subsequent years. Additionally, as shown in ► Figure 2, very few GPs replaced their EHR system after 2004.

### Transition toward paper-free workflows

The responses showed that most GPs still kept paper-based archives in 2008, but only a small minority (4%) of GPs regularly consulted their paper-based records during office visits. At the same time, 10% of hospitals still considered paper-based records as the main source of medical information; 65% reported using the EHR system as their main source of record-keeping but used paper-based records in tandem. The last 25% of hospitals have made the transition to completely paper-free records. The most common approach to this transition was to scan the old paper-based records when a patient is hospitalized. The differences among the four health regions were small.

The survey population was asked about the possibilities for communicating with external partners via their EHR system. All health care providers in Norway (both private and public) are obligated to use a publicly owned, secure national network established especially for electronic communication between health care providers. At the time of the survey, 100% of hospitals were connected, 71% of general practices were connected, and 36% of municipalities were connected.

Out of the hospitals, 59% reported that their EHR systems could receive electronic referrals from GPs. All hospitals (100%) could send electronic discharge letters, and 91% could send electronic laboratory results to GPs. However, 86% of hospitals reported that they were unable to send electronic discharge letters to other hospitals.

Of the general practices, 24% were able to send electronic referrals, but more than 50% of the referrals were sent together with a paper-based copy. GPs received more than 90% of discharge letters and laboratory reports electronically, but paper copies were also received for 55% of discharge letters and 45% of laboratory reports. Approximately 20% of GPs used electronic communication through their EHR systems to send sick-leave certifications and bills. The use of electronic communication in other primary care services hardly existed. As indicated in ►Figure 1, many of the municipality health care participants did not have an EHR system, and many of them were not connected to the secure national network. This scenario naturally inhibits some of the possibilities for electronic collaboration.

## Challenges regarding the future use of EHR

The respondents in this survey were also asked about what they perceived to be the main challenges to EHR use in the future. Comparisons of the answers from the three groups of users are summarized in ►Table 1.

►Table 1 shows that all three groups saw rising costs as the most important challenge to the use of EHR systems in the future. GPs were also concerned about the daily operation and maintenance of their EHR systems. This concern was reported by municipal health administrations as well. In addition to costs, hospitals reported insufficient integration between EHR systems and other clinical and administrative systems, in addition to inadequate usability and a lack of realized benefits. The hospitals were also seemingly dissatisfied with their vendors. Only a few respondents reported that resistance to the use of EHRs among health personnel was a problem; nevertheless, training was perceived as a challenge by both hospitals and municipalities.

## Discussion

This study describes the diffusion of EHR systems in Norway from their initial introduction to the present. To our knowledge, no other studies have addressed this topic. The most striking finding was the period of time from the availability of the first adequate EHR systems until full coverage was reached. Even the most intense period of diffusion lasted for over ten years. Our findings are in line with Bower's suggested adoption rate for EHRs [9], and he compares the diffusion of EHR systems to the diffusion of ICT systems in other industries. Our findings show that the diffusion of EHR systems in general practice follows Rogers' classical s-curve for the diffusion of innovations [10].

## Diffusion of EHR systems among general practitioners

The first EHR system for Norwegian GPs was brought into use as early as the late 1970s. This system was the ProMed system [11]. Another system, commonly called "The Balsfjord System", was developed in the small municipality of Balsfjord in 1980 [12]. The market leader during the first decade was Infodoc [13]. The first systems were mainly based on clients running on DOS operating systems. When new systems based on the newer MS-Windows platform were introduced, many of the users not only changed the version of their EHR but also changed their vendor. This process is illustrated in ►Figure 2. This large shift took place without influencing the slope of the curve. As a result, we conclude that GPs are willing to change systems and vendors when significant developments in ICT occur. Today, three vendors dominate the market for EHR systems in general practice in Norway.

GPs in Norway funded their own EHR systems, without any government subsidies or incentives. We believe that this diffusion was driven by an important "epidemic effect", as described by Anderson [14]; because diffusion took off when early adopters started reporting substantial gains. ►Figure 1 shows that general practice in Norway had close to full coverage by 2002. According to Nøhr et al. [6–7], 95% of Danish GPs had access to EHR systems in 2004. An international survey from 2007 [15] showed that there was coverage at levels comparable to Norwegian general practice in countries such as Finland, Denmark, United Kingdom, the Netherlands and Estonia. In the United States, however, the adoption of EHR systems has progressed significantly slower. Gans et al. [16] surveyed a group of medical practices in the United States. They found that the adoption of EHR systems is

progressing slowly and that the implementation of these systems was more complex than expected. Protti and Nilsson compared IT in general practice in ten countries [4–5]. These investigators suggest that one reason for the slow uptake of EHR systems in primary care in the United States and Canada might be due to the fragmentation of the market in addition to the fact that in comparison to North America, many European countries have highly centralized health systems.

