Histories of the electronic medical record in The Netherlands 1970 - 2015

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Master's thesis
August 31, 2023

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Acknowledgments

This thesis owes its existence to my wife Ricky van Oorschot, who urged me to keep busy intellectually after my retirement from Erasmus University Rotterdam and wanted to prevent me becoming a couch potato. I thank my fellow students of the HPS class of 2019 for their collegiality. In the same spirit I thank my teachers from whom I learned much about the history of science and made me a historian of science.

I was fortunate to find a supervisor who immediately understood my desire to write a history of the electronic medical record and helped to scope the subject. Thank you, Timo Bolt for our interactions. I am also grateful to the Utrecht University supervisors, professors Toine Pieters and Frank Huisman, who took a serious interest in what I wanted to do and consented that Timo as member of the Descartes Centre would be the daily (external) supervisor.

I appreciate very much professors Albert Bakker and Johan van der Lei, Khing Njoo and my sister Odette Aarts for granting me interviews. It helped enormously to contextualize my research.

My interest in the history of biomedical informatics started to brew in history workshops organized by the American Medical Informatics Association and the International Medical Informatics Association. It enabled me to interact with pioneers in the field. Special thanks go to Casimir A. (Kaz) Kulikowski from Rutgers University and Edward H. (Ted) Shortliffe, formerly Stanford University, for intensive discussions about the history of our field.

1. Introduction

> *"The clinical case record freezes in time that episode in life called illness. It is a story in which patient and family are the main characters, with the doctor serving a dual purpose as both biographer and part of the plot. The content of this biography varies greatly, reflecting its many purposes: to recall observations, to inform others, to instruct students, to gain knowledge, to monitor performance, and to justify interventions."*[1]

In this citation, the medical historian Stanley J. Reiser summarized the pivotal role of the medical record in clinical practice. The electronic medical record has been a counterpoint in my academic studies of information technology in health care. Its key role is my motivation to write its history in the Netherlands. While having a pivotal role in medical practice and health care at large, very few historical studies have been written. My thesis aims to fill that gap and contribute to its historiography.

1.1. Defining the medical record

The medical record has been defined by its different roles. First, it is a repository of data of the illness of a patient. Second, it is a place that allows the doctor to write down her or his observations and opinions about the true nature and cause of the illness. In the course of time, its role has been expanded to medical research and education, health care planning and quality assurance.

The source of the data is usually diverse: symptoms, findings of a physical examinations, answers to questions, laboratory tests, x-ray examinations, etc. Thus, a medical record serves as an aide-memoire for the doctor, but also organizes medical knowledge about the patient's medical problem. From a sociotechnical point of view the medical record plays an *active* role in medical work; in more general terms technology is said to have *agency*.[2] It acts as a communication device between patient and doctor, it

[1] S.J. Reiser (1991), The clinical record in medicine, part 1: learning from cases, Annals of Internal Medicine, vol 114, p. 902-907.

[2] M. Berg (1996), Practices of reading and writing: the constitutive role of the patient record in medical work. Sociology of Health and Illness, vol. 18, pp. 499-524.

enables communication with other providers, such as doctors, nurses and pharmacists, facilitates planning of future activities pertinent to patient care, and finally it serves billing and resource planning of hospital services. Probably, I am not complete in describing the active role that I attribute to the medical record. Support of medical work is the focus in this thesis.

The study of the electronic medical record (EMR) or electronic health record (EHR) has been central to the discipline of biomedical informatics.[3] Volumes have been written about the definition of the discipline, which emerged in the Netherlands around 1970. In 1971 Albert Bakker became the first appointed full professor of medical and biological information processing in the Netherlands at Leiden University, followed in 1973 by Jan H. van Bemmel at the Free University of Amsterdam. The name of van Bemmel's chair explicitly included *medical informatics*. Though the naming of the discipline underwent a number of changes and extensions, its core idea is that modern biomedicine produces enormous amounts of data and needs a scientific basis and computing power to make sense of it. Biomedical informatics includes methods and tools to structure, mine, visualize and reason with data and information to produce medical knowledge.[4] Moreover, the discipline provides also the scientific basis for the incorporation of data and information into workflows. Over time the discipline has expanded from a narrow basis of understanding the technology and its (software) tools to the nature of formalized medical knowledge built on quantifiable data and concepts applied to the wider health care context in which this knowledge can be used.

1.2. Histories of computing

According to the untimely deceased historian of science and technology, Michael S. Mahoney, the history of computing has mainly been centered around the machine and the

[3] The terms 'electronic medical record', 'electronic patient record', and 'electronic health record' are used interchangeably, while 'medical computing' designates a more generic way to indicate computing support of medical work, for example automated laboratory testing, ECG recording and interpretation and digital imaging.

[4] E.H. Shortliffe, J.J. Cimino, M.F. Chiang, editors (2021). Biomedical informatics, computer applications in health care and biomedicine, 5th ed, Cham: Springer, p. vii.

things that could be done with it.[5] This resulted in historical accounts of scientific tabulations and statistics, calculations, and informational needs of business, industry and governments. The consequence was that two major groups of computing communities were discerned. The first group of scientists and engineers saw the computer as a calculating machine. The second group of commercial and government origin comprised data processing.[6] Medical computing belonged to the latter category. The accounts of the history of computing converged on the post-war electronic digital computer and the evolution of different forms of computer technology ultimately tied together by the internet.[7]

Mahoney advocated a different approach to the history of computing. Instead of focusing on the machine and its users, he stipulated that a historical study of computing should address its origins and specific contexts. Moreover, Mahoney argued that different groups of people saw different possibilities in computing and had different experiences as they figured out how to realize those possibilities. For a history of the electronic medical record, it was no different. In the Netherlands, the origins of the electronic medical record were rooted in two different communities of medical practice, primary care and hospital care. General practitioners and medical specialists had different needs and purposes. They encountered different problems and different levels of difficulty in fitting their practice to it. Following Mahoney, I therefore use the plural 'histories' in the title of this thesis.[8]

1.3. Periodization

The title of the thesis covers a period between 1970, when the first computers were introduced in clinical medicine, and 2015, when a new generation of hospital information systems relegated paper-based medical records to the dustbin of history. However, in order to understand the origins, I go back well before computing appeared in Dutch medicine. I follow Michael Barr's argument that the appearance of the structured paper record more

[5] M.S. Mahoney (2011), The histories of computing(s), in: M.S. Mahoney and T. Haigh (editor), Histories of computing, Cambridge (MA): Harvard University Press, pp. 57-58.

[6] Ibid., p. 61.

[7] Ibid., pp. 62-63.

[8] Ibid., p. 64.

than a century ago was a necessary step.[9] Contexts, such as budgetary constraints in health care, government regulation, professional development and affordance of computing technology, influenced development. The contexts varied with time and place. The reform of medical education and practice in the United States in the early 20th century was an important incentive to reform the medical record. There is no evidence of a comparable reform in the Netherlands in the same period. The reform of medical records is well documented in the United States through contemporary articles in medical journals, while not in the Netherlands. However, Dutch hospital physicians were aware of it through visits to the United States, evidenced by articles in a Dutch magazine for hospital administrators; they were very opiniated. Therefore, the history of the structured medical record in the United States is described in chapter 3 with an eye on its impact on the Netherlands. After the Second World War Dutch health care changed drastically and that was part of the context that had an impact on the reform of Dutch medical records. Within the framework of contextualization and inspired by social theories, the influences changing he adoption by doctors of electronic medical records are described in this thesis in terms of incentive and power. Incentives can be loosely defined as events or actions influencing behavior. Again, they can be different and specific for people in place, time and context.

1.4. Historical sources

History writing is about going back to the primary sources. Here the histories of medical computing present a paradox. At the one hand tons of articles about medical computing have been published in international biomedical informatics journals, which started to appear since the 1960s. These articles present contemporary accounts of applications development and medical research enabled by the new technology. Similarly medical journals have published occasionally about medical computing. The Dutch medical magazine *Medisch Contact* was an outlet of information and opinions about medical computing and proved to be an important primary source. The scientific journal for primary care *Huisarts en Wetenschap* proved to be an important source to reconstruct the history of medical computing for general practitioners. The *Vereniging voor Medische en*

[9] M.S. Barr (2010), The clinical record: a 200-year-old 21st -century challenge, Annals of Internal Medicine, vol. 153, pp. 682-683.

Biologische Informatieverwerking (VMBI), founded in 1970 as a society for researchers and practitioners of information technology in health care, published from 1984 until 1997 a magazine, *Tijdschrift voor Medische Informatica*. It contained articles about medical informatics research and applications mainly in the Netherlands, but little about context. They were occasionally used to ascertain information found in other sources.

On the other hand, a number of documents describing policy issues could not be found. Only from references in Dutch magazine articles their existence and contents could be inferred. The archives proved to be incomplete as well. Of the period 1970 – 1980, only an archive of a specific ministerial department dealing with budgetary and policy issues of academic hospital computing is kept in the National Archives. Government related policy documents of the same period could not be found. Only after 1980 the situation improved and policy documents related to parliament proceedings could be retrieved from the internet. Like Mahoney, I believe that because of the volatility of computing technology associated documentation was volatile as well.[10]

Mahoney problematized the position of pioneers and participants in the history of computing, whether as active members of panels and workshops, as subjects of interviews, or as historians of their own work.[11] As academic researcher in biomedical informatics, I have done all of these. I used my documentation collected over a period of forty years. The only way to mitigate bias is to check personal experience against documented evidence.

For this thesis I have conducted four interviews with persons who were involved in hospital and primary care computing. The interviewees were professor Ab Bakker, the developer of the hospital information BAZIS; Johan van der Lei, professor emeritus of medical informatics at Erasmus MC; dr. Khing Njoo, general practitioner and retired staff member for information technology at the *Nederlands Huisartsen Genootschap* (NHG, the Dutch scientific society for general practice); and Odette Aarts, retired general practitioner and early user of an electronic medical record system. The interviews helped to scope the historical study reported in this thesis. Statements about events were corroborated through documented evidence and this evidence was used as a primary

[10] M.S. Mahoney (2011), Issues in the history of computing, in: M.S. Mahoney and T. Haigh (editor), Histories of computing, Cambridge (MA): Harvard University Press, pp. 44-47.

[11] Ibid., p. 39.

source. Summarizing, lots of articles were published about research and technology, much less about context

1.5. Research questions and structure

Given the paucity of relevant historical materials, the study in this thesis is explorative and descriptive guided by the concepts of Mahony. It follows from his approach that because of different contexts, multiple histories of medical computing can and should be told. Thus, in this thesis, the different historical pathways the electronic medical record took in primary and secondary care are described and understood by contextualizing them. However, Mahoney's historical perspective of the beginnings and contexts of new technology has limited explanatory power. He offers no analytic tools for more specific explanations of events and developments. I therefore resort to social theories to understand incentives, agency and power in different contexts.[12] These considerations above lead to the following research questions:

- How can the histories of electronic medical records in the Netherlands be described according to Mahoney's concepts of beginnings and context?
- How can the histories of the electronic medical record in primary and secondary care be explained and compared?
- What were the incentives to adopt the electronic medical record in the communities of primary and secondary care?

After the introduction in this chapter, chapter 2 addresses a historiography of biomedical computing of mainly English language books on the topic. Chapter 3 presents a history of the structured medical record in the United States before the Second World War, laying the foundations for medical computing after the war. It includes also the Dutch response. Chapters 4 and 5 deal with the early beginnings of medical computing in Dutch hospitals and primary care respectively. Chapter 6 analyzes the context and incentives that led to the adoption of electronic medical records in secondary care. Chapter 7 describes a yet unfinished history of medical computing in the 21st century, in which the role of patients is strengthened. Finally, chapter 8 presents a conclusion, in which the findings are

[12] S. Sismondo (2010), An introduction to science and technology studies, Chichester: Wiley-Blackwell.

tied together and a few suggestions for further research are made. In an appendix the historical sources and literature are listed.

2. Historiography

The historiography will be guided by Mahoney's questions of origins and context. The study of electronic medical records is subsumed in the scientific domain of (bio)medical informatics. Though historical studies of medical records have been published in academic journals, the number of book publications is limited. A search on the literature database WorldCat produced five titles that met the criteria of including electronic medical records or databases. One title is a revised edition of a previous publication. The books will be analyzed below, largely in chronological order, oldest first. I will end with discussing a few journal articles on the history of medical computing.

2.1. ACM History of medical informatics conference

In November 1987 the Association for Computing Machinery (ACM) convened a conference with collaboration of the National Library Medicine about the history of medical informatics in the United States as part of a series of conferences devoted to the history of computing.[13] The organizers listed three reasons for this. First, at the time the field was young and the pioneers were still in good health to share their experiences and insight. Second, the field had made important contributions to computer science and lessons were to be learnt from the interaction between theory and application. Finally, an understanding of the early goals of medical informatics could provide insights how the goals of the field could change vis-à-vis the opportunities of new computer technology. Nineteen papers and one panel about the early beginnings were presented covering computing systems, signal and image processing, clinical data processing, health care information systems, patient management systems and clinical decision making. Most of the projects described by their developers were funded through research grants of the federal government. Unmodified, the presentations and panel were published in a book as part of the ACM History Series;[14] to the book were added forewords by Mahoney, a preface

[13] B.I. Blum, ed. (1987), Proceedings of ACM conference on the history of medical Informatics, New York: The Association for Computing Machinery (https://dl.acm.org/doi/proceedings/10.1145/41526, accessed 30 July 2022)

[14] B.I. Blum, K.A. Duncan, eds. (1990), A history of medical informatics, New York: ACM Press/Reading (MA): Addison-Wesley Publishing Company.

by the editors and transcripts of the discussions. The contributions by Molnar and Clark, Barnett, Collen and Hodge bear relevance for the Netherlands. Charles Molnar and Wesley Clark developed in the early sixties the first minicomputer for the processing of biomedical signals.[15] The computer became the basis of the line of minicomputers developed and sold by Digital Equipment Corporation. The resulting PDP and Vax computers became extremely popular, including in the Netherlands, where the PDP computer was the core of the Leiden University BAZIS hospital information system (HIS). Octo Barnett designed an electronic medical record system for ambulatory care. He and his team needed a programming language suitable for handling transactions and it was developed alongside the record system. The language became known as MUMPS (Massachusetts General Hospital Utility Multi-Programming System). In the Netherlands MUMPS became the programming language for the interactive development of the first electronic medical record in primary care. In the next chapter I describe how Kaiser Permanente became a model for integrated care.

In 1951 Morris Collen, director of Kaiser Permanente Medical Services, established a system of regular health checkups for their patients and included a battery of screening tests, which was called multiphasic screening.[16] Medical data of multiple phases in the lifespan of a patient were routinely collected. Preventive medicine was one of the basic services that was included as a prepaid benefit. In 1961 Collen automated this multiphasic screening program and it became the basis for a comprehensive electronic medical record system, allowing analysis of large amounts of medical data and identify health risks.[17] It was very similar to the mechanical data analysis in structured medical records before the war, described in the previous chapter. In the Netherlands the concept

[15] C.E. Molnar, W.A. Clark, Development of the LINC, in: Blum, Duncan (1990), pp. 119-37.

[16] D. Amstrong (2012), Screening, mapping medicine's temporal spaces, Sociology of Health Illness, vol. 34, pp. 177-193.

[17] M.F. Collen, Health care information systems: a personal historical review, in: Blum, Duncan (1990), pp. 290-307.

of multiphasic screening was adopted by *Philips Medische Dienst*, which offered a comparable integrated care health service for Philips employees.[18]

Finally, Melville Hodge described a medical information system that revolved around the concept of medical orders that became operational in 1972 in El Camino Hospital in San Francisco.[19] Hodges argued that medical orders, or in computer terms medical transactions, were the core of clinical hospital activities, in which the physician placed an order such as medication, a blood test, or a radiology screening and received a result. In his view automating this process would reduce costs by taking out manual transcription and processing of orders, and copying results in the electronic medical record. His business model that the hospital only needed to pay for the computer system and the software it could show benefits. It was the system that Radboud University Hospital in the Dutch city of Nijmegen would implement in 1996.

All and all, these proceedings of 1987 ACM history conference are mainly descriptive and contain little historical analysis. They are what Mahoney writes in his foreword: "What follows is the beginning of a chapter in the early development of computing, reflecting a variety of perspectives and storing up resources for future historians."[20] It is a collection of primary sources of value to historians of science.

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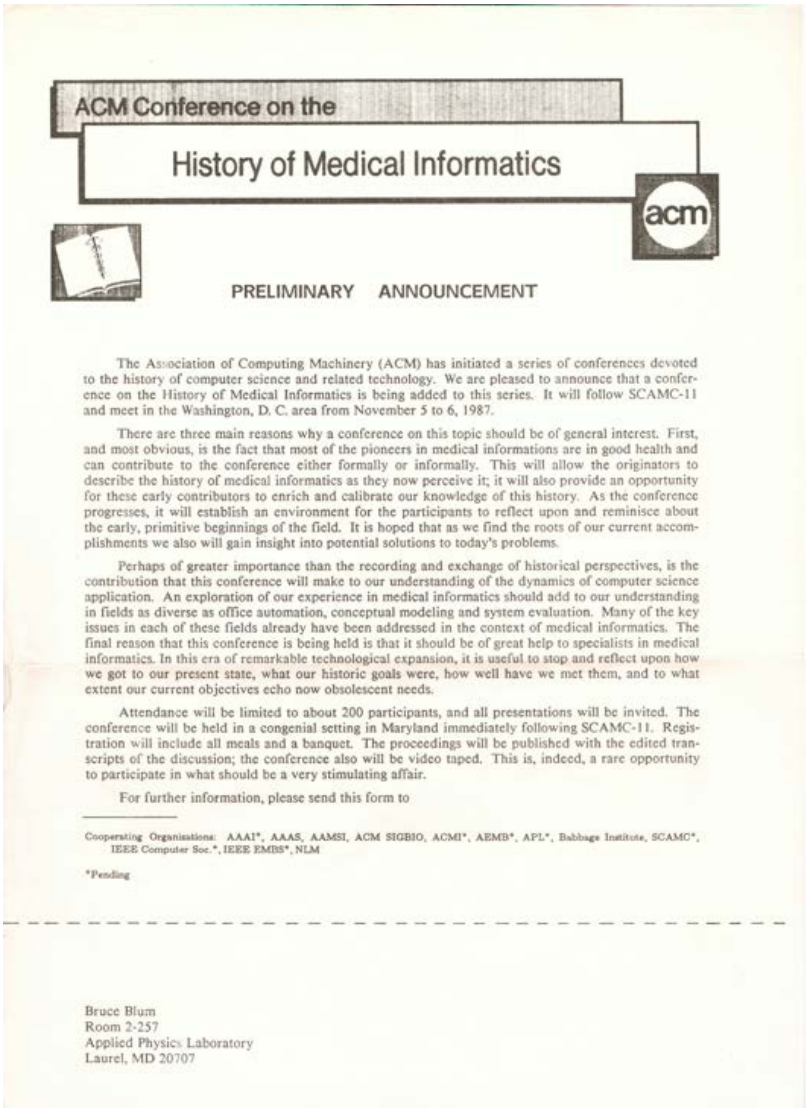
[18] H.H.W. Hogerzeil, H.R. Beukers (1972), Een geautomatiseerd systeem voor de medische geschiedenis per persoon, in: H.H.W. Hogerzeil et al. Computer en medische zorg, Leiden: Stafleu's Wetenschappelijke Uitgeversmaatschappij, pp. 55-67.

[19] M.H. Hodge, History of the TDS medical information system, in: Blum, Duncan (1990), pp. 328-344.

[20] M.S. Mahoney, Book foreword, in: Blum, Duncan (1990), p. vi.



ACM Conference on the

History of Medical Informatics

acm

PRELIMINARY ANNOUNCEMENT

The Association of Computing Machinery (ACM) has initiated a series of conferences devoted to the history of computer science and related technology. We are pleased to announce that a conference on the History of Medical Informatics is being added to this series. It will follow SCAMC-11 and meet in the Washington, D. C. area from November 5 to 6, 1987.

There are three main reasons why a conference on this topic should be of general interest. First, and most obvious, is the fact that most of the pioneers in medical informations are in good health and can contribute to the conference either formally or informally. This will allow the originators to describe the history of medical informatics as they now perceive it; it will also provide an opportunity for these early contributors to enrich and calibrate our knowledge of this history. As the conference progresses, it will establish an environment for the participants to reflect upon and reminisce about the early, primitive beginnings of the field. It is hoped that as we find the roots of our current accomplishments we also will gain insight into potential solutions to today's problems.

Perhaps of greater importance than the recording and exchange of historical perspectives, is the contribution that this conference will make to our understanding of the dynamics of computer science application. An exploration of our experience in medical informatics should add to our understanding in fields as diverse as office automation, conceptual modeling and system evaluation. Many of the key issues in each of these fields already have been addressed in the context of medical informatics. The final reason that this conference is being held is that it should be of great help to specialists in medical informatics. In this era of remarkable technological expansion, it is useful to stop and reflect upon how we got to our present state, what our historic goals were, how well have we met them, and to what extent our current objectives echo now obsolescent needs.

Attendance will be limited to about 200 participants, and all presentations will be invited. The conference will be held in a congenial setting in Maryland immediately following SCAMC-11. Registration will include all meals and a banquet. The proceedings will be published with the edited transcripts of the discussion; the conference also will be video taped. This is, indeed, a rare opportunity to participate in what should be a very stimulating affair.

For further information, please send this form to

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Room 2-257
Applied Physics Laboratory
Laurel, MD 20707

Figure 1: The announcement for the 1987 ACM conference on the history of medical informatics, in collaboration with SIGBIO and the NLM (from: ACM).

2.2. Morris Collen's history books

Morris Collen, one of the contributors to the ACM history conference, wrote two books on the history of medical informatics in the United States, twenty years apart. The first book, published in 1995, dealt with the period 1950 – 1990 and was commissioned by the National Library of Medicine.[21] Collen wrote about how people applied computers to solve problems driven by using information in medicine. The book consists of two parts, the first part about the origin of computing and medical informatics as a scientific

[21] M.F. Collen (1995), A history of medical informatics in the United States, 1950 – 1990, Bethesda: American Medical Informatics Association.

discipline and the second part about application areas. The development of a whole range of applications are described in detail, more or less like a catalogue. There is no attempt to place the history of applications in context, as the author writes that he did not try to interpret why people did what they did.[22] The second book is an enlargement and update;[23] it includes new application areas, such as imaging. Remarkably, paragraphs that dealt with evaluation of systems were not included in the new version. Morris Collen was able to finalize a draft manuscript before he died at the age of 100 in 2013. Both books are a rich encyclopedic resource for historians, but offer no historic analysis in context.

In 2012, Collen also published a book about the history of computerized medical databases, with which he was familiar as the developer of the automated multiphasic screening system, in which large amounts of patient data could be processed.[24] An electronic medical record is inconceivable without computerized databases. There are many components to make a database work. Hardware and storage capacity are needed to enter, store and retrieve data. Data formats need to be defined to make them findable. Data need to be standardized and standards need to be agreed upon to facilitate communication between systems and users.[25] Collen described the history of computerized databases and diverse applications in health care, following the same procedure as he did in his books on the history of medical informatics, that is: he described who did what in a particular time with references to their original publications. Thus, the book offers no context in which the developments took place, but like his other two books it is an excellent encyclopedic resource for historians of medical computing.

2.3. Writing medical computing history in the spirit of Mahoney

In his book *Biomedical computing, digitizing life in the United States*,[26] published in 2012, the historian of science Joseph November cited Mahoney: "The electronic digital computer,

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[22] Collen (1995), p. x.

[23] M.F. Collen, M.J. Ball, eds. (2015), The history of medical informatics in the United States, second edition, London: Springer.

[24] M.F. Collen (2012), Computer medical databases, the first six decades (1950 – 2010), London: Springer.

[25] Collen (2012), pp. 1-31.

[26] J. November (2012), Biomedical computing, digitizing life in the United States, Baltimore: Johns Hopkins University Press, p. 8.

became what various groups of people made of it. The computer thus has little or no history of its own. Rather, it has histories derived from the histories of the groups of practitioners who saw in it, or in yet some form be envisioned from of it, the potential to realize agendas and aspirations."[27] In this spirit November set out to analyze the early history of medical computing in the United States. In the subtitle, *Digitizing life in the United States*, he did not make a clear distinction between biomedical research and medicine; it was all about digitizing life. November's narrative starts in the late fifties, when the US Congress was alarmed about the technological competition with the Soviet-Union and public demand for better health care and not happy with biologists and physicians hesitant to consider computers. It allocated over $50 million dollar to the National Institutes of Health to fund computing in biomedical research. The projects that emerged from it are the subject of November's historical analysis.

November argued that current biomedical computing was not the inevitable outcome of these projects; it was the result of contingencies and opportunities seized. He showed that the heavily subsidized Laboratory Instrument Computer project laid at the roots of minicomputers and personal computers of the 1970s and the 1980s[28]. Computerizing medical practices was according to Octo Barnett considerably more difficult than computerizing laboratory science,[29] but November devoted relatively little attention to electronic medical records, only mentioning MUMPS[30] that became "the most commonly used programming language in the United States for clinically oriented medical applications during the 1970s and 1980s."[31] MUMPS is the core of EPIC, the most used electronic medical record system in the United States, but it had according to November become a software nightmare.[32] I will return to MUMPS when discussing the first electronic medical record system in primary care in the Netherlands. November did

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[27] M.S. Mahoney (2005), The histories of computing(s), Interdisciplinary Science Reviews, vol. 30, pp. 119-35, p. 119.

[28] November (2012), pp. 165 ff.

[29] November (2012), p. 271.

[30] November (2012), p. 208.

[31] Collen (1995), p. 15, cited by November (2012), p. 208.

[32] J. November (2016), Ask your doctor … about computers, IEEE Annals of the History of Computing, vol. 38, no. 1, pp. 3-5.

pay a lot of attention to key persons, who saw potential to use computers in biomedicine and seized the opportunity of federal funding to get their projects started, most notably Lee Lusted and Robert Ledley who developed respectively a mathematical model for diagnostic reasoning and algorithms for computerized medical image analysis. But most of all, for November origins and context were essential to understand how biomedical computing became embedded in American medical research and practice.

2.4. Journal papers

Unfortunately, no monograph has been written about the history of medical computing in Europe or individual countries. Anyhow, a comprehensive study would be difficult because of the different health care systems and computing systems in each country. The number of medical computing history papers published in scientific journals is limited. In an interesting paper, Andrew Lea, historian of medicine and physician, described how a computerized diagnostic tool evolved from paper data practices associated with patient questionnaires and surveys.[33]

The journal *IEEE Annals of the History of Computing* contains a few publications about medical computing. Castleman describes Bolt Beranek and Newman (BBN) as the first commercial R&D company that developed electronic medical records.[34] Paul Castleman was associated with Barnett's laboratory to develop the Costar medical record system for primary care. November's paper was later rewritten for his book.[35] Finally, Stephen Davies wrote a study of the first computing initiative for the English National Health Service, which was considered a failure.[36] Interestingly, epidemiology under the influence of the social medicine movement had a focus on chronic disease management that relied on statistical methods and data processing. But the discipline carried too little

[33] A. Lea (2019), Computerizing diagnosis: Keeve Brodman and the Medical Data Screen, Isis, vol. 110, pp. 228-49.

[34] P. Castleman (2006), Medical applications of computers at BBN, IEEE Annals of the History of Computing, vol. 28(1), pp. 6-16.

[35] J. November (2011), Early biomedical computing and the roots of evidence-based medicine, IEEE Annals of the History of Computing, vol. 33(2), pp. 9-23.

[36] S.M. Davies (2017), The Experimental Computer Programme: the first computing initiative for the National Health Service in England, IEEE Annals of the History of Computing, vol. 39(2), pp. 65-79.

weight to convince the British Medical Association of the value of medical computing[37]. According to Davies this history remains relevant with regard to how governments in countries with publicly funded centralized health care systems can support hospital computer initiatives.[38]

2.5. Conclusion

"Voyeurism is no substitute for experience,"[39] wrote Richard Hamming[40] in 1980, "A historian who merely reads about the field without getting involved … is apt to be a mere voyeur. … But the expert in the field, who does not get serious training in history, is apt to produce anecdotal stories rather than history." This is how I want to characterize the current historiography. Morris Collen was an expert in the field who lived a long life. He amassed a lot of knowledge about applications, what they were and who developed them, but his books are a dazzling collection of facts with no analysis. His books are encyclopedic and therefore a treasure trove for historians. *A History of Medical Informatics*, edited by Bruce Blum and Karen Duncan is a beautiful collection of personal testimonies, which is "the beginning of a chapter in the early development of computing … storing up resources for future historians."[41] Finally, the historian Joseph November wrote the only book about the history of medical computing with a keen eye for the origins and context, not surprising for a student of Michael Mahoney.[42]

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[37] Davies (2017), p. 70.

[38] K. Cresswell, A. Sheikh, B.D. Franklin, et al. (2022), Benefits realization management in the context of a national digital transformation initiative in English provider organizations. Journal of the American Medical Informatics Association, vol. 29, pp. 536-45.

[39] N. Metropolis, J. Howlett, G.C. Rota, eds. (1980), A history of computing in the twentieth century, New York: Academic Press, p. 8.

[40] The mathematician Richard Hamming is the inventor of error-correcting codes, which as *Hamming codes* are used ubiquitously in (computer) telecommunications.

[41] M.S. Mahoney, Book foreword, in: Blum, Duncan (1990), p. vi.

[42] I came recently aware of a new historical study about medical computing, *Digitizing diagnosis, medicine, minds and machines* by Andrew Lea, to be published on 25 July 2023 by Johns Hopkins University Press. It was not possible to include this study in the historiography.

3. The roots of the structured medical record

In this chapter I will argue that in the United States the origins of the electronic medical record are rooted in the reform of medical education and practice, after scientific and technological advances in the second half of the nineteenth century changed the practice of medicine profoundly and improved the success of treating patients. By the end of the century many individuals wanted to jump on the bandwagon of success and numerous medical schools sprouted to fulfill the need for doctors. The quality of education and practice turned out to be low. In the first decennium of the twentieth century reform was instituted to set standards for medical education and practice. Medical records were restructured as well to become an instrument of learning about patient cases and documenting interventions and their outcomes. Dutch physicians and hospital administrators before the Second World War were aware of the reforms in the United States, but did not embrace them.

3.1. Reform of American medicine

In his history of medicine *Bad Medicine* David Wootton states that modern medicine began after 1865.[43] Until then, there was little that a physician could do but comfort the patient and hope for the best. Physicians rivalled with homeopathic and spiritual healers, midwives, traveling medicine men, peddlers and pharmacists, who dispensed their medicinal products with health advice, to treat patients.[44] An understanding of the causation of infectious diseases, especially the germ theory of disease, the discovery of chemical compounds that could cure diseases and surgical technologies transformed the practice of medicine. The famous physician William Osler remarked that "the physician without physiology and chemistry flounders along in an aimless fashion, never able to gain any accurate conception of disease, practicing a sort of popgun pharmacy."[45] Hospitals

[43] D. Wootton (2006), Bad medicine. Oxford: Oxford University Press, p. 283.

[44] C.F. Chapin (2015), Ensuring America's health, the public creation of the corporate health care system, New York: Cambridge University Press, pp. 10-15.

[45] R. Porter (1997), The greatest benefit to mankind, a medical history of humanity, New York: W.W. Norton & Company, p. 305.

morphed from filthy places of dubious reputation to modern hygienic institutions with surgical theaters, laboratories, clean wards and doctor's offices.

Against this background, the American Medical Association (AMA) sought to improve the authority of physicians through lobbying for state licensure requiring that only doctors with a diploma from a medical school could practice medicine. It increased the need for graduates. The effect was that the number of medical schools of questionable quality mushroomed, some being just diploma mills. It impacted the standards of medical practice negatively. Membership of AMA still consisted of physicians of various educational backgrounds and they could not agree on reforming schools.

It fell to an outside institution, the Carnegie Foundation, to commission a study of the quality of medical schools and it became known as the Flexner Report, which was published in 1910.[46] The report recommended amongst others the extension of length of medical education and a prominent role for scientific and clinical training. Medical schools should be equipped with well stocked libraries, laboratories for clinical science education and tied to hospitals for clinical training. Most importantly in the context of this thesis, it recommended that medical records should be structured and used as a tool for clinical case training. No longer, records should be used as a personal casebook for practicing physicians.[47]

The Flexner Report had considerable impact. As its recommendations were immediately embraced by the AMA, the report strengthened the power of the association to set standards for the medical profession and weed out incompetent and poorly educated doctors. In 1913, surgeons founded the American College of Surgeons (ACS) to do exactly the same thing, setting standards for the practice of surgery. A direct result was that the number of medical schools and students declined substantially.[48]

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[46] A. Flexner (1910), Medical education in the United States and Canada, a report to the Carnegie Foundation for the Advancement of Teaching, New York: The Carnegie Foundation for the Advancement of Teaching; see also P. Starr (1982), The social transformation of American medicine, the rise of a sovereign profession and the making of a vast industry. New York: Basic Books, p. 118.

[47] A. Flexner (1910), pp. 99-100

[48] Editorial (1915), Medical education, a review of fifteen years progress, Journal of the American Medical Association, vol 65, pp. 717-718.

In the Netherlands such discussions were much less prominent. In 1865 the Dutch parliament enacted legislation at the behest of the head of government, minister-president Rudolf Thorbecke, that only university-trained medical doctors could be licensed to practice medicine. It was left to the academic medical community to define the contents of the medical curriculum and standards of practice.[49] There is no historical record of medical record keeping as part of a professional standard.

3.2. Reform of medical record keeping

Record keeping has been part of medicine for thousands of years. While physicians may have kept personal notes about their private patients, information about patients in charity hospitals were kept in ward ledgers and not in individual records. The ledger was a daily account of patient events, how they looked and ate, whether they were feverish, what medication they took, etc. It was therefore difficult to reconstruct the disease course of an individual patient, let alone to show numbers that would help see improvements or deteriorations and compare them with other patients. The need to treat patients with the latest medical knowledge and skills, growing complexity of diagnostic and therapeutic services made ward-based records untenable, and hospitals introduced medical records for individual patients.

Change was gradual and diverse across hospitals. In 1821 Massachusetts General Hospital (MGH) opened its doors, admitted annually 300 patients and documented each patient's stay using a systematic record keeping protocol. It enabled one of the founders, James Jackson to conduct an analysis of bloodletting of pneumonitis patients[50]. He found to his surprise that it did not matter for recovery whether patients were bled or not. Only early admission had some effect. In this study, published in 1836, James Jackson followed the French method of systematic counting of observed symptoms and lesions and disease categorizations and see what statistical analysis could reveal.[51] It foreshadowed the important role of the medical record for clinical research and epidemiology. A house

[49] R. Aerts (2018), Thorbecke wil het, biografie van een staatsman. Amsterdam: Prometheus, pp. 598-601.

[50] L.G. Kahn, A. Morabia (2015), Using the numerical method in 1836, James Jackson bridged French epistemology and American medical pragmatism. Journal of Clinical Epidemiology, vol. 68, pp. 397-404.

[51] W.F. Bynum (1994), Science and the practice of medicine in the nineteenth century. Cambridge: Cambridge University Press, p. 42-4.

officer, usually a medical student, wrote in notebook a medical history of a patients at admission. Under the heading of a case, usually the admission diagnosis, the patient history was copied into a casebook. When physician was making bedside rounds, he dictated aloud the record of the day for each patient and if necessary, prescriptions and the house officer wrote them in the notebook. At the end of rounding the dictated records were copied into the casebook. Thus, the casebook contained in chronological order patient information under the case heading. Casebooks still contained cases of all patients admitted to MGH during a specific period. When Jackson studied the effects of bloodletting in pneumonia patients, he still had to consult 68 casebooks. He could analyze 34 cases pneumonia.[52]

At the first decennium of the twentieth century, hospitals were expected to provide for fully equipped operating theaters, modern clinical and pathological laboratories, X-ray facilities and comfortable nursing wards to attract physicians bringing in their patients to create income. At the other hand they could not serve the communities for which they were founded, if they did not have well-trained doctors[53]. In his address to the 11th meeting of the American Hospital Association (AHA) Flexner hoped that "it might well be that every hospital in America should in some measure contribute to the progress of medical science and knowledge."[54] In 1913 the American College of Surgeons (ACS) was founded with the exact purpose of defining standards for the practice of surgery, to which surgeons had to adhere and which, not surprisingly, hospitals complied with, because surgery was the mainstay of hospital operations and income.[55] According to the ACS surgeons should base their practice on the science of medicine and achieve the best possible result for their patients.[56]

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[52] J.J. Jackson (1836), Appendix, In: P.C.A. Louis, Researches on the effects of bloodletting in some inflammatory diseases. Boston: Hilliard, Gray & Company, pp. 100-102.

[53] A. Flexner (1911). Hospitals, medical education and research, In: Transactions of the American Hospital Association, Thirteenth Annual Conference. Toronto: American Hospital Association Office of the Secretary, p. 363.

[54] Flexner (1911), p. 371.

[55] Stevens (1989), p. 75.

[56] E.A. Codman, W.W. Chipman, J.G. Clark, A.B. Kanaval, M.J. Mayo (1914), Report of Committee on the Standardization of Hospitals. Boston Medical and Surgical Journal, vol. 170, pp. 71-73.

The ACS stipulated the need for clinical review meetings in which patient cases would be discussed, evaluated and facilitate learning.[57] As a consequence, information was to be written down in structured case records for each individual patient. In a presentation about the need of an adequate system for case records in smaller hospitals Dr Horace Stevens summed up the ACS requirements for structured records: it should contain templates for a patient history pertinent to the complaint, a diagnosis on which the treatment was based (which was called a preliminary or working diagnosis), physical and laboratory findings, issues arising from the surgery or treatment, a post-operative diagnosis, complications during recovery and finally autopsy findings.[58] The requirements looked very similar to the medical record as we know it today. In the ensuing discussion Dr Homer Gage observed that almost no hospital in Massachusetts kept case records, except of a patient's admission and discharge.[59] The medical historian Reiser reported that physicians were not alone in obstructing good record keeping.[60] They were joined by hospitals who objected to the funding of personnel and infrastructure to manage the records. However, changes in the practice of medicine and technology improved the situation. In 1923 Dr Frederick Slobe reported that over four-fifths of the hospitals in the United States and Canada hospitals had adopted the principles of the ACS minimum standard.[61]

The surgeon Ernest Amory Codman went a step further.[62] In 1914 he wrote: "We must formulate some method of hospital report showing as nearly as possible what are the results of the treatment obtained at different institutions. This report must be made out and published by each hospital in a uniform manner, so that comparison will be possible.

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[57] E.A. Codman (1914), Standardization of hospital records, Boston Medical and Surgical Journal, vol. 170, p.63.

[58] H.C. Stevens (1919), Case records and histories in the smaller hospitals, Boston Medical and Surgical Journal vol. 180, pp. 324-29, p. 325.

[59] Stevens (1919), p. 328.

[60] S.J. Reiser, (2009), Technological medicine, the changing world of doctors and patients, New York: Cambridge University Press, p. 85.

[61] F.W. Slobe (1923), Applying minimum standards to hospitals, The Modern Hospital, vol. 20(2), pp. 166-8, p. 168

[62] Reiser (2009), p. 79-82.