In Norway, most GPs operate their own EHR systems and technical infrastructure. This type of operation involves administrative tasks such as backup routines, maintenance of local networks, management of external communications, implementation and rollout of new versions and software updates. GP knowledge about information systems is mostly self-taught. At the same time, the complexity of these systems has increased, especially after the introduction of electronic communication. This trend is reflected in ► Table 1, which shows that GPs are most concerned about the management of EHR systems.

## Diffusion of EHR systems in Norwegian hospitals

In comparison to the development of EHR systems for GPs, the Norwegian government has provided significant funding for the development of hospital EHR systems. Nevertheless, the diffusion of EHR systems into hospitals was slower than that of primary care. By 2008, all Norwegian hospitals had started using EHRs. Compared to other countries [3], only Finland achieved such a high coverage of EHR systems in hospitals. In Denmark [6–7], only 7% of hospital beds were covered by an EHR system in 2004. The diffusion growth was also moderate; four years earlier in 2001, only 5% of hospital beds were covered by an EHR system.

In 2008, three major EHR systems were in use in hospitals, with one vendor having secured a significantly larger market share than the others. The leading system originated in a small Norwegian hospital, where the first version was developed in close collaboration with the users at that hospital. According to Lærum et al. [1], this scenario contributed to the development of a system that offered a high degree of support for users in their daily work processes. Initially supported by a limited number of users, this system is now in use at many hospitals, both large and small, all over Norway.

The hospital procurement process has often involved groups of hospitals. Because Norwegian hospitals are administered by Regional Health Authorities, procurement has often been performed at a regional level. This structure helps explain some of the steps in the diffusion curve for the hospitals in ► Figure 1, as groups of hospitals tend to make the decision to implement a new system at the same time. The fairly low number of hospitals may have also influenced the shape of the curve.

Ellingsen and Monteiro [2] found that establishing EHR systems in hospitals, especially larger hospitals, has been notoriously difficult. The increase in organizational, institutional, political and technological complexity was seriously underestimated during early years of implementation.

The benefits of EHR systems in hospitals for supporting the daily work processes of clinicians [12] have not been as evident as compared to the benefits reported for general practice. Diffusion has also taken much longer. While general practice clinicians themselves drove procurement processes, most hospital procurement processes have been managed by the hospital administration. Hospital EHR systems are more complex as compared to their GP counterparts, further complicating the procurement process. As a result, in the end, health care professionals in hospitals had only a limited amount of influence on final EHR decisions. We believe that both EHR complexity and procurement processes have influenced the shape of the diffusion curve for hospitals shown in ► Figure 1. These relationships are also indirectly reflected in ► Table 1, which shows that hospitals perceive usability, integration with other information systems, and vendor capability to deliver as more important challenges than the GPs.

## EHR systems in community care

The first EHR systems were introduced in community care as late as 1995. The diffusion curve for EHR systems in nursing homes and maternal and child health centers seems to follow the same pattern as hospitals and GPs. Until 2008, the diffusion curve for maternal and child health centers was steeper than that of nursing homes. This difference might be due to a similar reason as the difference between GPs and hospitals. Maternal and child health centers represent small units with a less com-

plex organization, and their EHR systems have similar consequences in contrast to nursing home EHR systems. It is difficult to find research from other countries that studies the diffusion of EHR systems in primary care services other than general practice.

The municipalities are already responsible for a rather diverse set of information systems that serve schools, technical offices and public administration in addition to health care. The breadth of this responsibility may have contributed to why the diffusion process started later. The slower diffusion in smaller municipalities might be related to relatively higher costs, lower competence or simply because the need is perceived as less pressing in communities where with strong social ties. Costs and complexity were also ranked as the most important challenges by the municipalities in ► Table 1.

## The use of paper in parallel

Most GPs stopped using paper-based health records fairly soon after implementing an EHR system. The hospitals did the same, but more gradually [17]. Research by Lium [18] shows that the removal of paper-based records from the clinical workflow in hospitals does not change many routines, which limits the potential of EHR systems.