With such a report as a starting-point, those interested can begin to ask questions as to management and efficiency."[63] He wanted hospitals and surgeons not only to record what they saw and did, but also the outcome of their treatments in a standardized manner. A comparison would show which hospital and surgeon would have the best results and which the worse. He called his approach the End-Result System. In his view it would help improve medicine, which he found not only important for the medical profession but also for the patient as a customer. The public health physician and pioneer of health assessment studies, Avedis Donabedian noted that the concurrent assessment of medical care and its consequences is the hallmark of Codman's method.[64]

The End-Result System met resistance. Physicians felt threatened because they thought that accountability for the outcome of care would undermine their reputation and power in the hospital, and refused to be compared with each other and subjected to patient scrutiny. However, it helped the ACS, supported by the AHA, to press for its agenda of pursuing of good quality of care for all branches of medicine, mainly by certifying surgeons, for which the ACS would provide, availability of excellent hospital facilities, structured case records for teaching and research, and an organized medical staff that would establish their own committees supervising standards of medical care.[65] It ensured that hospitals and physicians would remain autonomous with a responsibility laid down locally. The published examples of case records in hospitals like Massachusetts General Hospital and the Mayo Clinic showed how structured medical records could be designed. The End-Note System remained dormant, but eventually Codman's vision and the ACS efforts lead to a system for accreditation of hospitals, embodied by the Joint Commission for the Accreditation of Hospitals founded in 1951.[66] In 2022 the Joint Commission

[63] E.A. Codman (1914), The product of a hospital, Surgery, Gynecology and Obstetrics, vol. 18, pp. 492-496, p. 494 (italics by Codman).

[64] A. Donabedian (1989), The end results of health care: Ernest Codman's contribution to quality assessment and beyond, The Milbank Quarterly, vol. 67, pp. 233-256, p. 239.

[65] R. Stevens (1989), In sickness and in wealth, American hospitals in the twentieth century, New York; Basic Books, p. 77-78.

[66] Donabedian (1989), p. 239.

accredited and certified more than 22,000 organizations and health care programs in the United States and worldwide.[67]

3.3. Structured medical records

Structured case records, or medical records as they were called later, were an essential condition for the hospital standardization program. Structured meant standardization of formats and naming of contents. In 1907 the physician, scientist and inventor Henry Plummer developed in the Mayo Clinic a registration system in which all information of an individual patient were held chronologically in a single folder with a unique identifier.[68] Because the Mayo Clinic had both inpatient and outpatient services, a unique record system for a patient population came into existence. It would lay the foundation for epidemiologic research. After having received samples of clinical records from different hospitals the physician James Brotherhood summarized what he thought would be the ideal medical record and formulated rules for charting.[69] It should consist of four sets of sheets, a front sheet devoted to vital statistics of the patient, such as demographics, the doctor who took the history, diagnosis; the second sheet would contain space for note taking; the third would contain the results of laboratory tests, special examination and space for photographs and instrument readings and the fourth would show graphs of the patient's temperature, heart rate, blood pressure, etc. Records should be stored in a central place, but when in use by a physician, a cross-index card system can keep track of their location in the hospital.

In 1933 a study reported that a majority of hospitals subscribed to the central unit record system.[70] The reported advantages were better statistical work, increased accessibility of patient information, higher standards of record keeping, better

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[67] Joint Commission FAQs, https://www.jointcommission.org/about-us/facts-about-the-joint-commission/joint-commission-faqs/ (accessed 20 July 2022).

[68] L.J. Melton (1996), History of the Rochester epidemiology project. Mayo Clinic Proceedings, vol. 71, pp. 266-74.

[69] J.S. Brotherhood (1913), Hospital clinical records, Journal of the American Medical Association; 60:1205-8.

[70] J.H. Stokes, R.A. Kern, L.K. Ferguson (1933), What sixty-six hospitals think of the central unit record system, The Modern Hospital, vol. 40(1), pp. 87-92.

understanding of a patient case, increased knowledge of treatment and better opportunity to do research. Favorable, but to lesser extent, were the achieved organizational savings. Surprisingly, there was less enthusiasm about raising and enforcing standards of practice. Perhaps the doctors still felt uneasy with the dominance of their professional bodies. Gradually, the medical record was no longer the domain of the physician only; clerks were needed to transcribe, store and retrieve them. Reiser observed how over time the medical record was knitting constituencies together.[71]

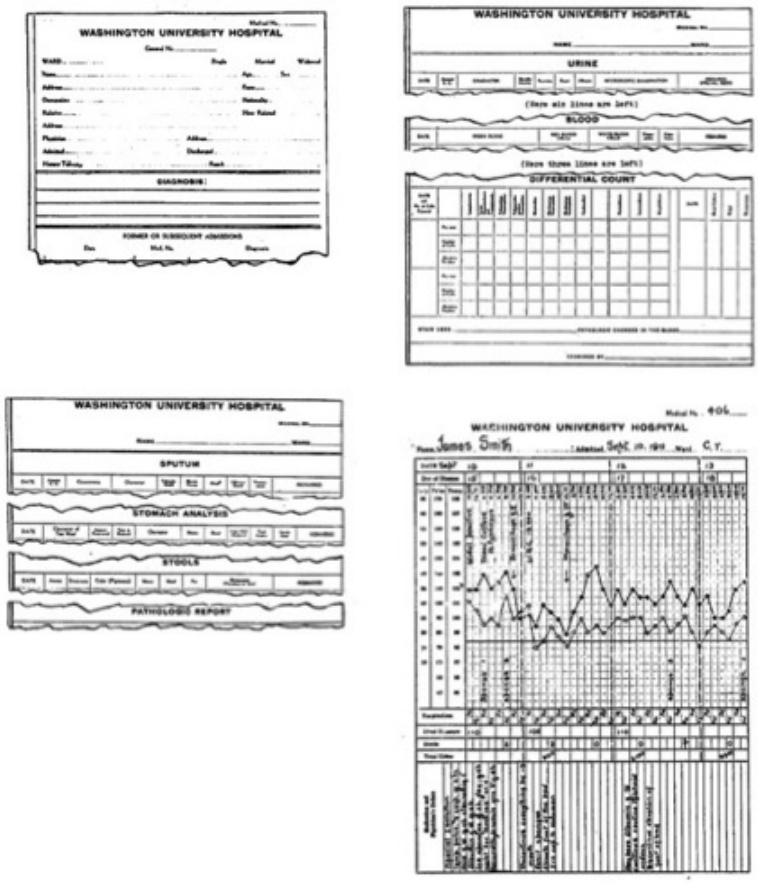

Figure 2: A set of four clinical record templates of Washington University Hospital in St. Louis in 1913. At the upper left the history front for recording vital statistics and diagnosis and below space for remarks. At the upper right is a pink sheet for laboratory tests. Physicians could either use the sheets to make their own notes or have clerks copy them from their personal notes. The clinical record of each patient was stored centrally. The present-day medical record is not much different (from: J.S. Brotherhood (1913), Journal of the American Medical Association, vol, 60, pp. 1205-1208).

[71] Reiser (2009), p. 103.

In the nineteenth century personal and idiosyncratic histories of a patient's illness written by physicians in a case books became abstracted into a disease as a result of the growing scientific basis of medicine. In a textbook from 1859 the Irish physician Robert Lyons offered a classification of diseases that could help physicians to examine patients at the bedside using four classes characterizing its suspected origin.[72] Each class was subdivided in orders, for example class III, diseases related to single organs, was ordered amongst others into brain, heart, lung, bowel and kidney diseases. Lyons wrote that his classification was indebted to the work of the statistician William Farr, who was most known for a nosology to sign death certificates. [73]

The eclectic nosology became ultimately the *International Classification of Diseases* (ICD), which is nowadays a key component to code diseases in electronic medical records.[74] Yet, defining a disease and how to diagnose remained a debate. It was not only because of uncertainties in medical knowledge, but also on agreements to name a disease and what symptoms were minimally necessary to decide a diagnosis. In the act of diagnosis, the medical historian Charles Rosenberg wrote, a patient is necessarily objectified and recreated into a structure of linked pathological concepts and institutionalized social power.[75] I have already noted above the value of structured records for medical research and how it became an instrument to improve standards of medical practice and education. The expansion to other constituencies than physicians having an interest in medical records started already in the early twentieth century.

3.4. Analytics with medical records

During most part of the nineteenth and the early twentieth century symptoms, diseases and pathological findings were described qualitatively. With the arrival of sophisticated

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[72] R.D. Lyons (1859), Handbook of hospital practice, an introduction to the practical study of medicine at the bedside, London: Longman, Brown, Green, Longmans and Roberts, pp. 4-11.

[73] Bynum (1994), Science and the practice of medicine in the nineteenth century, Cambridge: Cambridge University Press, p. 76.

[74] H.O. Lancaster (1994), Quantitative methods in biological and medical sciences, a historical essay, New York: Springer-Verlag, pp. 194-198.

[75] C.E. Rosenberg (2007), Our present complaint, American medicine, then and now, Baltimore: The Johns Hopkins University Press, p. 18.

instruments such as thermometers, sphygmomanometers, microscopes, urometers, blood analyzers and x-ray machines the importance of quantitative medical science grew. Though the importance of using numbers in clinical medicine was recognized in early nineteenth century (see Jackson above),[76] the statistician Raymond Pearl argued that medicine lagged behind and that through the development of appropriate techniques eventually any observable phenomenon could also be quantitatively measured.[77] He proposed to establish statistical departments in hospitals to collect and tabulate routinely statistical data.

In Pearl's view the medical record room was the brain of a hospital, where the assembled medical records served as a source of statistical data. He recommended that case records should routinely include 26 items like demographics including unique case number, medical data such as diagnosis, date of admission and condition at admission making a distinction between first entry and readmission, similar data for discharge, treatment and possible pathological complications. He also proposed to cross-index the data elements. Then he proposes how cross-indexing could help find patients with a similar diagnosis and how this population can be studied.[78]

Pearl argued that cross-indexing of routine information is only possible with a mechanical tabulating and indexing machine, invented by Herman Hollerith. Data were punched on a 45-column card, now known as the Hollerith card. He presented a study of 1000 prostatectomies extracted from case records that were analyzed with Hollerith cards containing data elements for this study.[79] Finally, he outlined the staffing for the statistical department of Johns Hopkins Hospital, which included statisticians, a punch clerk, a machine operator, but also a 'computer', a person who would do the calculations.[80] Fifteen

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[76] W.F. Bynum (1994), pp. 42-44.

[77] R. Pearl (1921), Modern methods in handling hospital statistics, Johns Hopkins Hospital Bulletin 32:184-94, p. 184.

[78] R. Pearl (1921), pp. 188-189.

[79] R. Pearl (1921), p. 193.

[80] It is interesting to note that 'computers' were women. In a non-fiction book *Hidden figures: the American Dream and the untold story of the black women mathematicians who helped win the space race* Margot Lee Shatterly recounts how black women were key for the crucial Apollo spacecraft calculations. In a paper *When computers were women* Jennifer Light describes a similar role of women of performing ballistics computations in the

years later the physician Joseph Berkson described a similar Hollerith system in the Mayo Clinic to analyze patient diagnosis and treatment data using a classification of diseases based on the *International List of Causes of Death*, the precursor of the ICD, which is in now in its tenth release.[81]

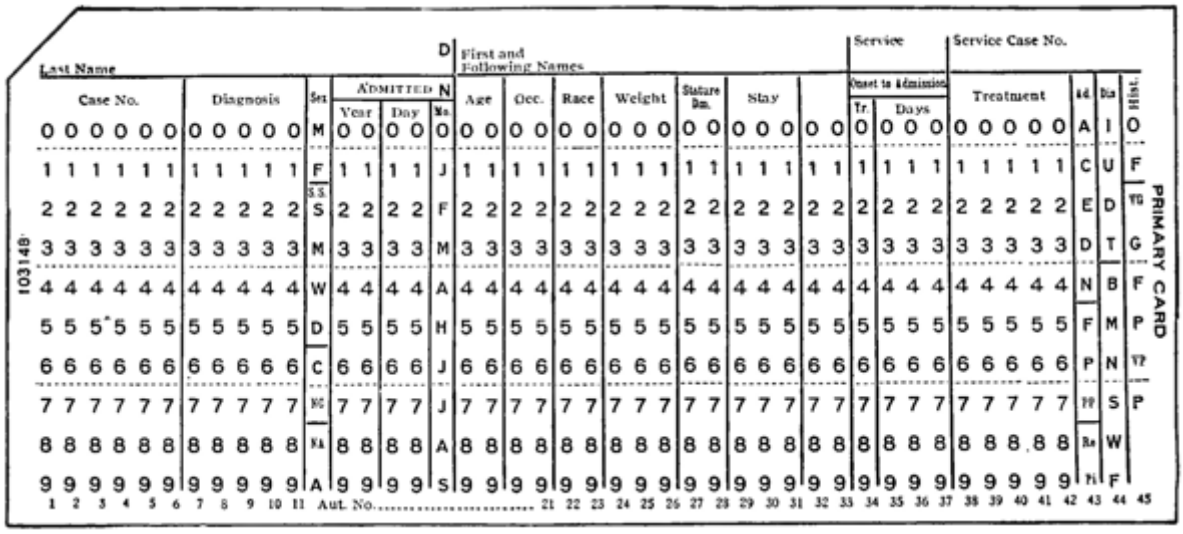

Figure 3: A 45 column Hollerith punch card, the first or face card form of set of cards containing vital statistics for mechanical tabulation and indexing routine hospital statistics (from: R. Pearl (1921), Bulletin of Johns Hopkins Hospital, vol. 32, pp. 184-194).

3.5. Impact in the Netherlands

The obvious question for this thesis is why a Dutch history of the medical case record is not included. The simple answer is that examination of pre-war journals like the *Nederlandsch Tijdschrift voor Geneeskunde* and *Het Ziekenhuiswezen* did not produce any results. However, Dutch physicians and hospital administrators did know what was happening in the Unied States. *Het Ziekenhuiswezen*, founded in 1928, published in each monthly issue a summary of selected papers of foreign journals in Germany, France, England, Denmark and the United States. Sometimes complete articles from the monthly *The Modern Hospital* were translated into Dutch. In 1929 a delegation of Dutch 'geneesheer-directeuren' (physician-directors) visited the first International Hospital Congress in Atlantic City, which led to the foundation of the International Hospital

development of digital computers in wartime (Technology and Culture 1999, vol. 40, pp. 455-483). Pearl did not mention the gender of his 'computer.'

[81] J. Berkson (1936), A system of codification of medical diagnoses for application to punch cards with a plan of operation, American Journal of Public Health, vol. 20, pp. 606-612.

Association (IHI).[82] In a report of the trip to the United States in *Het Ziekenhuiswezen* Jan Wortman, physician-director of the Tesselschade Ziekenhuis in Amsterdam mentioned the ACS minimum standards and noted that as a result processing of case records had become an important service.[83] He observed in Columbia-Presbyterian Medical Center in New York the detailed attention for medical records with a technical construction to send case records from the central records office to the floors and, in his view, exaggerated attention for detailed disease descriptions and coding.[84] Interestingly, Wortman took issue with the high level of education of American nurses that made them into semi-physicians with little dedication to hands-on bedside nursing.[85] In the same monthly dr. W.H. Mansholt, physician-director of the Provincial, Municipal and Academic Hospital of Groningen, asked the question what European and American hospitals could learn from each other.[86] Like Wortman, he noted that unlike in Europe American local and state governments did not play a role in improving hospital and professional standards but that it was in the hands of private organizations like the ACS and the AHA. He also questioned the sophistication of hospital record systems technology, which he thought was a waste of money. Moreover, he questioned the relevance of statistical analysis of patient data, because it would lead away from a focus on the individual patient. Therefore, it appears that the awareness of American hospital reform and the role of a centralized case record system did not impact Dutch hospitals and medicine.

3.6. Conclusion

At the eve of the Second World War a structured medical record system was well embedded in American hospitals.[87] Key factors for the emergence were the reform of

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[82] What is the International Hospital Federation?, https://www.ihf-fih.org/about/ (accessed 27 July 2022).

[83] J.L.C. Wortman (1929), Naar het internationaal ziekenhuis-congres te Atlantic City, Het Ziekenhuiswezen, vol. 2, pp. 480-6, p. 483.

[84] Ibid., p. 484.

[85] Ibid., p. 484.

[86] W.H. Mansholt (1931), Wat kunnen Europeesche en Amerikaanse ziekenhuizen wederkerig van elkaar leeren? Het Ziekenhuiswezen, vol. 4, pp. 28-42.

[87] Doctors still liked their personal notes. In a historical study of medical record keeping in New York Hospital, dr. Eugenia Siegler found that physicians circumvented the restrictions of the structured record

American medicine, the reform of medical education proposed by Flexner, which made medical record essential for case-based learning and professional reform advanced by the AMA and ACS with a focus on scientific medicine and standards of professional practice. [88] Ernest Codman may have gone too far by including outcomes of patient care outcome in medical practice, but he seeded the ideas for a quality system that revolved around data in medical records. The medical record became part of the infrastructure of a hospital that served the needs not only of physicians, but included donors, trustees, superintendents, hospital administrators and nurses. The infrastructure included physical space for storing records, pre-formatted forms and mechanical data processing machines, and skilled staff to copy, store, manage and analyze records.

In line with argument of Michael Mahoney that a proper history computing should look at the origins and context,[89] I argued that the infrastructure of medical records in American hospitals, which existed in 1940 was a necessary, but obviously not a sufficient condition for the emerging of computerized medical record systems after the war. As the reform can be traced back to 1910, perhaps thinking of a 'longue durée' is not completely inappropriate.

Dutch health care professionals were aware of American developments, but they did not impact medical practice. However, Dutch health care kept an interest in things American as I will show in the next chapters about electronic medical records in hospitals and primary care.

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to write down their own personal observations. R.L. Siegler (2010), The evolving medical record, Annals of Internal Medicine, vol. 153, pp. 671-677.

[88] S.J. Reiser (1991), The clinical record in medicine, part 2: reforming content and purpose, Annals of Internal Medicine, vol. 114, pp. 980-985.

[89] M. S. Mahoney (2011), Histories of computing, Cambridge: Harvard University Press, p. 57.

4. The beginnings of medical computing in Dutch hospitals, 1970 – 1990

This chapter addresses the question how medical computing began in Dutch hospitals. I will argue that collecting medical data for clinical research and medical resource planning in hospitals, which began in the early 50s, was a necessary precursor. It became more pressing in the 60s when in a time of unprecedented growth of hospital care statutory sick funds feared that the rising costs would make insurance premiums too expensive for employees. Medical data needed to be accessible not only for the private interests of physicians and hospitals, but also health insurance organizations. and required therefore structured medical records from which data could be extracted by qualified administrative hospital staff. However, medical specialists remained wary from external influence on their practice and therefore the introduction of the electronic medical record was not an aim. Medical computing or hospital information system HIS under which it became known was aimed at making applications and medical data available and accessible within the hospital via terminals linked to a central computer. Gradually, automation of clinical laboratories and radiology made possible to share test results and radiology reports in HISs. Medical specialists could consult this information on terminals in clinical departments.

4.1. Growing awareness

In 1947 the physician-director of Leiden University Hospital J. Mulder returned from the United States with an enthusiastic report about medical record keeping in the university hospital of the University of Michigan in Ann Arbor.[90] He observed how much clinicians were supported by a large number of qualified administrative personnel for the organization of medical records. He saw standardized medical forms used by every medical specialty in the hospitals augmented by forms for reporting surgical procedures, lab results and radiology findings. The support staff aimed to reduce the administrative burden of clinicians to free up their time for medical care. Medical records were kept up-to-date each

[90] J. Mulder (1947), Indrukken van een studiereis naar Amerika I, clinische administratie en registratie in Amerika en Nederland, Nederlands Tijdschrift voor Geneeskunde, vol. 91, pp. 2547-2550.

stay and stored in a central archive. In the archive a medical statistician could make analyses at the request of physicians to study large populations. Mulder regretted that Dutch hospitals did not have any knowledge how medical administration should be organized and that it had never been the subject of study in the Netherlands. The hospital simply had no responsibility for medical records. That was up to the individual clinician. For three clerical staff in Ann Arbor there was only one in Leiden. Mulder made a few recommendations how to improve medical administration in hospitals.

The fundamental problem of hospitals taking responsibility for medical records and medical administration at large was that it would take an organizational role cutting right into the domain of the medical specialist. Dutch physicians admitting their own patients claimed that they owned their medical records and that the hospital, as a physician's workshop, had no legitimate interest of its own in documenting or monitoring patient care. Only for clinical research medical specialists were willing to share their patient data.

There is no published research about how hospital physicians in the Netherlands dealt with medical record keeping and their attitudes towards use for other purposes than patient care, but a German study sheds light on the motives of physicians to share medical data with public authorities. In 1980s the German statutory sickness funds that covered 90% of the population were confronted with ballooning health care costs.[91] The funds and government wanted to know what doctors were doing, arguing that aggregate medical decisions collectively determined health care spending. The physicians did not want to share medical data on grounds of professional autonomy and doctor-patient confidentiality. A solution was found that physicians shared their medical data with the state *Ärztekammer*, a statutory body that licensed doctors for treating sickness fund patients. The *Ärztekammer* acted as an intermediary that tabulated medical data in such way that they could not be deduced to individual doctors and patients and made them in this form available as claims data to the sickness funds and the federal and state

[91] L. Frohmann (2017), Redefining medical confidentiality in the digital era: healthcare reform and the West German debate over the use of personal medical information in 1980s, Journal of the History of Medicine and Allied Sciences, vol. 72, pp. 468-499.

governments. A comparable approach could be seen in the Netherlands when the question arose whether medical data could be used for other purposes as well.

4.2. First initiatives of collecting medical data outside medical practice

In 1952 the *Gezondheidsorganisatie TNO*, the Dutch organization for applied health research, responded to suggestions made by a number of hospitals and medical specialists to study the problem of documenting medical data in a structured fashion.[92] It said that experience had learned that medical record keeping was idiosyncratic and as long an individual physician could find its way in it that there was no problem, but matters changed when patient histories had to be reconstructed and shared for clinical and/or patient population research and planning hospital bed capacity. An advisory committee was tasked to conduct a field study in which three hospitals volunteered to participate. The study aimed to recommend a registration system that could store large and diverse amounts of data for the above-mentioned purposes. For example, it would help relate increased treatments in medical specialist care to needed bed capacity. The study led to recommendations for demographic, medical, economic and financial data to be collected. The committee advised to code medical data for easy identification and retrieval, using the International Statistical Classification of Diseases, Injuries and Causes of Death for coding diagnoses.[93]

Implementation of a medical registration systems entailed a number of requirements. Qualified administrative staff with knowledge of medicine would be needed to acquire data from medical records, code and register them in a central system of records and tables, and analyze them. A central medical registration department should be established and provided with electromechanical equipment to enter, retrieve and analyze data, such as Hollerith card punchers and tabulators. Finally, agreement should be reached what medical data to be collected and how to standardize data elements for comparative analyses and planning.

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[92] Gezondheidsorganisatie TNO (1958), Waardering van medische gegevens uit ziekenhuizen, Assen: van Gorcum.

[93] Gezondheidsorganisatie TNO (1958), p. 21

There was a strong feeling in the committee that medical data was not be shared with the government. It was one of the reasons that the field study led to the founding in 1963 of the *Stichting Medische Registratie* (Foundation for Medical Data Registration, SMR)[94]. The SMR, governed by medical specialists and hospitals, would acquire data of participating hospitals for analysis and planning. In 1980, 95% of the Dutch hospitals shared their patient admission data with SMR.

The committee did not recommend how medical specialists could structure their medical records. However, it was evident that collecting medical data in the hospital would have consequences how physicians would handle patient data at the bedside. Preparing specialists to view their medical record as a responsibility shared with hospitals was a painstakingly slow process and not satisfactorily resolved until Dutch hospitals had implemented full electronic health record systems in 2015. In 1975 SMR proposed a structured design for the hospital medical record, including forms and templates, use of unique patient identifiers and central archiving, some 60 years after the AHA and the ACS made similar proposals in the United States.[95] However, when HISs were considered in the late 1960s and early 1970s, the development of electronic medical records for physicians was not part of the equation.

4.3. Planning for medical computing 1960 – 1970

In the period 1963 – 1968 the growth of the Dutch national health care budget was unprecedented.[96] In the 1960s successive governments became concerned with ballooning health care costs, and feared especially that health insurance premiums would increase and reduce accessibility to health care. Beginning in 1965 the government tried to limit hospital expenditures and expensive resources, especially medical technology investments

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[94] W. Ekker (1980), Wat is, wat doet de Stichting Medische Registratie? Nederlands Tijdschrift voor Geneeskunde, vol. 124, pp. 1060-1065.

[95] O. Fokkens (1972), De inrichting van het medisch dossier, rapport van de Commissie Medische Status, Utrecht: Stichting Medische Registratie; see also previous chapter.

[96] A. van der Werff (1983), Structureren en herstructureren in de gezondheidszorg 1950 – 2000, in: G. Schrijvers, J.M. Boot, eds., Een halve eeuw gezondheidszorg, 1950 – 2000, Lochem: Uitgeversmaatschappij De Tijdstroom, pp. 119-21.

as a result of innovation, specialization in medicine and new treatments.[97] One of the ideas was to assess health care needs at a regional level to ensure that a panoply of services would be guaranteed. Constraining the volume of physician care was not considered because it was expected that the profession itself would take responsibility for cost consciousness, and it would meet strong resistance. It became clear that cost containment could only rely on data of hospital activities. SMR had already experience in handling medical data, it even had a computer for central processing, but depended on manual processing of data in hospitals. A need for medical computing in hospitals was identified.

In 1967 the newly founded *Nationale Ziekenhuisraad* (NZr, National Hospital Council), a collaborative of the Dutch hospitals to advocate their shared interests, commissioned a report with the then still denominational economic institutes for public and catholic hospitals to assess the opportunities of computing in their member organizations.[98] These two institutes would shortly afterwards merge into the *Nationaal Ziekenhuisinstituut* (NZi, National Hospital Institute), a think tank and advisory body for the NZr. The latter emphasized the need for an economic perspective on computing, and encouraged to include medico-organizational aspects as well. The report explained for a lay readership, which hospital administrators were, the workings of computer technology and programs, hospital applications, an implementation strategy and proposes a national approach to introduce computing in Dutch hospitals.[99] The report was a combination of a literature study and policy advice. A few recommendations of this report are worth mentioning, since they would determine the future development and implementation of medical computing in hospitals.

The report first recommended to evaluate short- and long-term opportunities and desiderata for hospital computing in diverse administrative, medical and nursing activities

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[97] K.P. Companje, T. Kappelhof, R. Mouton, P. Jeurissen (2018), Vijftig jaar kostenbeheersing in de zorg, Deel I, 1966 – 1990, Den Haag: Sdu, p. 25-26.

[98] G.J.M. Stulemeijer (1967), Letter 67.0456, February 21, 1967, Computer-toepassing ziekenhuiswezen, Den Haag: Stichting Nationale Ziekenhuisraad.

[99] Anon. (1968), Rapport inzake betekenis van de computer voor het ziekenhuiswezen, uitgebracht aan het bestuur van de stichting Nationale Ziekenhuisraad, Den Haag: Instituut voor Ziekenhuiseconomie van de Stichting Het Nederlandse Ziekenhuiswezen en Economisch Instituut voor het Katholieke Ziekenhuiswezen.

with emphasis on internal and external communication and articulate a policy to achieve these goals.[100] This advice is accompanied by recommendations to document projects, train computer experts, develop standardized coding of data, share experiences and develop communities of (computing) practice. The most important recommendation was to require regional hospital collaborations to develop computer applications and acquire computers. The efforts were to be supervised and coordinated by experts of the computing department of the newly founded NZi. Between 1969 and 1972 NZi staff members undertook study tours in Europe and the United States.[101] They reported that in no country a total HIS was achieved. Only a few hospitals in the United States were close to this goal. In all countries governments had subsidized development and implementation of various medical computing applications. Sweden, England and Denmark had government run health care systems, and the influence on medical computing was strong. The travelers noted that American hospitals were just as autonomous as the Dutch. There was no national strategy, but the autonomous hospitals embraced regional collaboration because of the high cost and received substantial federal subsidies for medical computing development and deployment.[102] It resonated well with the advice in the policy report of 1968.

In 1961 the Dutch government had given away her legal instruments to keep hospital costs in check. In the 1960s when the ballooning costs came evident an attempt to retake control met with resistance of hospital associations, statutory sick funds and private insurers. Instead, they founded in the same year the *Centraal Orgaan Ziekenhuistarieven* (COZ) as a platform to negotiate hospital pricing.[103] Pricing was based on bed occupancy. Hospitals were reimbursed for each bed occupied by a patient. Reimbursement would pay for all non-medical costs such as personnel (including nursing), materiel and overhead, but medical specialists, being self-employed, were reimbursed outside the hospital budget. It should not come as a surprise that the pricing model was

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[100] Ibid, pp. 26-27.

[101] Anon. (1971), Ziekenhuisautomatisering in Zweden, Denemarken, Engeland en de Verenigde Staten, rapportage en bevindingen tijdens enkele buitenlandse studiereizen, Utrecht: NZi (publicatie nr. 1.71.09).

[102] Ibid (1971), p. 11.

[103] R. Bertens, J. Palamar (2021). Het Nederlandse zorgbeleid in historisch perspectief 1941 – 2017, Den Haag: Wetenschappelijke Raad voor het Regeringsbeleid, p. 36.

an incentive to maximize bed occupancy and expand hospitals. 'A built bed is a filled bed.'[104] The COZ would play a key role in the planning of hospital computing.

4.4. Beginnings of hospital computing 1970 - 1990

The introduction of medical computing in hospitals began in 1972 in the form of HISs. The very idea of a HIS, pictured in figure 1, is a centralized computer database that integrates administrative and patient data. Morris Collen defines a HIS as having agency in terms of its goal to use computers and communication technology to collect, store, process, retrieve and communicate relevant patient care and administrative information for all activities and functions within the hospital.[105] A diversity of applications or subsystems interacts with a database allowing to store, process and retrieve data. Usually, a distinction is made between patient and administrative applications, but in practice the line is blurred. For example, to bill a patient, it is necessary to know when the patient was admitted, how long a bed was occupied and which tests and treatments the patient underwent. The applications or subsystems are integrated within the system, with the advantage that they access the same patient demographical data.

Figure 4: The components of a hospital information system (from: author).

Though the costs of programming applications were still high in the 1970s, computer technology became affordable through the advent of minicomputers, which were a lot cheaper than their mainframe brethren. The minicomputers were less expensive because of the use standardized plug-in circuitry components. The most popular minicomputer was the PDP 11 of Digital Equipment Corporation. The PDP 11 (see figure 2) was versatile and its capacity could be expanded easily. The computer had also a very innovative architecture, which made it possible to connect a multiple array of peripherals such as printers, teletypewriters and video terminals. The earlier models could accommodate up 30 users concurrently and later models even 100. It was advantageous

[104] M.I. Roemer (1961), Bed supply and hospital utilization: a "natural" experiment, Hospitals 35 (Nov. 1): 36-42.

[105] M.F. Collen (1988), HIS concepts, goals and objectives, in: A.R. Bakker, M.J. Ball, J.R. Scherrer, J.L Willems, eds, Towards new hospital information systems, Amsterdam: North-Holland, p. 4.

for hospitals, because now terminals could be installed in clinical wards, departments and laboratories. Though users were assigned usernames and passwords, the terminals were not intended for individual use as personal computers later were. The computer facilitated messaging and sharing records between users and departments. Professor Albert Bakker, the then director of BAZIS, the collaborative of academic hospitals, recounted that the newly installed PDP 11 computer in Leiden University Hospital eliminated the need of carting around paper files between departments, which were at the time housed in different pavilions on the hospital compound.[106] Apart of the BAZIS installation, the PDP 11 became the workhorse of clinical laboratories in the Netherlands.

Two hospitals had already acquired computers before 1970 for payrolling and bookkeeping.[107] Other hospitals had contracted external service bureaus for the same purpose, with the advantage that costs could be kept down by paying only for computer time used. In line with the recommendations of the advice and the results of the study visits by NZi staff, COZ decided that the costs of HISs would be accommodated in hospital pricing if a number of conditions were met.[108] First, COZ stipulated regional institutionalized collaboration between non-academic hospitals. The collaboration would include joint acquisition of computers, acquisition and/or development and maintenance of application software. Collaboration should at least entail 2000 beds for general hospitals and 5000 for psychiatric hospitals. Second, NZi would coordinate and support computing efforts and act as an advisor to COZ. NZi was not authorized to make binding decisions, but COZ could and that was what happened. Computing applications that would support diagnostic and therapeutic interventions were explicitly excluded, because it would directly interfere with medical practice or entail investments for expensive technology, in places like in intensive care, radiology and clinical laboratories. Finally. NZi offered training for prospective developers and managers of HISs.

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[106] Interview with A.R. Bakker, May 25, 2021.

[107] E. Berkers, E.G. Daylight (2016), De geest van de computer, een geschiedenis van software in Nederland, Utrecht: Stichting Matrijs, p. 203.

[108] Nationaal Archief, Ministerie van Binnenlandse Zaken en Koninkrijksrelaties: Directie Organisatie en Automatisering (DOA), nummer toegang 2.04.93, inventarisnummer 935, volgnummer 4606, Appendix of letter of the Staatssecretaris van Binnenlandse Zaken to dr. G. Klein, 29 March 1974.

Initially four regional collaboratives were formed, which were designated as application development centers.[109] Ten years later the number was five through mergers, one of which bundled academic and a few non-academic hospitals.[110] The collaboratives were established as non-for-profit organizations that evolved into service bureaus for the participating hospitals and hired personnel for software development and maintenance. Also, the collaboratives leased computers and the participating hospitals were connected through leased telephone lines with terminals. In 1978 the requirements for regional collaboration were lifted, but the collaboratives of non-academic hospital remained active until the late 1990s. Gradually these collaboratives were acquired by commercial companies and hospitals moved towards individual contracts with vendors.

4.5. The BAZIS hospital information system

The purpose of the SMR, namely the systematic collection of medical data for planning and control, was the reason for the Working Group Medical Data (WMI) of Leiden University Hospital to propose the design and implementation of a HIS as a scientific experiment.[111] However, contrary to non-academic hospitals the introduction of medical computing in Leiden appeared to be motivated by the fear of brain drain and losing the competitive scientific edge in computer technology from countries like the United States and United Kingdom.[112],[113] Being part of universities, university hospitals were in 1970 still under the budgetary responsibility of the Ministry of Education and Science. Amongst others, it meant that purchase of expensive equipment needed ministerial approval.

In 1968 Leiden University Hospital automated data processing in the clinical chemistry department using an IBM computer housed in the medical school for scientific

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[109] NL-HaNa, BiZa/DOA, 2.04.93 inv.nr. 935, volgnr. 4447, Letter of P.H. Kool, Nationaal Ziekenhuisinstituut to F.G. Kordes, Ministerie van Binnenlandse Zaken, 26 February 1974.

[110] O. van Rijen (1985), Een kwart van ziekenhuizen ontwikkelt eigen deelsystemen voor informatieverwerking, Het Ziekenhuis, vol. 15(9), pp. 310-313.

[111] A.R. Bakker, L. Costers, J.L. Mol (1978), Concluding report on the Nobin-Zis-Project 1972 – 1976, Leiden: Academisch Ziekenhuis Leiden, p. 6.

[112] Ibid. (1978), p. 6.

[113] A.R. Bakker, F.A. Leguit (1999), Evolution of an integrated HIS in the Netherlands, International Journal of Medical Informatics, vol. 54, pp. 209-224, p. 209.

computing. It was used for daily results and weekly cumulative reporting. In 1969 the laboratory's biochemical auto-analyzers were connected to a PDP minicomputer to feed measurements of blood samples such as cholesterol level into the IBM computer.

Based on this experience with laboratory data processing Leiden University Hospital applied in 1971 for funding of a HIS. The proposal was accepted and a complex governance structure was set up to guide the project. Many stakeholders were involved: the hospital with threefold responsibility for patient care, education and scientific research; the Ministry of Education and Science which through the *Stichting Nederlands Orgaan voor de Bevordering van de Informatieverzorging* (Nobin) aimed to advance a national agenda of scientific computing in research, technology and private companies; the Ministry of Economic Affairs, which sought to advance the computer and software industry in the Netherlands. The governance structure led to *Nobin-Zis* (*Zis* standing for HIS) as the responsible organization for the project.

The development and implementation of the HIS was set up as an experiment. To emphasize its scientific nature in 1971 the project leader, Albert Bakker, was appointed professor on a new chair of medical and biological information processing in the medical faculty of Leiden University. Nobin-Zis received full funding for a period of four years from 1972 until 1976. In a memorandum (nota) to the ministry *Nobin* pointed out that the Minister had full political responsibility for academic hospitals for their operations including computing.[114] However, Nobin also emphasized that the experiment should not only focus on planning and control, but also support clinical research, for example study of patient histories.[115] As part of government's industrial policy, publicly funded organizations, which intended to invest in computing were required to tender the Dutch company Philips. Soon it turned out that Philips could not meet the technical needs of the project, moreover it lacked trust because it had no history in building computers while American companies had. *Nobin* decided for the PDP 11 configuration, the already

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[114] Nationaal Archief, Ministerie van Binnenlandse Zaken en Koninkrijksrelaties: Directie Organisatie en Automatisering (DOA), nummer toegang 2.04.93, inventarisnummer 7881, volgnummer 7080., Nota appended to the letter of the Minister van Onderwijs en Wetenschappen to COZIS, Leiden University Hospital, 18 July 1974.

[115] Werkgroep Beleidsplan (1975), Bevordering van de informatieverzorging in Nederland, 's-Gravenhage: Nobin, p. 74.

mentioned versatile and 'cheap' minicomputer. Shortly afterwards Philips abandoned manufacturing computers.[116]

Figure 5: The Digital Equipment Corporation PDP 11/40 minicomputer which formed the core of the Nobin-Zis hospital information system (from: Wikipedia).

Bakker and his team built the Leiden HIS from scratch. They developed the operating system of the minicomputer, because it was cheaper than a license for off-the-shelf system software, and developed a custom-made database and applications software. Figure 6 shows the scheme of the *Nobin-Zis* HIS sketched in 1972.[117] Conceptually it is identical with figure 4, but offers more detail what applications or subsystems were conceived. Interestingly, the scheme presents in picturesque way the intended users of the various applications. So, we see administrative staff, a head nurse, a physician, dietary service, personnel services, a professor, all of whom can access applications indicated by solid lines. It is important to note that for most users the applications are not interactive. They can see information, while data for most applications input is done by clerks. By 1976 most applications were available and in use in the Leiden University Hospital.

[116] D. de Wit (1994). The shaping of automation, a historical analysis of the interaction between technology and organization 1950 – 1985, Hilversum: Uitgeverij Verloren, p. 224.

[117] Anon. (1972). Globale projectbeschrijving Nobin-Zis, Leiden: Academisch Ziekenhuis Leiden.