To reduce the use of paper for communications seems to be harder. Many GPs received laboratory results electronically as early as the late 1990s. By 2008, nearly half of them still received results on paper as well as electronically. We found similar numbers for discharge summaries and imagery results. On the other hand, less than 10% of the electronic referrals and laboratory requisitions from the GPs were sent with paper in parallel. We have not been able to find any research that shows to what extent the parallel use of paper occurs in other countries. We do not know whether it is conservatism or that the parties do not trust the electronic communication from the hospitals. Another reason could be that paper-based information still offers a better user experience for specific and/or important medical tasks [19–20].

## Limitations of the study

The response rate among GPs and hospitals was satisfactory. GPs who responded could have disproportionately represented early EHR adopters, but a similar diffusion percentage of EHR in primary care was also documented by the Ministry of Health and Social Affairs in 2000 [21]. The low response rate from municipalities could be related to the fact that a similar study was undertaken by the Directorate of Health and The Norwegian Association of Local and Regional Authorities (KS) in the same population only a few months prior to ours [22]. This study showed similar results to our study where there were overlapping questions.

Questionnaires were sent to the officially appointed data controller at hospitals and municipalities. However, we do not know whether the controller or someone delegated to complete the questionnaire had the necessary insight to answer all of the questions.

When stakeholders were asked about the possibility of electronic communication, we believe that their responses indicate a gap between what was theoretically possible and the actual use of electronic message exchange. This gap arises both because of the fact that not all collaborating partners had EHR systems that could communicate, and at the same time, not all users had started using all of the electronic communication possibilities to their full potential. There are reasons to believe that this gap is smaller in the case of GPs, where there are fewer communication partners and the appointed data controller is often a clinician and user him/herself.

For some questions, we had to rely on the memory of respondents to obtain historical data about the dissemination of EHR systems. For some of our respondents, our questions go back almost 25 years. Still, we believe that the accuracy is satisfactory. The implementation and/or substitution of EHR systems is a significant event and fairly easy to track in the system itself. The smoothness of the data distribution in ► Figure 1 (showing the diffusion of EHR in general practice) partly supports this claim.

Finally, it is also well documented that the diffusion of EHR has progressed differently in other countries [4, 5]. The generalizability of our results to other regions or countries might therefore be limited.

## Conclusions

Norway has achieved almost full coverage of EHR systems in both general practice and hospitals. The diffusion process has taken nearly 20 years in general practice and even longer in hospitals. The main lesson learned is that authorities and stakeholders have to take into account a much longer perspective on health information system development and diffusion than what has been commonly expected. The slow diffusion rate of EHR systems also influences the diffusion of electronic communication because data often need to be transferred to or from EHR systems.

This long diffusion time should also be taken into account in evaluation processes. Early evaluations might turn down projects that have the potential to succeed in the long run.

Even if EHR systems are already in use, there is an increasing need for further development of these systems, and their complexity is increasing. Costs related to both purchase and maintenance are reported to be important concerns for all stakeholders.

### Clinical Relevance Statement

This study on the diffusion of EHR systems at the national level should enable health and ICT policy makers to better predict the effects of EHR system implementation policies. The role of GPs in purchasing their own EHR systems is different from the role of health personnel in other health services and has probably contributed positively to the successful implementation and diffusion of EHR systems in general practice in Norway.

### Conflicts of Interest

The authors declare that they have no conflicts of interest in this research.

### Protection of Human and Animal Subjects

This study was approved by the Norwegian Privacy Ombudsman for Research (NSD). NSD is the Privacy Ombudsman for all Norwegian universities, university colleges and hospitals and research institutes. The Norwegian Data Inspectorate has delegated responsibility to NSD with respect to the Personal Data Act and the Personal Health Data Filing System Act.