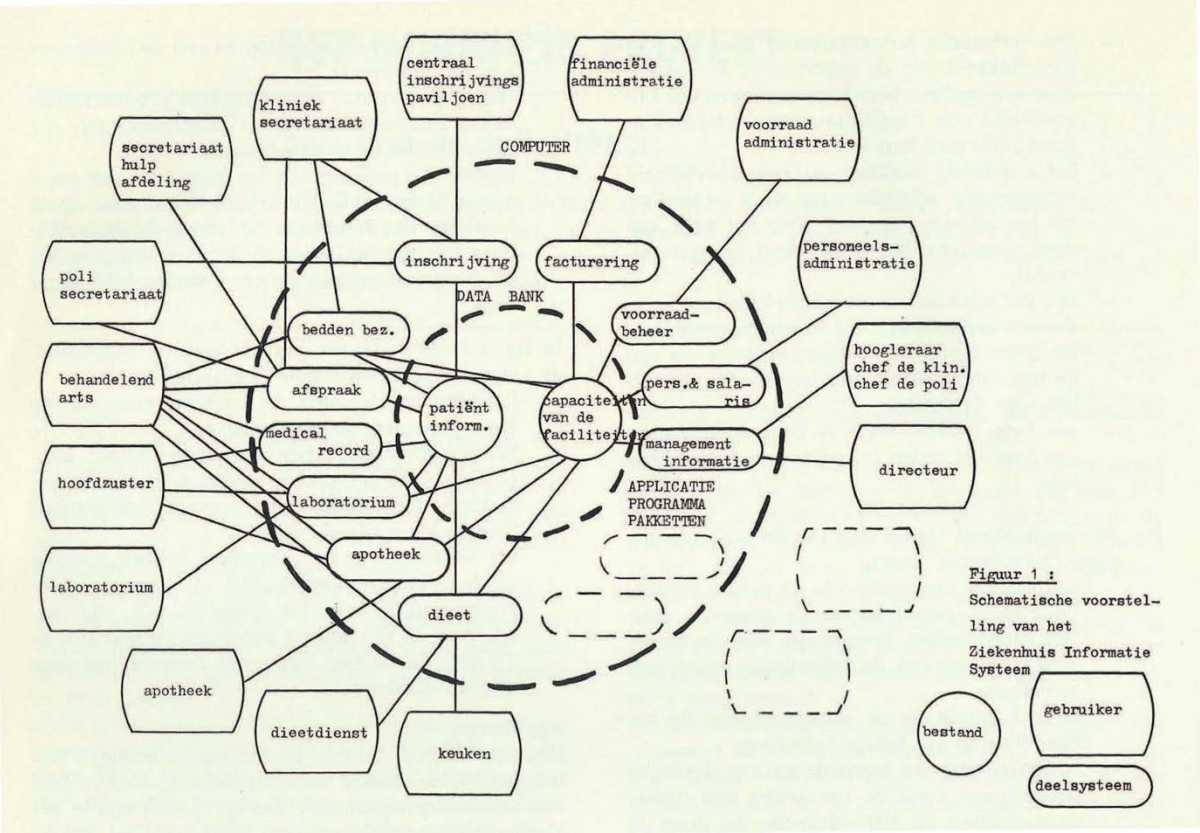

Figure 6: Scheme of Nobin-Zis Hospital Information System (from: Globale Projectbeschrijving Nobin-Zis, 1972).

As a scientific experiment the project has been evaluated extensively. In 1978 Leiden University Hospital published a report of the *Nobin-Zis* project.[118] It contains a detailed description of the philosophy, the governance, the computing environment and the applications, which were realized in the period between 1972 and 1976. It concluded that the budgetary benefits did not exceed the total costs, and several subsystems showed satisfactory gains.[119] Furthermore, the technology and software proved to be very robust and fast with very little downtime. It was the reason of high user satisfaction at the end of the experiment.[120] As funder of the *Nobin-Zis* project the Ministry of Education and Science commissioned also an external evaluation.[121] Though the report agreed with most positive findings of the *Nobin-Zis* project self-evaluation, it was remarkable critical about

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[118] A.R. Bakker, L. Coster, J.L. Mol (1978), Concluding report of the Nobin-Zis-Project 1972 – 1976, Leiden: Academic Hospital Leiden.

[119] Ibid. (1978), p. 183.

[120] Ibid. (1978), p. 191.

[121] Van de Bunt Adviseurs voor Organisatie en Beleid (1979), De evaluatie van het Ziekenhuis Informatie Systeem (ZIS), 's-Gravenhage: Staatsuitgeverij.

a number of organizational issues. Though the experiment was successful, the committee judged that such a true scale subsidized experiment carried a serious risk of failure, which would be almost incalculable.[122] A second issue was that a gap grew between the capabilities of the system and organizational readiness. Organizational development at the managerial level that would accommodate the system was needed direly. Especially middle-management had little knowledge of the opportunities of medical computing and was poorly prepared. Finally, it concluded that the focus was on medical clerks processing medical data for hospital planning and statistics, much in line with the aims of the SMR. The project hardly provided information for the medical and nursing profession.[123]

Already during the experimental phase, the academic hospitals of Erasmus University Rotterdam and Utrecht University decided to participate in *Nobin-Zis*. The hospitals decided to centralize a collaborative in Leiden for further development and maintenance of the hospital information system, which became known as the non-for-profit organization BAZIS. Soon other academic hospitals joined BAZIS as a condition for funding by the Ministry of Education and Science, except for Radboud University Hospital, which chose her own path as a Catholic institution in collaboration with the computer company IBM. Non-academic hospitals joined as well. At the end of 1984, BAZIS counted nine hubs of participants, including five university hospitals (figure 5). Each hub had its own computing facilities, but worked together in the joint development of applications. Physicians were hardly involved in the development and use of applications, but interestingly nurses in the Leiden University Hospital were interested in an automated nursing care plan system to guide the care of patients. It led to a nursing information system VISY built around the concept of the nursing process.[124] The nursing process includes the components of patient assessment, planning and delivery of care and evaluation of patient outcomes. The concept bears likeness to the problem-oriented medical record advocated by Larry Weed, which will be examined in the next chapter. Unfortunately, VISY remained in use in only one nursing department in Leiden

[122] Ibid. (1979), p. 14.

[123] Ibid. (1979), p. 17.

[124] H.B.J. Nieman, A.R. Bakker (1991), Vision on bedside nursing information systems., in: J.P. Turley, S.K. Newbold, eds., Nursing informatics '91, pre-conference proceedings, Berlin: Springer-Verlag, pp. 15-23.

University Hospital and found no following in other departments and hospitals. As development and pilot, it was widely published in conference proceedings and was influential to cement a relation between nursing and medical computing.

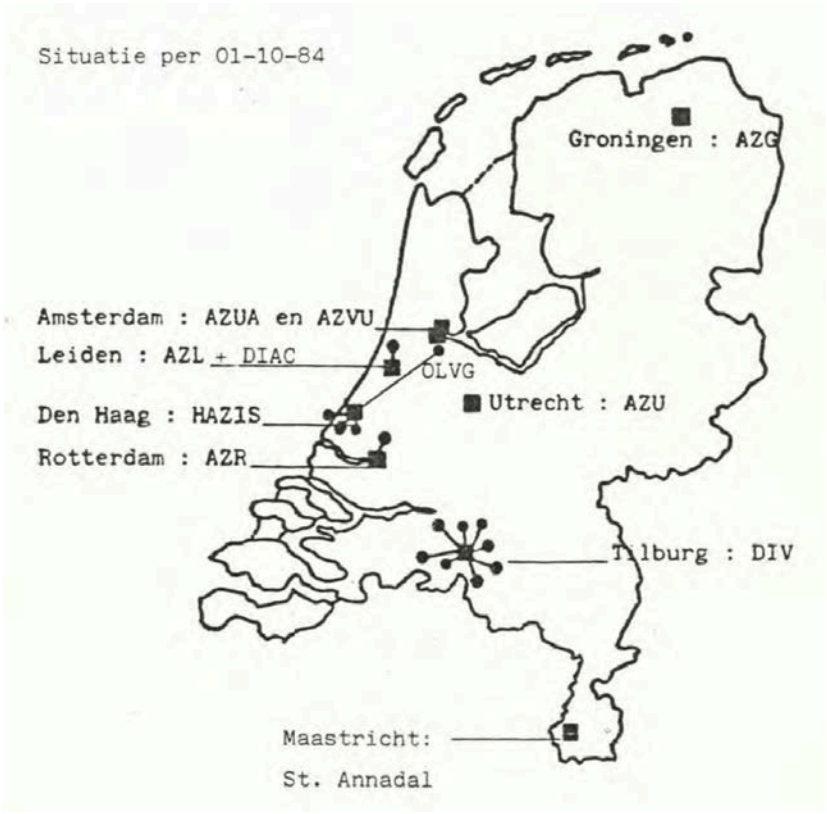

Figure 7: The BAZIS collaboration in 1984. The black squares are the hubs of the collaboration with their own computer centers. The black dots are hospitals linked with the hubs (from: Anon. (1985)., Het ZIS in vogelvlucht, Leiden: BAZIS).

4.6. Government role

The government played, what I would call, a hybrid role in the introduction of medical computing in hospitals. After two decades of laissez-faire, the COZ as a semi-public organization saw hospitals hospital information systems as an important technology to be informed about medical activities taking place and the occupancy of hospital beds. The COZ as an organization of the public sick funds was afraid that the ballooning costs of medical care would make insurance premiums unaffordable for low income insurees. COZ did not seek to curtail what physicians were doing. It hoped that better information would lead to better allocation of human and material resources. A hospital information system was seen as an instrument of planning and control. Because computers and software were expensive, it decided in 1972 that only when hospitals entered into regional collaboratives the costs of computing could be accommodated in hospital budgets. In 1977 the condition

was withdrawn, but the collaboratives remained in place and took the role of system provider for the participating hospitals, It was already mentioned that the Ministry of Education and Science, played an active role in medical computing. After the completion of the *Nobin-Zis* experiment the Ministry agreed to subsidize its successor BAZIS for two years, after which the participating hospitals agreed to share the costs. Only after the transfer of academic hospital patient budgets around 1993 to the generic health insurance system, computing costs were treated equally with those of non-academic hospitals. Despite the fact that the government did not directly influence medical computing in non-academic health care institutions, it established in 1974 a consultative group to bundle expertise from the different ministries, including home affairs, education and health, to guide and support developments in the practice field. The *Beleidsadviescollege Automatisering Gezondheidszorg* (BAG) became the first of successive government departments to advise about policy and legislative conditions for medical computing, especially with respect to privacy, patient rights and standardization.[125]

4.7. Conclusion

Between 1970 and 1980 the implementation of hospital information systems became a reality in Dutch hospitals. The incentive was the ballooning costs of medical care after a period of unlimited expansion in the 60s. Study travels to United States and European countries informed policy making how to implement such systems. Hardware and software were expensive in the late 60s and therefore a policy of sharing computing resources was introduced. In regional collaboratives hospitals could jointly acquire computers and develop applications. Despite accountable to different ministries with their own political agendas, there was no difference between non-academic general hospitals and university hospitals. The advent of cheaper minicomputers made medical computing affordable and restrictions were lifted. However, the collaboratives remained in existence and hospitals contracted them for computing services. The essence of a hospital information systems was a central database with centralized applications or subsystems. Bakker wrote: “The

[125] Nationaal Archief, Ministerie van Binnenlandse Zaken en Koninkrijksrelaties: Directie Organisatie en Automatisering (DOA), nummer toegang 2.04.93, inventarisnummer 935, volgnummer 4606, Letter of the Staatssecretaris van Binnenlandse Zaken to dr. G. Klein, 29 March, 1974.

centralized system (for applications or subsystems) is for the time being the preferred solution in cases where an adequate hospital information system is available."[126] Current hospital information systems are still based on the same principle. The purpose of hospital information systems was planning and control, as *Nobin* had it in its memorandum: "computing is primarily a business resource to optimize hospital operations." The State Secretary of Health, J.P.M. Hendriks, emphasized in his *Structuurnota Gezondheidszorg* of 1974 the need of informatics for a better allocation of health resources.[127] He wrote that current information resources were fragmented and inadequate for health care planning and control. He made proposals how that might be achieved.

An electronic medical record was not envisaged. However, the SMR recommendation for a structured medical record and the availability of medical data in hospital information systems planted the seeds for electronic medical records. We will see in chapter 6 that it was a necessary, but not sufficient condition for electronic medical records.

[126] A.R. Bakker, W. Heijser, M. Mulder (1983), A centralized system, still the best network, in: O. Fokkens et al., eds. Medinfo 83 seminars, Amsterdam: North-Holland Publishing Company, p. 247.

[127] J.P.M. Hendriks (1974), Structuurnota Gezondheidszorg, Tweede Kamer, TK 13 012, Zitting 1973-1974, pp. 30-33.

5. The electronic medical record in primary care, 1970 - 2015

This chapter deals with the introduction and use of the electronic medical record in primary care. Its roots can be already traced back to 1956 with the founding of the *Nederlands Huisartsen Genootschap* (NHG). The college aims to strengthen the scientific basis of primary care medicine. One of its founders and first chairperson, dr. H.H.W. Hogerzeil, became later the director of the Philips Medische Dienst, which was a unique population-based health service for Philips employees. In this role he showed how patient population data could be used to monitor health status of company employees. In 1984 the leadership of NHG embraced the advent of the personal computer to set standards for the structure of electronic medical record and primary care data. With adaptations during the 1980s and 1990s, the electronic medical record became used widely in the profession by 2000 and despite innovations in technology remained the same thereafter. All and all, the path to medical computing in primary care differed strongly from that in hospitals. In large part, this can be attributed to contingent factors.

5.1. The foundation for a structured medical record

On 29 December 1956 Hogerzeil emphasized in his inaugural address the audience of the just founded NHG the need for self-initiated research in primary care medicine and the role of proper registration of patient data.[128] "Before the current improvements, economically weak, without any scientific tradition and educated by physicians who are experts in their own specialty, but not knowledgeable about primary care medicine, there was no opportunity for the primary care physician to converse with like-minded colleagues and there was no recognition and structure of his tasks in the full specter of health care," he said. The task of the primary care physician was defined by others, Hogerzeil continued, citing ongoing controversies with medical specialists about treatments.

In the same issue of *Huisarts en Wetenschap*, the Study Group for Patient Registration presented its recommendations for the future structure and contents of the medical record in primary care.[129] The record should be structured such that patient information of office visits and house calls including referral letters are easily accessible.

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[128] Editorial (1957), Geachte collegae, Huisarts en Wetenschap, vol. 0, pp. 5-8, 11.

[129] Studiegroep patiëntenregistratie (1957), Huisarts en Wetenschap, vol. 0, pp. 9-11.

Then records should allow for easy selection of patient groups who meet certain medical (diagnostic and therapeutic) criteria, for example patients with a prescription for a particular drug to check on side-effects. Most importantly, the study group proposed a registration system that would allow patient group and population studies at the level of a single primary care physician or physician groups. Finally, since a primary physician needed an income too, financial and billing information was to be combined with patient information.

One year later, in 1958, the proposed medical record system for primary care was a reality.[130] Its core was a standard size (A5, 148 x 210 mm) cardboard with rounded corners. The card had four rubrics: (1) a top edge with numbers from 0 to 9, that the physician can use for coding and easy access; (2) a rubric for demographic data, (3) a rubric for static medical data, for example, allergies and other medical conditions that will not change over time, and (5) a rubric for non-static medical information, the part that contains the patient's chronological medical history, including findings, lab tests, diagnosis and therapy. There would be a card for each patient, and if the card was full, a second card would be added. In normal use the card was expected to last fifty years. An important feature were color-coded metal tabs that could be placed on the top edge, allowing easy selection of groups of patients. For example, cardiac patients would have a red tab. The color of the card was light green because it was seen as less tiring for the eyes and the card would not stain easily. The primary care medical record card would become universally known by its color as the 'groene kaart' or green card.[131]

The green card boards were sold by the NHG for a low price per item. The system was to have a huge impact. It standardized medical records in primary care. Just two years later, an editorial in *Medisch Contact* announced that over 500,000 copies were sold.[132] In 1979, that number was 15,000,000.[133] 1979 was also the year that the structure of the

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[130] Studiegroep Patiëntenregistratie (1958), De werkkaart, Huisarts en Wetenschap, vol. 1, pp. 86-92.

[131] 'Green card' is not to be confused with its American counterpart, which is a permanent residency permit for non-US citizens.

[132] Editorial (1960), Een half miljoen bereikt, Medisch Contact, vol. 15, p. 71.

[133] E. van Osselen et al. (2016), Achter de schermen: de praktijkvoering, Huisarts en Wetenschap, vol. 59, p. 366.

medical record changed into a problem-oriented medical perspective. It would become the basis for the electronic medical record, which will be described later in this chapter.

5.2. Primary care computing at Philips Medical Service

Ten years after the founding of the NHG the same Hogerzeil published a paper in *Huisarts en Wetenschap* about computing in primary care. [134] He placed its use in the practice of medicine, medical research and health care policy, defining a pivotal role for the primary care physician. He envisaged that to reap the benefits of computing, a primary care practice should have a certain size for a sufficient amount of patient data. He coined the term *AMICE* to classify medical computing applications for primary care. First, the *A* stands for administration of patient data that can be processed, counted and analyzed. *M* refers to automated medical technologies such as laboratory and ECG signal analysis. The role of automated medical literature retrieval to keep the physician informed is the *I* in the term. Increasing complexity of patient care would necessitate the *C* of communication with other providers for better diagnosis and therapy planning. Finally, the *E* points to improved evaluation of medical decision-making and scientific evaluation, which would help to gain better knowledge about progress and the results of medical treatments. These themes, presented in a talk to the NHG in 1966, would be recurrent in the following years.

It did not come as a surprise to see Hogerzeil advocate medical computing. Since 1962 he was a staff physician at *Philips Medische Dienst* (Philips Medical Service) and between 1969 and 1973 its director. *Philips Medische Dienst* was a comprehensive health group practice for 40,000 employees of the multinational Philips and their families. In 1972, it employed 15 primary care physicians, 13 occupational health physicians and 9 medical specialists. There were departments for cardiology, respiratory medicine, trauma, radiology, ob-gyn, dental medicine, rehab medicine and medical psychology. It counted two pharmacies and several clinical-chemical laboratories. The comprehensive health service for 'cradle-to-grave' care was supplemented by the *Philips Ziekenfonds* (Philips Sick fund). Philips employees in the lower pay scales were obliged to participate in the sick fund

[134] H.H.W. Hogerzeil (1967). De huisarts op weg van de wereld zonder, naar de wereld met computor, Huisarts en Wetenschap, vol 10, p. 375-378. Hogerzeil misspelled Collen's name, but the reference describes the multiphasic screening system (see footnote 137).

and use of the medical service was mandatory.[135] As a tripartite organization of patients, providers and insurer, it was unique in the Netherlands and bore strong resemblance to Kaiser Permanente, an integrated managed care consortium active in California and other American states. In the 60s the *Philips Medische Dienst* became a showcase for medical technology manufactured by Philips. For example, in the radiology department the latest X-ray imaging modalities could be found. Similarly, Philips saw an opportunity to use its computers for medical computing. Hogerzeil was aware of Collen's work on multiphasic screening of patients, discussed in chapter 2.[136] Multiphasic screening entails a periodic health examination of patients using a battery of tests including laboratory, radiology and cardiology.[137] The results of the tests and physical examination are stored a computer system and available to the physician when seeing the patient. Collen developed this system for Kaiser Permanente to screen enrolled patients annually. The organization was founded at the instigation of Kaiser Shipyards in California as a comprehensive medical service for its employees. In collaboration with the computing division of Philips, Hogerzeil developed a similar system, the *Medisch Informatie en Communicatie Systeem* (MICOS), with a centralized medical record accessible to physicians of the service after proper authorization.[138] MICOS contained many of Hogerzeil's ideas about medical computing. The electronic medical record contained the medical history of encounters with providers and the test results of the periodical screenings. However, Hogerzeil questioned the sustainability of his system and suggested that it could become part of a regional system, where physicians could share and communicate medical data.[139]

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[135] S. Stoop (1992), De sociale fabriek, sociale politiek bij Philips Eindhoven, Bayer Leverkusen en Hoogovens IJmuiden, Leiden: Stenfert Kroeze, p. 79.

[136] Hogerzeil (1967), p. 378.

[137] M.F. Collen (1966). Periodic health examinations using an automated multitest laboratory, Journal of the American Medical Association, vol. 195, pp. 142-145.

[138] H.H.W. Hogerzeil, H.R. Breukers (1972), Een geautomatiseerd systeem voor de medische geschiedenis per persoon, in: H.H.W. Hogerzeil et al, Computer en Medische Zorg, Leiden: Stafleu's Wetenschappelijke Uitgeversmaatschappij, pp. 55-67.

[139] Ibid., p. 67.

5.3. The problem-oriented medical record

In 1979 the NHG introduced problem-oriented card as an update to the *groene kaart*.[140] The new card was based on the concept of the problem-oriented medical record proposed by Lawrence Weed.[141] Weed was as a professor of medicine at Yale University very dissatisfied with the level of scientific thinking of medical doctors, especially with regard to how patient problems could be integrated with scientific knowledge.[142] In an interview he said: "*When I pick up a chart that is a bunch of scribbles, I say 'that's not art. It certainly isn't science. Now, God knows what it is*'".[143] Weed set out to develop a problem-oriented medical record for the rest of his life and saw huge potential in medical computing; he realized his ideas at the University of Vermont.

In Weed's view patient data in the medical record should not be ordered chronologically, but based on health problems that needed to be resolved. He described what this entails as following: "Inherent in the problem-oriented approach to data organization in in the medical record is the necessity for completeness in the formulation of the problem list and careful analysis and follow-through on each problem as revealed in the titled progress notes, requiring that the proper data be collected and that the conclusions drawn from this data are logical and relevant."[144] In his view the progress notes were the most crucial part of the record. Simple problems could be written in free text, but complex problems could be dealt with through flowcharts outlining a path of action. Preferably problems should also be coded using a medical classification system, such as the ICD or the *International Classification of Primary Care* (ICPC). A medical computing system would help doing so.

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[140] H. Levelink, W.A. Meyboom (1979), Probleemgeoriënteerd registreren in de huisartspraktijk, Huisarts en Wetenschap, vol. 22, pp. 6-8.

[141] L.L. Weed (1968), Medical records that guide and teach, New England Journal of Medicine, vol. 278, pp. 593-600.

[142] A. Wright, D.F. Sittig, J. McGowan, J.S. Ash, L.L. Weed (2014), Bringing science to medicine: an interview with Larry Weed, inventor of the problem-oriented medical record, Journal of the American Medical Informatics Association, vol. 21, pp. 964-968.

[143] Ibid., p. 965.

[144] Ibid., p. 599.

The new NHG problem-oriented card followed Weed's model and was structured using the headings *Subjective*, *Objective*, *Assessment* and *Plan* (SOAP-structure).[145] Under the heading *Subjective* the health complaints of the patient can be found, under *Objective* the physical examination of the physician and results of tests. Core is *Assessment* under which the physician articulates the health problem and under *Plan* the physician indicates what he or she thinks to do. A patient could have multiple problems. Each would be numbered separately, allowing easy follow-up. The revision would ultimately lead to a NHG guideline for proper medical record keeping in primary care.[146] The SOAP-structure of the *groene kaart* would form the basis of the development of the electronic medical record in the 1980s. It will be the subject of the next paragraph.

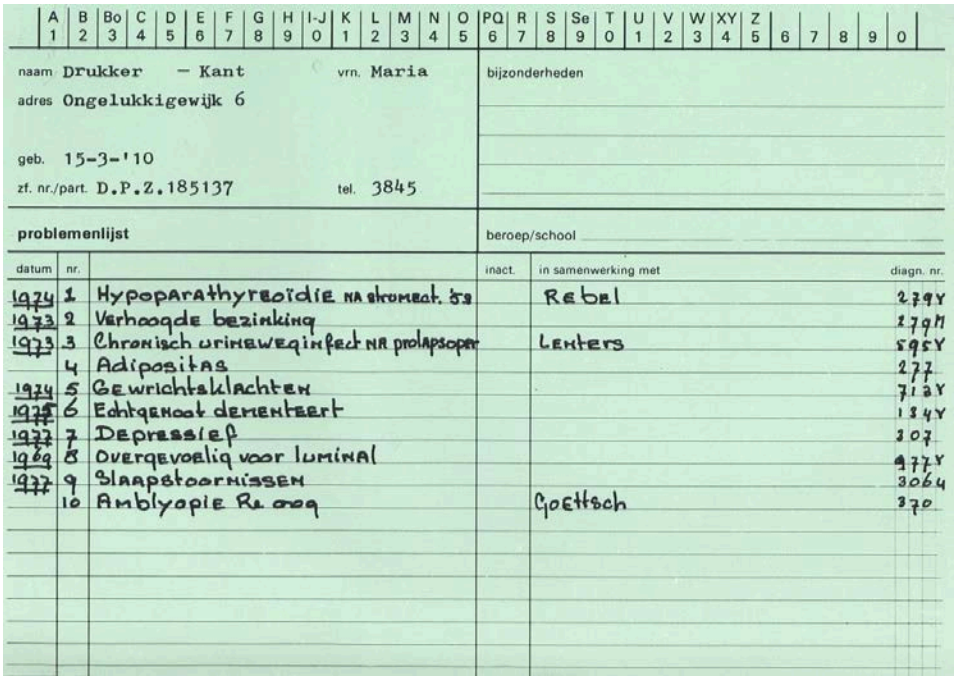

Figure 8 The revised 'groene kaart'. The top shows demographic patient information, the left side the problem list, the right side collaborators and coded diagnoses (from: NHG).

5.4. Electronic medical records

Hogerzeil wrote in 1967 what a computer could do for primary care and made it a reality at the *Philips Medische Dienst*. In 1983 the Dutch Minister for Education stipulated that teaching and research about extramural health care should be concentrated at two medical

[145] W.A. Meyboom (1979), Handleiding voor het A-5 model, probleemgeoriënteerde registratiekaart, Huisarts en Wetenschap, vol. 22, pp. 13-21.

[146] NHG (1990), Medische verslaglegging, Huisarts en Wetenschap, vol. 33. pp. 114-117.

schools, one being the medical school of the Vrije Universiteit in Amsterdam. In 1984, the Department of Medical Informatics and the Department of Primary Care agreed to develop an electronic medical record system based on the revised *groene kaart* of 1979.[147]

The head of the department, professor Jan van Bemmel, knew Octo Barnett from Massachusetts General Hospital in Boston. In 1964, Barnett had developed a medical computing system for ambulatory care, which became known under its acronym COSTAR. Especially for this purpose Barnett designed the programming language MUMPS, of which he wrote: "It is a useful and effective tool for the development and support of interactive data management systems."[148] Van Bemmel chose this programming language to build his information systems; moreover, he and his team built an easy-to-use interactive application development tool AIDA.[149] With this tool the department staff developed information systems for pharmacy, neonatology and ICU.[150] They were mainly used for medical research.

The medical record system for primary care was also built with AIDA. Elias, as the system was called, consisted of modules. A basic module would contain demographic patient data, and other administrative data, such as a list of employees in the practice, an address list of specialists, other people and organizations, with whom the practice would communicate frequently. The medical module is the actual medical record based on the SOAP structure of the *groene kaart*. Diagnoses could be coded according to the International Classification of Primary Care. Coding would enable research on diagnostic data. The pharmacy module contains data on prescription medicines that were approved in the Netherlands. The financial module contains billing and reimbursement data for

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[147] W.M. Boon et al. (1987), The role of AIDA in a primary care information system, Computer Methods and Programs in Biomedicine, vol. 25, pp. 287-296.

[148] J. Bowie, G.O. Barnett (1976), MUMPS, an economical and efficient time-sharing system for information management, Computer Programs in Biomedicine, vol. 6, pp. 11-22. MUMPS stands for **M**assachusetts General Hospital **U**tility **M**ulti-**P**rogramming **S**ystem. Its development has been funded by the U.S. Federal Government and has been made available publicly for software and hardware vendors. It is interesting to note that the data management system of the EPIC electronic health record system has been written in MUMPS.

[149] B. Franken, J.S. Duisterhout, F.S.C. Witte, J.H. van Bemmel (1987), AIDA's fourth-generation software functionality, Computer Methods and Programs in Biomedicine, vol. 25, pp. 245-258.

[150] Ibid., p. 253.

patients enrolled in the practice. Finally, there was a module for communication with systems outside the practice, such as the pharmacy. Figure 2 shows the encounter screen of the medical module. The screen design is quite similar to that of the *groene kaart*.

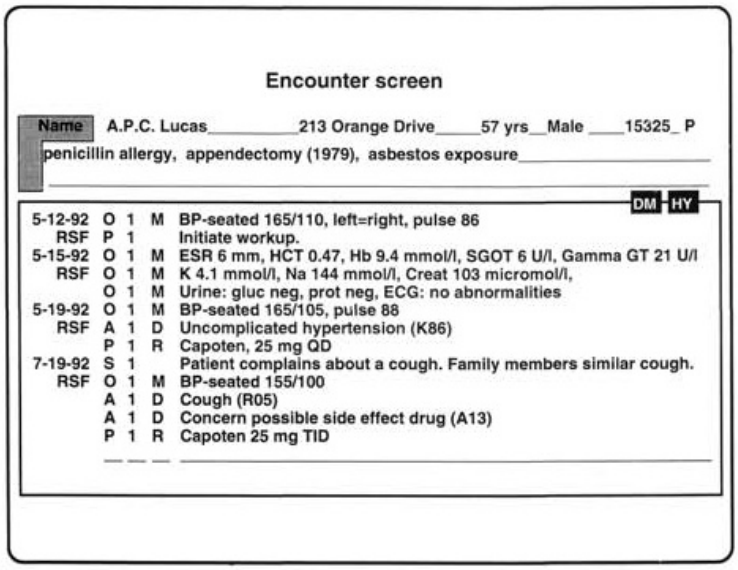

Figure 9: The encounter screen of ELIAS. The top shows patient demographics and alerts about previous medical issues. Below, from left to right are shown the date, then SOAP coding, the third shows coding from the problem list, the fourth coding from the data resource (M for measurements, D diagnosis and R for prescriptions), the fifth contains short descriptions. To the right two markers are visible for diabetes mellitus (DM) and hypertension (HY) (from: van der Lei et al. (1993), The introduction of computer-based patient records in the Netherlands, Annals of Internal Medicine, vol. 129, pp. 1036-1041).

In a 1993 paper published in *Annals of Internal Medicine*, the authors argued that a number of incentives that made the development of Elias possible.[151] First, the less expensive PDP 11/70 minicomputer made it feasible to develop AIDA and Elias. When the even less expensive personal computer was introduced on the market in 1984, both AIDA and Elias were ported to the new platform. With AIDA, Elias had been developed in a relatively short period of time. Second, research to develop the software was funded by government grants. Additional funding was obtained from a private company through an agreement to commercialize Elias. The department retained the rights to conduct research in primary care with Elias, which turned out to be very successful. Third, board members of the NHG and *Landelijke Huisartsen Vereniging* (LHV, the national association

[151] J. van der Lei, J.S. Duisterhout, H.P. Westerhof, E. Van der Does, P.V.M. Cromme, W.M. Boon, J.H. van Bemmel (1993), The introduction of computer-based patient records in the Netherlands, Annals of Internal Medicine, vol. 119, pp. 1036-1041.

for primary care physicians) were involved from the onset. It created a support base for Elias. Two authors, Henk Westerhof and Paul Cromme, of the *Annals* paper were affiliated with NHG and LHV.

At the same time a working group, *Werkgroep Coördinatie Informatie Automatisering* (WCIA) of the NHG and the LHV drafted a reference model for primary care computing systems.[152,153] It was a response to a number of private software companies that wished to develop electronic medical record applications for primary care, now that because of the personal computer a vendor market was economically feasible. Also, the WCIA was aware that a sizeable number of primary care physicians intended to buy a computer system. The aim was to support medical practice in a meaningful way, to standardize information exchange with other providers for the purpose of medical practice, health research and policy, and ensure long-term availability of the system.

The reference model of the WCIA described requirements for software vendors. A medical record system should be modular. The basic module should contain patient demographics, patient contacts, billable interventions and billing contacts. The medical module, the actual medical record, should be based on the SOAP approach and the medication module should support medication prescribing and contain a formulary and information on drug interactions. The reference model was to evaluate compliance of the vendor systems with the requirements. The evaluation reports were published in *Huisarts and Wetenschap*, the scientific journal for general practitioners.[154] The LHV negotiated in 1991 with the government a reimbursement fee for medical computing, provided that general practitioners would buy electronic medical record systems meeting the requirements of the WCIA. It proved to be an important incentive. In 1992, 900 primary care physicians using Elias were reported.[155]

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[152] S. Buijs (1984), Een informatiesysteem voor huisartsen, Medisch Contact, vol. 40, pp. 1287-1288.

[153] P.V.M. Cromme (1985), Huisarts en informatisering, Nederlands Tijdschrift voor Geneeskunde, vol. 129, pp. 1576-1578.

[154] WCIA (1987), Declamed en MicroHIS, Huisarts en Wetenschap, vol. 30, pp. 84-85. This publication benchmarked two medical computing systems for primary care and approved them for use. It also advised primary care physicians to use the NHG evaluation reports before purchasing a system.

[155] J. van der Lei et al. (1993), p. 1037.

5.5. Conclusion

The founding of the NHG in 1956 sowed the seeds for medical computing in medical in general practice. The NHG was a response to the threatening marginalization of primary care medicine vi-à-vis hospital based medical specialties. Its core aim was to define the profession and provide for a scientific basis. In the view of the NHG, it could only be achieved by research and proper medical record keeping. A year after its founding, a NHG workgroup presented a model for medical record keeping in primary care, the so-called *groene kaart*. The model was revised in 1979 to include the new insights of the problem-oriented medical record. If there is a name that could be attached to the early foundation of medical record keeping, then that would be of Hein Hogerzeil. Dr. H.H.W. Hogerzeil was one the founders of the NHG and later, from 1969 until 1973, director of the Philips Medische Dienst. In the latter capacity he developed the first medical computing system for primary care.

Like hospitals primary care could profit from cost-effective minicomputers and from 1984 even cheaper personal computers. In a fruitful collaboration between a university department of medical informatics and primary care with support of the NHG, Jan van Bemmel and his team developed the computerized medical record system Elias for practice and research. It helped NHG and LHV to develop a reference model to benchmark electronic medical records in primary care. In 1993, a study of the introduction of the computer-based patient record in the Netherlands reported 900 Elias users, not counting the users of systems of other vendors. Without exaggeration, it can be stated that the electronic medical record in primary care was a reality by 1990.

6. Incentives for electronic medical records, 1991 - 2010

"I can tell you that over 80% of all general practitioners use a computer and over 50% an electronic medical record … Paradoxically, hospital physicians hardly use any computers for direct patient care," said the Minister of Health, Welfare and Sports, Els Borst-Eilers, on 27 November 1995 in her opening address to an international medical informatics conference audience in Amsterdam[156]. The divergence between primary care and hospital could not have been expressed more clearly. She goes on that the difference might be explained by massive legacy systems,[157] or in other words, outdated hospital information systems.[158] Minister Borst-Eilers was right that legacy systems could constrain choices, but the costs of hospital computing went already down substantially in the 1980s. The ministry said also in 1996 that health care organizations were responsible themselves for the computing infrastructure and that there was no role for the government.[159]

While in 1990 the foundations for electronic medical records were well in place in primary care, this was not the case in hospitals. This chapter addresses five events or occasions that together formed an impact influencing the involvement of especially hospital physicians in medical computing. They were (1) patient safety, (2) regulation of the relationship between physician and patient, (3) quality of care policies, (4) opportunities for electronic communication between systems and (5) usability, the capacity of a computer system to make safe, effective, efficient and enjoyable use possible.

In the early 1990s the concern for medication safety grew, when it became evident that the number of medication prescribing and administration errors impacted patient safety. In a more general sense hospitals became subject to scrutiny of their performance, which resulted in expanding accountability, audit and oversight. The relationship between provider and patient became codified in a law regulating contractual agreement. Amongst

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[156] E. Borst-Eilers (1995), Opening address AMICE, Tijdschrift voor Medische Informatica, vol. 24, pp. 190-193.

[157] In computing, a legacy system signifies amongst others an old computer system that is outdated, yet still in use (Wikipedia, Legacy systems, available from https://en.wikipedia.org/wiki/Legacy_system).

[158] Borst-Eilers (1995), p. 191.

[159] B. Franken, E.J.S. Wever (1996), Informatietechnologie in de zorgsector, feiten en opinies, Tijdschrift voor Medische Informatica, vol. 25, pp. 69-70.

others there were provisions for proper medical record keeping and protection of confidential patient information. Next, the need for communication between the echelons of hospital and primary care was felt, since it became policy to substitute expensive hospital care. Referral letters were in effect patient summaries. Finally, improved access and usability influenced physician acceptance of medical computing.

6.1. Medication safety

In 1991 a publication in the *New England Journal of Medicine* caused ripples and eventually shockwaves, when it reported that the hospital was not particularly a safe place for patients[160]. Further investigation showed that the majority of the errors related to preventable medication errors causing adverse drug events.[161] Adverse drug events are defined as patient injuries that are the outcome of medical interventions involving drugs. One can think of overdosing, allergies or interaction of multiple drugs. The injuries range between mild, intoxicity or even mortality. In 1995, the internist and patient safety researcher, David Bates and his colleagues opined in the *Journal of the American Medical Association* that computerized approaches would be ideal to reduce medication errors, because reliability could reach 100%, while reliance on human intervention would be error prone.[162]

The solution was to be found in Collen's dictum that physicians should their orders directly into the computer to avoid errors in illegible handwriting.[163] It remained a controversy for at least twenty years in the United States whether it was a physician task to interact with computers, until it dawned that physicians had to take responsibility for entering their drug orders electronically to ensure medication safety.[164] Already in 1971,

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[160] T.A. Brennan, L.L. Leape et al. (1991), Incidence of adverse events and negligence in hospitalized patients, New England Journal of Medicine, vol. 326, pp. 370-376.

[161] D.W. Bates et al. (1995), Incidence of adverse drug events and potential adverse drug events, implications for prevention, Journal of the American Medical Asssociation, vol. 274, pp. 29-34.

[162] Ibid. p. 33.

[163] M.F. Collen (1970), General requirements for a medical information system (MIS), Computers and Biomedical Research, vol 3, pp. 393-406.

[164] D.F. Sittig, W.W. Stead (1994), Computer-based physician order entry: the state of the art, Journal of the American Medical Informatics Association, vol. 1, pp. 108-123.

the American company TDS developed a computerized physician order entry (CPOE) system, but then it focused on achieving financial savings though economic use of drug prescriptions.[165] Only in the 1990s it became clear that the system could help increase the safety of drug prescribing. In the Netherlands, the TDS-CPOE system would be acquired by Radboud University Hospital in Nijmegen in 1995.[166]

In the same year the Academic Medical Center (AMC) of the University of Amsterdam started a pilot project of electronic prescribing on three nursing wards.[167] According to Marcel Levi, who was then a medical resident in internal medicine, one of the reasons of the pilot was the complaint by residents that prescriptions of attending physicians were hard to read, because they were filled out by hand or literally carbon copied from the original, or contained crossed out text.[168] The application as part of the hospital information was developed by Hiscom, the company that resulted from a merger between BAZIS and regional collaboratives (see chapter 4). The components of the application were a module for order entry, a database with approved medicines linked to a database containing drug-allergy and drug-drug interaction rules that could cause side-effects and possible harm. In case of a potential harmful interaction an alert would be generated that the physician could read. It would allow her to adjust the prescription. The prescription would finally be printed in the pharmacy and in the nursing ward for dispensing and administration to the patient. The quintessence was that only a physician was authorized to enter medication orders. By 2001 about 800 physicians were trained to

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[165] M.H. Hodge (1990), History of the TDS medical information system, In: B.I. Blum, K. Duncan, editors, A history of medical informatics, New York: ACM Press/Reading: Addison-Wesley Publishing Company, pp. 328-344.