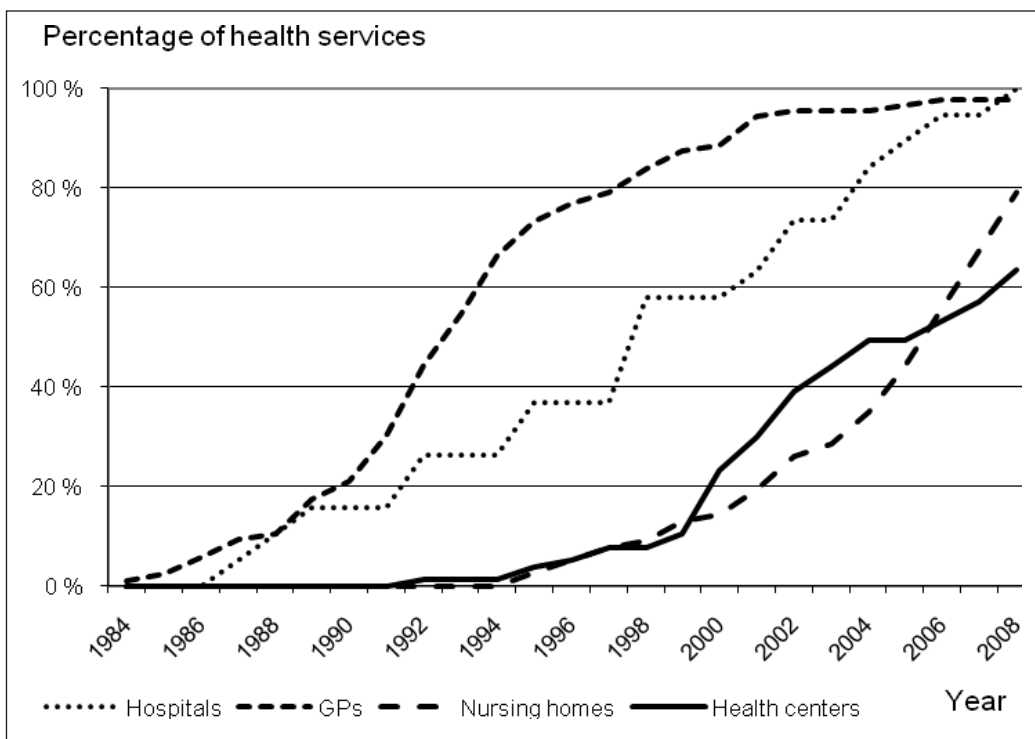


Fig. 1 The accumulative percentage of different health services that had implemented or were in the process of implementing their first EHR system from 1984 to 2008.

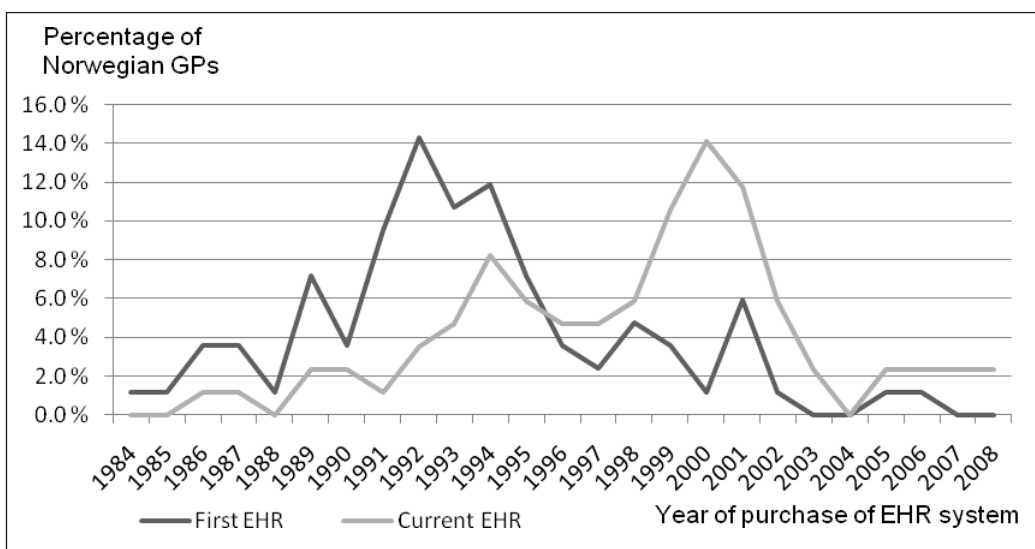


Fig. 2 The year and percentage of GPs purchasing their first and current EHR system from 1984 to 2008.



**Table 1** Highest rated challenges regarding the further diffusion and development of EHR systems in terms of percentage of respondents marking this challenge on the survey

Challenges	Hospitals (%)	GPs (%)	Municipalities (%)
High costs	80	54	67
Poor functionality	50	36	22
Complexity of system maintenance	28	52	49
Complexity of system upgrade	28	21	17
Resistance toward change among users	10	8	19
Lack of standards	35	29	24
Educating users	40	18	44
Poor integration between EHR systems and other systems	63	44	39
Achieving substantial benefits	53	28	32
Legislative demands	20	15	14
Vendors do not deliver as promised	55	27	17

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