[166] J. Aarts, H. Doorewaard, M. Berg (2004), Understanding implementation: the case of a computerized physician order entry system in a large Dutch university medical center, Journal of the American Medical Informatics Association, vol 11, pp. 207-216.

[167] M.D. Kalmeijer, W. Holtzer, R. van Dongen, H.J. Guchelaar (2003), Implementation of a computerized physician medication order entry system at the Academic Medical Centre in Amsterdam, Pharmacy World & Science, vol. 25, pp. 88-93.

[168] M. Levi (2023), Email message to author, February 26, 2023. (Marcel Levi is currently president of NWO (Netherlands Organization for Scientific Research) and professor of general internal medicine at Amsterdam UMC.)

use the application.[169] It was a watershed departure from the custom that only nurses and non-medical staff used medical computing in support of medicine. Despite the fact that electronic prescribing could improve medication safety, for physicians it remained contested, because they considered it not part of their professional responsibility. In the Radboud University Medical Center a physician project leader for the TDS CPOE system said that the system required a doctor to send electronic notes. "Doctors don't send notes. They have other people doing that for them."[170] The implementation of CPOE was not a particular success. In another Dutch hospital nurses acted as a proxy for physicians, where through an 'agent for' construction they could use a physician login to enter medication orders.[171]

6.2. Regulating physician behavior

In Chapter 3 we saw that medical practice became increasingly bureaucratic through setting standards for the structure and contents of medical records. Through their professional organizations medical specialists agreed to share centrally their medical data to improve resources to allocate specialist care and improve medical research with aggregated data. Self-interest to regulate resources for their profession laid at the heart. When the government and health insurers moved in the 1980s towards more control of health care expenditures, they relied on the medical profession to regulate its own affairs. Van Herk states that only legal and financial instruments could influence specialist behavior.[172]

The laws concerning the contractual relationship between providers and patient and quality of health care organizations were a direct consequence from an increasing number of patient litigations in civil and medical disciplinary courts in the 1980s.[173] The law regulating the relation between patient and provider (WGBO) was designed to

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[169] Kalmeijer et al. (2003), p. 89.

[170] Aarts et al. (2004), p. 213.

[171] E. Goorman, M. Berg (2000), Modelling nursing activities: electronic patient records and their discontents, Nursing Inquiry, vol. 7, pp. 3-9.

[172] R. van Herik (1997). Artsen onder druk, Doctoral thesis, Erasmus University Rotterdam, p. 20 (available from: https://repub.eur.nl/pub/18416/).

[173] Ibid., p. 139, ff.

reinforce the position of the patient. The patient is entitled to be fully informed about the purpose of diagnostic procedures and intended treatments inclusive of their outcomes. Care delivered should be documented in a medical record and accessible to the patient. Therefore, the WGBO required a provider to maintain a medical record. Because the patient was entitled to see the record, it had to become more structured and readable.

The legislation did not stipulate how a medical record should be organized and was neutral whether the record would be computerized or only paper-based. Patient data in the medical record should be kept confidential and can only be shared by other providers involved in the treatment of the patient after consent. The patient had a right to see the record and request correction of factual errors. A contractual agreement should undergird the patient-provider relation (informed consent). Physicians objected that the increased bureaucracy would mean more writing in the medical record. An evaluation of the WGBO in 2001 showed that it functioned satisfactorily; there were only a few instances that physicians refused to provide copies of the medical record to patients.[174]

6.3. Hospital quality

On April 1, 1996 the law regulating the quality of health care organizations became effective. The law entails systematic monitoring, governance and improvement of quality of care. Individual behavior of physicians remains out of scope. The law requires that health care organizations adopt requirements, rules, guidelines and protocols to ensure set standards of quality. A quality system covers elements such as budget, infrastructure, and also includes a complaints committee, which handles patient grievances. Hospitals are obliged to publish annually a quality report, that describes quality initiatives, results of quality measures and incidents.

Because of professional physician autonomy medical practices in hospitals and hospitals were separate legal entities, which each negotiated budgets separately with health insurers, governments and other legal bodies. As the hospital was also legally accountable for all quality issues, the separation was untenable and led to an integration of medical governance with hospitals in 2000, and made physicians integral part of the

[174] J.K.M. Gevers (2001), Evaluatie van de Wet op de Geneeskundige Behandelingsovereenkomst (WGBO), Nederlands Tijdschrift voor Geneeskunde, vol. 145, pp. 509-512.

organization.[175] From then on, only hospitals negotiated with insurers about budgets for hospital care, of which a part could be allocated to physicians.

After a period of piloting, the NZr established in 1998 an accreditation institute for regular external assessment of quality management in hospitals.[176] Participation was voluntary, but peer pressure led to participation of many hospitals. A few hospitals sought international accreditation by inviting the international branch of the *American Joint Commission on the Accreditation of Hospitals* to accredit their organizations. Quality management is resource intensive and a bureaucratic process, which implied the need of a lot of data to be obtained from health care processes.[177] In 2009 Dutch medical specialists in collaboration with hospitals and insurers launched the *Dutch Institute for Clinical Audit* (DICA) to evaluate clinical processes and improve outcomes, which relied heavily on patient data in electronic medical records.[178] It is interesting to note that an accreditation body (Joint Commission) and a clinical auditing body (DICA), which was the result of the work of E. Codman, finally came to the Netherlands (see chapter 2).[179] Accreditation and auditing bodies demanded outcome data and it required hospitals to maintain large comparative computerized databases, which were available in their hospital information systems.[180] Obviously, without medical computing quality assurance, accreditation and auditing were impossible. Medical records were not yet computerized and administrative staff was needed to extract data from the records and enter in hospital information systems.

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[175] T. Tamboer, R.M.J. Schepers, N.S. Klazinga, A.F. Casparie (2002). De veranderende positie en rol van de medische staf in het Nederlandse ziekenhuis sinds de Tweede Wereldoorlog, Tijdschrift voor Sociale Geneeskunde, vol. 80, pp. 49-57.

[176] E.M.S.J. van Gennip, P.A.E. Sillevis Smit (2000), The Netherlands Institute for Accreditation of Hospitals, International Journal for Quality in health Care, vol. 12, pp. 259-262.

[177] P. Triantafillou (2014), Against all odds? Understanding the emergence of accreditation of the Danish hospitals, Social Science and Medicine, vol. 101, pp. 78-85.

[178] See: https://dica.nl/, accessed July 24, 2023.

[179] N. Beck et al. (2020), The Dutch Institute for Clinical Auditing, achieving Codman's dream on a nationwide basis. Annals of Surgery, vol. 271, pp. 627-631.

[180] B. Kaplan (1995), The computer prescription: medical computing, public policy, and view of history, Science, Technology and Human Values, vol. 20, pp. 5-38, p. 20.

6.4. Communication

During the most of the 1990s electronic medical record systems were a locked box. It was simply not possible to share medical data with other providers and health care organization. A hospital information system allowed limited data sharing internally. Medical record systems in primary care had already a communication module that made simple messaging via telephone possible. Thus, in 1985, the general practitioner F.W. Zwaan was able to report enthusiastically about how a simple connection with local pharmacy enabled him to send prescriptions.[181] Partly, because of the medical record and pharmacy system were designed by the same company, he could see on his computer screen a complete list of medications that a patient was on and receives alerts about potential interactions.

Zwaan was, despite this enthusiasm, well aware that a number of preconditions should be met in order to able to communicate electronically in such an effective manner. While human communication utilizes cues and gestures to make a message understood, electronic communication requires strict and formal standards. It is easy to login a single information system as above. A message needs both a receiver and sender with an address; it needs to be stored temporarily when the receiver is not available; header and contents need to be identifiable; a message sent needs to be recognizable at the receiving end; the receiver needs to be informed about urgency. Electronic messaging imposed therefore strict requirements and definitions for computer communication technology and software, communication technology including connectivity and the structure and contents of the message. And all these requirements and definitions needed to be standardized. The internet as we know it today, functions because of it.

In the late 1980s experiments were started to assess the feasibility of electronic messaging between primary and secondary care. The first experiment studied electronic messaging between general practitioners and two hospitals about admission and discharge of patients, laboratory results and free text for general patient information.[182] It compared

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[181] F.W. Zwaan (1985). Huisarts met computer, een goede zaak? Nederlands Tijdschrift voor Geneeskunde, vol. 129, pp. 297-300.

[182] P.J. Branger, et al. (1992), Electronic communication between providers of primary and secondary care, British Medical Journal, vol. 305, pp. 1068-1070.

a group of doctors who looked in physical mailboxes for information about their patients and a group with an electronic mailbox for receiving and sending patient admission and discharge data and receiving laboratory results. One of the findings was that electronic messaging speeded up same-day availability of test results. After the experimental period the communication system remained despite the fact that the general practitioners were billed for its use, while paper-based and telephone calls did not carry an extra charge.

The second experiment studied the autonomous exchange of electronic messages between general practitioners and hospitals[183]. Increasingly primary care doctors were using electronic medical records and the idea was that hospital laboratory systems could push messages. These messages had to be standardized both in structure so that they could be recognized as such, and in contents, namely the results of the laboratory tests. A similar experiment was set up for messaging between primary care and public pharmacies. The standards, called EDIFACT, for the contents of the messages were derived from commerce, where electronic exchange of messages for administrative purposes was already common. Also, this project proved to be successful. However, attempts to upscale the project for practical use failed because there were no rules to fund interorganizational collaboration in health care. It would take another fifteen years before an electronic patient referral system for primary care physicians became operational.[184]

6.5. Usability

Computers until the early 1990s had a character-based user interface. General practitioners were accustomed to it, but is not a particular incentive for less savvy users. Medical specialists were such a category of users. When Microsoft introduced in 1985 a graphical user interface (GUI) for personal computers, Windows, it quickly replaced the character-based operating system in the early 1990s. A surgeon in a small hospital thought that a graphical interface would improve access to data in a hospital information system. He developed a workstation, Mirador, to give medical specialists access to medical data in

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[183] A. Hasman, et al. (1992). Inter-institutional information exchange in healthcare, International Journal of Biomedical Computing, vol. 31, pp. 5-16.

[184] R. Bal, et al. (2007). The product and process of referral. Optimizing general practitioner-medical specialist interaction through information technology, International Journal of Medical Informatics, vol. 76, Suppl 1, pp. S28-S34.

a hospital information system. The workstation was designed in such a way that there was no need for the physician to enter data and it contained easy-to-use search tools to retrieve medical data including laboratory test results and radiology reports. Bakker wrote: "Only when we introduced GUI-based workstations in our HIS, we experienced broad interest of physicians."[185] Access did not include the medical record; they were still maintained on paper in ledgers. The workstation was successful; a few thousand were installed in Hiscom/BAZIS hospitals.

6.6. Conclusion

In this chapter I have described five occasions that influenced medical computing in hospitals. Only the last one, the medical workstation, could be related to advances in computing, moving from a character-based to graphical user interface, but even then, a need for physician access to medical data was a contributing factor. The other four, medication safety and organizational quality, communication between providers and improvement of the position of the patient, became more urgent and required availability of hospital data. The law that mandated a contractual agreement between provider and patient (WGBO) for treatment and gave the patient a right to access her or his medical record, did stipulate proper medical record keeping, but not how it should be done. Each incentive was not sufficient to introduce electronic medical records in hospitals, but together with the increasing ubiquity of computing made it inevitable that sooner or later the medical record could not escape computerization.[186]

[185] A.R. Bakker, F.A. Leguit (1999), Evolution of an integrated HIS in the Netherlands, International Journal of Medical Informatics, vol 54, pp. 209-224, see pp. 220-221.

[186] C. Ciborra (2002), The labyrinths of information, challenging the wisdom of systems, Oxford: Oxford University Press, p. 7.

7. An unfinished history: sharing, standardization, and patients

In 2015 the electronic medical record would eventually become a reality for hospital physicians. This chapter offers a brief sketch of the trends and themes that would influence the evolution of medical computing and the electronic medical record in the Netherlands in the new century. If there was one key issue to be named, then it would be the strengthening of the position of the patient through unlimited access to the electronic medical record. It culminated in legislation effected on 1 July 2020, giving patients access via a personalized internet health portal. Partly because of the lack of historical distance, this sketch is necessarily tentative and incomplete.

At the beginning of the new century the medical computing landscape showed that nearly all primary doctors and very few hospital physicians used electronic medical records. It didn't mean that hospital physicians were not exposed to computing. Laboratory test results were processed on computers and available HISs. In radiology analog films of x-ray machines were replaced by digital images and modern imaging equipment such as CT and MRI scanners were completely digital. Where radiologists earlier read the x-ray photos in dimly lit reading rooms and shared their notes with requesting specialists, now digital images were communicated in a Picture Archiving and Communication Systems (PACS), which many hospitals acquired in the 1990s. Specialists who had a computer in their office, could now see the images themselves. It would have a profound influence on the practice of radiology.[187] Mirador, the medical workstation with a graphical user interface and already mentioned in the previous chapter, allowed specialists to see test results and images. It became extremely popular, because it gave physicians direct access to patient data without the need of entering data themselves. An almost invisible army of medical record administrators and other personnel did all data handling. The paper-based medical record remained untouched. BAZIS, which became later the commercial company Hiscom, developed Mirador and soon other HIS vendors followed suit.

The intensive care unit was the other place in the hospital where automation was ubiquitous. Sensors measured circulation, heart function, breathing and oxygenation and

[187] R. Wachter (2015), The digital doctor, hope, hype and harm at the dawn of medicine's computer age, New York: McGaw-Hill Education, pp. 47-63.

other physiological signals of admitted patients, which were shown on monitors and processed on computers. In fact, one of the earliest medical computing applications in the ICU was an expert system for managing mechanical ventilation of patients.[188] However, companies in this niche market never the crossed the line to larger hospital information systems. Only electronic medication systems were directly aimed at hospital physicians to eliminate illegible handwriting and reduce prescribing errors. But even then, physicians were reluctant to adopt electronic prescribing. A study of nurses' work showed how hospital doctors delegated clerical work of medical data handling to nurses, making the electronic medical record a tool for them.[189]

7.1. Internet

Internet did not figure in this thesis until now. Communication between medical information was a limited issue, except as a backup and distribution system for hospital information systems (chapter 4) and for a few pilots (see previous chapter). However, in 1994 Internet, or more precisely the world-wide web, made a breakthrough to the world. Before 1995 it was a niche for scientists after Tim Berners-Lee developed computing methods to index, find, access and retrieve thousands of documents at the European research center for high-energy physics in Geneva. The invention of a graphical browser bringing multimedia content made internet an immediate hit. The underlying software, communication protocols and hyperlink software to access documents on remote computers were made availably freely and became de facto standards for data representation and electronic messaging and communication.

Internet could not only be used as a public infrastructure providing access to every individual and organization to share information, but also as internal network system, known as intranet. Hospitals seized on the opportunity and created intranets to store and provide information for their employees. Everything from restaurant menus to care protocols could be found and shared on the intranet. Medical computing was the

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[188] L.M. Fagan, J.C. Kunz, E.A. Feigenbaum (1979), A symbolic processing approach to measurement interpretation in the intensive care unit, Proceedings of the Annual Symposium on Computer Applications in Medical Care, pp. 30-33 (retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2231952/).

[189] E. Goorman, M. Berg (2000), Modelling nursing activities: electronic patient records and their discontents, Nursing Inquiry, vol. 7, pp. 3-9.

exception, because of fear of patient data leaks and proprietary communication standards of hospital information systems. Nevertheless, internet became an infrastructure for the private and public digital world.[190] It was one of the reasons that computing became ubiquitous in the hospital, a circumstance that would nudge the medical specialist towards the electronic medical record.

7.2. A wavering government

The role of the government wavered. In the early phase of computing in health care it took firm control of the expenditures in university hospitals and through advisory bodies for non-university hospitals in requiring to share resources regionally. From the late 70s control on IT expenditures was relaxed and medical computing became an instrument for planning and control of health care costs. Computing became part of managerial overhead and the IT market was in the hands of private companies. It was a fit with the times that health care underwent a market-oriented reform. The government took a role of a market arbiter to strengthen the role of the patient as a consumer and ensure accessibility and quality of care. Key legislation such as the WGBO and the law regulating quality in hospitals were enacted.

The Ministry of Health struggled whether in this context it should play an active role or take a backseat and leave responsibility for medical computing to the health care field. In 1997 the Minister of Health, Els Borst-Eilers emphasized the importance of the electronic medical record to improve the quality and efficacy of care. In her view an electronic health record should contain a limited set of coded health data based on standardized disease classifications, and should also allow for free text entry. It should serve the purposes of providers, managers and policy makers. The minister saw no role for the government. It was up to health care field to initiate developments. At most, the government could provide for seed money and create regulatory conditions to enhance implementation.[191]

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[190] J. Wiedemann (2019), Web design, the evolution of the digital world 1990 – today, Köln, Taschen.

[191] Informatievoorziening in de zorg, Brief van de Minister van Volksgezondheid, Welzijn en Cultuur (1997), Tweede Kamer der Staten-Generaal, Vergaderjaar 1997-1998, 25 669, nr. 2, pp. 4-5.

In 2000 the Minister's position changed. She wrote that she would have expected that the health care field would assume responsibility for an agreed information technology infrastructure, but concluded that an active government role was inevitable.[192] The response was again to subsidize pilots such as modernizing authentication and authorization methods for providers and patients to access patient information, to develop electronic health records and standards for a communication infrastructure. In 2003 the then Minister of Health, Hans Hoogervorst, reported that the pilots were successful, but that disagreement existed how to implement the results in practice and who would pay for it.[193] He concluded that the government should take the lead for the sake of public interest. This wavering was part of the prelude to a number of themes that emerged in the first decade of the new century.

7.3. Data sharing and standardization

These three themes were communication between providers, patient access to their medical records and data privacy and confidentiality. First, electronic communication was seen as crucial to enhance quality because it would reduce errors. Influenced by reports about medication errors, different stakeholders including the government agreed to develop a national medication record that would contain all active medicines of a patient.

Another choice was the pro-loco medical record for out-of-hours primary care in GP cooperatives at hospital emergency departments. The pro-loco record would be based on an extraction of the electronic medical record available at almost all GP practices. Colloquially, the communication infrastructure would become known as the country-wide patient record (*landelijk patiëntdossier*). The term was confusing because there would be no electronic record that was to be stored in a central location. All records would remain in the place where they were created. A provider would 'google' where additional patient

[192] Informatie- en communicatietechnologie (ICT) in de zorg, Brief van de Minister van Volksgezondheid, Welzijn en Cultuur (2000), Tweede Kamer der Staten-Generaal, Vergaderjaar 2000-2001, 27 529, nr. 1, p. 1.

[193] Informatie- en communicatietechnologie (ICT) in de zorg, Brief van de Minister van Volksgezondheid, Welzijn en Cultuur (2003), Tweede Kamer der Staten-Generaal, Vergaderjaar 2002-2003, 27 529, nr. 3, p. 2.

information would be available elsewhere for the treatment of a patient. The provider would then issue a request to obtain an electronic copy after patient consent.

In order to make such a national system possible, standardization was crucial. It was the main reason to create in 2002 the *National Institute for Information and Communication Technology in Health Care* (Nictiz), which would be responsible for creating a national communication infrastructure and implement standards for the technical infrastructure and terminology of health care. Most medical computing systems in Dutch health care were not compatible and lacked interoperability, making communication of health data impossible. Initially the ministry encouraged the health care field to develop proposals for the national patient record with government funding.

7.4. Patient access, privacy and safety

Other emerging themes in the 21st century centered around the role and position of the patient. Under pressure of the patients' organization NPCF, the minister proposed in 2006 to give patients direct access to their data via the national medical record. Soon different stakeholders disagreed on the question who would be granted access and how data protection would be ensured. Physicians insisted that patients' request to see their records should be channeled through them as part of the WGBO. Seeing a medical record without intervention of the physician would only cause confusion how to understand the contents. Eventually the Ministry of Health decided to introduce a bill setting conditions for the national patient record and requiring providers to link to this infrastructure via a national switch point, a computer system that would channel requests for access and apply strict authentication, authorization and data protection procedures.

The proposed bill was an addendum to a recent adopted law that introduced a unique identifier for patients. The bill resulted in extensive discussions inside and outside parliament, but passed the lower chamber in 19 February 2009 with a large majority. However, on 5 April 2011 the bill was defeated in the upper chamber (senate) of the parliament. The main reason for this defeat was that the Minister of Health could not allay concerns of the senators that patient privacy and confidentiality of their data would not be guaranteed.

For a number of years private parties in health care tried to pick up the pieces to create an infrastructure to be used on a voluntary basis. When progress remained slow, the

government stepped in again and basically the same bill, only modernized vis-à-vis new technological developments passed the upper chamber on 18 April 2023.

Reinforcing the position of the patient has been a government policy goal since the 1990s. Approaches to do so included improving patient safety and giving access to medical records. Because the majority of medical errors concerned medication safety, it was no surprise that electronic prescribing became widely used in hospitals. A comparative study of e-prescribing implementation in 2009 showed that the Netherlands was ahead of major western countries, even the United States, though it did not exceed 20% of the hospitals.[194] The Dutch Health Inspectorate mandated electronic prescribing in medical practices in January 2012.[195] As a result, electronic prescribing is now common in hospitals and physicians and other providers with prescribing authority enter their own prescriptions. Providing full patient access to electronic medical records was another priority. The government stipulated that by 2021 patients should have full access to their data via a single portal. Standardization was required to enable access. Hospitals and IT companies dragged their feet, because for the former it was about retaining patients and not let them go easily to a competitor, the latter emphasized proprietary rights of their applications and standards.

7.5. The market of hospital information systems

While the government was most visible as an actor to create a national electronic patient record, hospitals faced increasing costs of maintaining collaboratives and remain involved in application development. IT vendors faced a fragmented hospital market and either merged, were acquired by other companies or withdrew from the marketplace. The consequence was that by 2010 a few companies dominated the market. They could make the necessary investments to comply with regulations imposed by the government, health inspectorate, insurers and other statutory bodies. In 2015 in almost all hospitals electronic medical records had replaced paper-based records. In 2021 the market of hospital information systems was reduced to two major vendors.

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[194] J. Aarts, R. Koppel (2009), Implementation of computerized physician order entry in seven countries, Health Affairs, vol 28, pp. 404-414.

[195] J. Aarts, R.A. Bal (2011), Elektronisch voorschrijven voorbarig, Medisch Contact, vol. 66, pp. 728-730, with rebuttal: J. Vesseur (2011), Elektronisch voorschrijven nu al nuttig, Medisch Contact, vol. 66, p. 731.

7.6. Conclusion

I sketched the history of the electronic medical record in the new century based on themes, which already emerged in the last decennium of the previous century. It can only be a sketch since technological and societal developments are in full swing. The shortage of health care personnel has opened the debate how IT can substitute people or make patients more responsible to manage their own care. In 1997 the minister of health, Els Borst-Eilers, envisaged a fully coded electronic medical record with free text capabilities for the physician to make notes. Would she have envisaged that twenty-five years later patients would be able to access their own medical records on their smartphones? The contents are still created at the encounter between the patient and the provider, but the electronic medical record has become an instrument of the patient as well.

For many years the medical record reflected how a physician practiced medicine. It was about her or his observations about the condition of the patients and considerations what course of action was needed; it was a personal instrument. Sociological studies showed how intertwined the medical record is with medical practices.[196] In the preceding chapters I tried to show, to paraphrase David Rothman, that over time strangers jumped on the medical record bandwagon.[197] Precisely for this reason hospital physicians especially were reluctant to computerize their medical records. Even when the WGBO stipulated that patients had a right to see their records and correct wrong information, the Dutch Royal Medical Society (KNMG) argued that records should be redacted before sharing with patients; the personal notes and line of thinking were privy to the doctor and part of his or her work practice. Now, the electronic medical record is shifting towards patients, becoming the electronic patient record.

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[196] M. Berg (1999), Accumulating and coordinating: occasions for information technologies in medical work, Computer Supported Cooperative Work, vol. 8, pp. 373-401.

[197] D.J. Rothman (1991), Strangers at the bedside, a history of how law and bioethics transformed medical decision making. New York: Basic Books.

8. Conclusion and reflections

In this thesis I have described the history of the electronic medical record in the Netherlands. Following Mahoney, the thesis hinges on two premises. First, it should be concerned about its beginnings; second it should consider context, that is the circumstances that allowed the development and use of the electronic medical record.

8.1. Conclusion

The structured medical record lies at the origin of the electronic record. In the United States the reform of medical education and practice in the early 20th century and its emphasis on case-based training necessitated structured medical records. A 'good' medical record became a standard of practice. Long before the arrival of the computer the pre-war structured medical record made it amenable for computing. The structured record, the emergence of a new profession of medical record clerks and the invention of new mechanical technology, such as the tabulating machine by IBM, made quantitative analysis possible and opened the field of population-based medical research. Its development in the early 20th century has been well documented in the United States.

In the Netherlands medical records remained descriptive because physicians considered them as personal notes of their patients. In the interbellum Dutch physicians and hospital administrators were well aware of reforms in American medicine, including medical record keeping and its use for education and research. However, Dutch doctors saw no value in it and claimed to learn more from individual clinical cases.

After the war the Dutch medical mindset changed when expansion of health care required planning of medical capacity and a need grew for patient-population based disease research, based on quantifiable patient data. Therefore, the development of the electronic record in the Netherlands cannot also be understood without the step of structuring the paper-based record to make patient data accessible, be it that the motives for medical specialists and general practitioners were different. In chapters 5 and 6 I described how two different communities of practice had their own history of the electronic medical record.

Mahoney's historical perspective of the beginnings and context of new technology has limited explanatory power. It follows from his approach that, because of different contexts, multiple histories can and should be told. Thus, in this thesis, the different

historical pathways the electronic medical record took in primary and secondary care are described and understood by contextualizing them. However, Mahoney offers no analytical tools for more specific explanations of events and development. I therefore resorted to social theories.

I used the term 'incentive' to make clear what made, in the case of this thesis, a physician to adopt the electronic medical record. For example, the fears of marginalization of the general practitioner, eventually contributed to an almost 100% use of the electronic medical record in primary care by 1990 (chapter 5). In hospitals, single incentives had much less impact (chapter 4); it was a more gradual process of small steps, some facilitated by availability of (computer) technology and the internet, others by regulation and legislation, and by societal shifts like the reinforcement of the position of the patient in the last 25 years (chapter 6). Meanwhile, privacy has been an elephant in the room; it has proved to be in some occasions a disincentive not to adopt an electronic medical record. Ultimately, the national electronic patient record was defeated in parliament in 2011, because of the fear of the risk that data confidentiality and patient privacy would be compromised (chapter 7). Thus, the striking differences found in this thesis between primary and secondary health care, as well the failure of the national electronic patient record legislation can, at least in part, be explained by the different role and impact of incentives and disincentives.

Closely related to incentive is power, with questions such as who or what can exert power to make changes. I used this concept in this thesis to identify and explain occasions to influence physician behavior. Though I never made it explicit in this thesis, social theory and especially sociotechnical theory can help explain why medical computing took a certain direction. In sociotechnical theory, agency is also attributed to technology. Kling and Scacchi argue how in their study of social patterns of computing a history of commitments constrains choices.[198] It goes without saying that the electronic medical record, as we now know it, is not the inevitable outcome of historical events, but is based on choices made in the past. At many occasions outcomes could have been different.

[198] R. Kling, W. Scacchi (1982), The web of computing: computer technology as social organization, Advances in Computing, vol. 21, pp. 1-90, p. 29.

8.2. Reflections

What's new in this thesis? Paraphrasing Stevin Shapin, there is no such thing as the history of the electronic medical record.[199] Mahoney has urged to look at the beginnings and context of computing. My contribution to the historiography of medical computing is that this thesis describes two distinct histories of medical computing in the Netherlands with their own beginnings and context, within hospitals and primary care respectively. Moreover, in order to understand these histories, one needs to go further than the beginnings of digital computing itself.

Mahoney also problematized the position of pioneers and participants in the history of computing, whether as active members of panels and workshops, as subjects of interviews, or as historians of their own work.[200] This proved to be relevant for this thesis too. For example, the history of the electronic medical record in Dutch primary care is usually thought to have begun as a scientific medical computing project of Jan van Bemmel at the Free University of Amsterdam in the early 1970s. However, it begun already in 1956, when the NHG, the Dutch scientific organization for primary care, was founded. One of its founders, H.H.W. Hogerzeil, developed in his capacity as director of Philips Medical Service, in the late 1960s a computing system for multiphasic patient screening, which influenced primary care computing (chapter 5). He was inspired by a similar project in the United States. The problem for the historian is, that surprisingly little is documented about this in the public literature – only passingly in 1992 about Philips Medical Service in a doctoral thesis about 'social factories' by S. Stoop[201] and in 1972 about the system in a chapter by Hogerzeil and Beukers in a book about computers in medical care.[202] This is an example of a finding of this thesis that warrants further research, in this case of a tripartite primary health care organization of patients, providers and local insurer, unique in the Netherlands. Despite scoping on two communities of medical practice, the thesis is

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[199] S. Shapin (1996), The scientific revolution, Chicago: The University of Chicago Press, p. 1

[200] Mahoney (2011), Histories of computing, Cambridge (Mass.): Harvard University Press, p. 39.

[201] S. Stoop (1992), De sociale fabriek, sociale politiek bij Philips Eindhoven, Bayer Leverkusen en Hoogovens IJmuiden, Leiden: Stenfert Kroese (Doctoral thesis Utrecht University).

[202] H.H.W. Hogerzeil, H.R. Beukers (1972), Een geautomatiseerd systeem voor de medische geschiedenis per persoon, in: H.H.W. Hogerzeil et al., Computer en medische zorg, Leiden: Stafleu's Wetenschappelijke Uitgeversmaatschappij, pp. 55-67.

still a descriptive and inventorying historical study of the electronic medical record. However, each of the events described may be a subject of further study.

My motivation for this thesis lies in the Mahoney's plea for a history of computing pursuing the contextual development of ideas, rather than merely listing names, dates, and places of "firsts." I'd like to end with citing Richard Hamming: "But the expert in the field, who does not get serious training in history, is apt to produce anecdotal stories rather than history."[203] I hope that I, being an expert of biomedical computing, have succeeded modestly in escaping that predicament.

[203] R.W. Hamming (1980), We would know what they thought when they did it, in: N. Metropolis, J. Howlett, G.-C. Rota (eds.), A history of computing, a collection of essays. New York: Academic Press, p. 8

Abbreviations

ACM	Association for Computing Machinery
ACS	American College of Surgeons
AHA	American Hospital Association
AMA	American Medical Association
BAG	Beleidsadviescollege Automatisering Gezondheidszorg (Advisory committee for computing in health care)
COZ	Centraal Orgaan Ziekenhuistarieven (Organization for hospital tariffs)
CPOE	Computer Physician (Provider) Order Entry
EHR	Electronic Health Record
EMR	Electronic Medical Record
EPR	Electronic Patient Record
GUI	Graphical User Interface
HIS	Hospital Information System
ICD	International Classification of Diseases
ICPC	International Classification for Primary Care
KNMG	Koninklijke Nederlandse Maatschappij ter bevordering van de Geneeskunde (Royal Dutch Society for Medicine)
LHV	Landelijke Huisartsen Vereniging (National society for primary care)
MICOS	Medisch Informatie en Communicatie Systeem (Medical information and communication system)
NHG	Nederlands Huisartsen Genootschap (Dutch society for scientific research in primary care)
Nobin	Stichting Nederlands Orgaan voor de Bevordering van de Informatieverzorging
NZi	Nationaal Ziekenhuisinstituut (National hospital institute)
NZr	Nationaal Ziekenhuisraad (National hospital council)
SMR	Stichting Medische Registratie (Foundation for medical data registration)
SOAP	Subjective, Objective, Assessment, Plan
WCIA	Werkgroep Coördinatie Informatie Automatisering (Workgroup for coordination of medical computing)

WGBO	Wet op de Geneeskundige Behandel Overeenkomst (Law on patient-provider treatment agreement)
VMBI	Vereniging voor Medische en Biologische Informatieverwerking (Dutch society for medical and biological information processing)
ZIS	Ziekenhuis Informatie Systeem (Hospital information system)

List of figures

Historical sources and bibliography

Interviews

Professor emeritus dr. Albert Bakker, 20 May 2021.

Dr. Khing Njoo, 14 June 2021.

Professor emeritus dr. Johan van der Lei, January 3, 2022.

Odette Aarts, general practitioner, 3 March 2022.

Archives

Nationaal Archief, Ministerie van Binnenlandse Zaken en Koninkrijksrelaties: Directie Organisatie en Automatisering (DOA), nummer toegang 2.04.93, inventarisnummer 935, volgnummer 4606.

Nationaal Archief, Ministerie van Binnenlandse Zaken en Koninkrijksrelaties: Directie Organisatie en Automatisering (DOA), nummer toegang 2.04.93, inventarisnummer 7881, volgnummer 7080.

Parliament proceedings

Hendriks, J.P.M. (1974), Structuurnota Gezondheidszorg, Tweede Kamer, TK 13 012, Zitting 1973-1974.

Informatievoorziening in de zorg, Brief van de Minister van Volksgezondheid, Welzijn en Cultuur (1997), Tweede Kamer der Staten-Generaal, Vergaderjaar 1997-1998, 25 669, nr. 2.

Informatie- en communicatietechnologie (ICT) in de zorg, Brief van de Minister van Volksgezondheid, Welzijn en Cultuur (2000), Tweede Kamer der Staten-Generaal, Vergaderjaar 2000-2001, 27 529, nr. 1.

Informatie- en communicatietechnologie (ICT) in de zorg, Brief van de Minister van Volksgezondheid, Welzijn en Cultuur (2003), Tweede Kamer der Staten-Generaal, Vergaderjaar 2002-2003, 27 529, nr. 3.

Reports

Anon. (1967), Computer-toepassing ziekenhuiswezen, Den Haag: Stichting Nationale Ziekenhuisraad.

Anon. (1968), Rapport inzake betekenis van de computer voor het ziekenhuiswezen, uitgebracht aan het bestuur van de stichting Nationale Ziekenhuisraad, Den Haag: Instituut voor Ziekenhuiseconomie van de Stichting Het Nederlandse Ziekenhuiswezen en Economisch Instituut voor het Katholieke Ziekenhuiswezen.

Anon. (1971), Ziekenhuisautomatisering in Zweden, Denemarken, Engeland en de Verenigde Staten, rapportage en bevindingen tijdens enkele buitenlandse studiereizen, Utrecht: NZi (publicatie nr. 1.71.09).

Anon. (1972). Globale projectbeschrijving Nobin-Zis, Leiden: Academisch Ziekenhuis Leiden.

Bakker, A.R., L. Costers, J.L. Mol (1978), Concluding report on the Nobin-Zis-Project 1972 – 1976, Leiden: Academisch Ziekenhuis Leiden.

Bertens, R., J. Palamar (2021). Het Nederlandse zorgbeleid in historisch perspectief 1941 – 2017, Den Haag: Wetenschappelijke Raad voor het Regeringsbeleid.

Van de Bunt Adviseurs voor Organisatie en Beleid (1979), De evaluatie van het Ziekenhuis Informatie Systeem (ZIS), 's-Gravenhage: Staatsuitgeverij.

Fokkens, O. (1972), De inrichting van het medisch dossier, rapport van de Commissie Medische Status, Utrecht: Stichting Medische Registratie.

Thesis

Van Herik, R. (1997). Artsen onder druk, Doctoral thesis, Erasmus University Rotterdam, (available from: https://repub.eur.nl/pub/18416/).

Books

Aerts, R. (2018), Thorbecke wil het, biografie van een staatsman. Amsterdam: Prometheus.

Bakker, A.R., M.J. Ball, J.R. Scherrer, J.L Willems, editors (1988), Towards new hospital information systems, Amsterdam: North-Holland Publishing Company.

Berkers, E., E.G. Daylight (2016), De geest van de computer, een geschiedenis van software in Nederland, Utrecht: Stichting Matrijs.

Blum, B.I. editor (1987), Proceedings of ACM conference on the history of medical Informatics, New York: The Association for Computing Machinery (available from: https://dl.acm.org/doi/proceedings/10.1145/41526).

Blum, B.I., K. Duncan, editors (1990), A history of medical informatics, New York: ACM Press/Reading: Addison-Wesley Publishing Company.

Bynum, W.F., (1994), Science and the practice of medicine in the nineteenth century. Cambridge: Cambridge University Press.

Chapin, C.F. (2015), Ensuring America's health, the public creation of the corporate health care system, New York: Cambridge University Press.

Ciborra, C. (2002), The labyrinths of information, challenging the wisdom of systems, Oxford: Oxford University Press

Collen, M.F. (1995), A history of medical informatics in the United States, 1950 – 1990, Bethesda: American Medical Informatics Association.

Collen, M.F. (2012), Computer medical databases, the first six decades (1950 – 2010), London: Springer.

Collen, M.F., M.J. Ball, editors. (2015), The history of medical informatics in the United States, second edition, London: Springer.

Companje, K.P., T. Kappelhof, R. Mouton, P. Jeurissen (2018), Vijftig jaar kostenbeheersing in de zorg, Deel I, 1966 – 1990, Den Haag: Sdu.

Flexner, A. (1910), Medical education in the United States and Canada, a report to the Carnegie Foundation for the Advancement of Teaching, New York: The Carnegie Foundation for the Advancement of Teaching.

Fokkens, O. et al., editors (1983). Medinfo 83 seminars, Amsterdam: North-Holland Publishing Company.

Gezondheidsorganisatie TNO (1958), Waardering van medische gegevens uit ziekenhuizen, Assen: van Gorcum.

Hogerzeil, H.H.W. et al. (1972), Computer en medische zorg, Leiden: Stafleu's Wetenschappelijke Uitgeversmaatschappij.

Lancaster, H.O. (1994), Quantitative methods in biological and medical sciences, a historical essay, New York: Springer-Verlag

Louis, P.C.A. (1836), Researches on the effects of bloodletting in some inflammatory diseases. Boston: Hilliard, Gray & Company.

Mahoney, M.S., T. Haigh, editor (2011), Histories of computing, Cambridge (Mass.): Harvard University Press.

Metropolis, N., J. Howlett, G.C. Rota, editors. (1980), A history of computing in the twentieth century, New York: Academic Press.

November, J. (2012), Biomedical computing, digitizing life in the United States, Baltimore: Johns Hopkins University Press.

Porter, R. (1997), The greatest benefit to mankind, a medical history of humanity, New York: W.W. Norton & Company.

Reiser, S.J. (2009), Technological medicine, the changing world of doctors and patients, New York: Cambridge University Press.

Rosenberg, C.F. (2007), Our present complaint, American medicine, then and now, Baltimore: The Johns Hopkins University Press.

Rothman, D.J., (1991), Strangers at the bedside, a history of how law and bioethics transformed medical decision making. New York: Basic Books.

Schrijvers, G., J.M. Boot, eds., Een halve eeuw gezondheidszorg, 1950 – 2000, Lochem: Uitgeversmaatschappij De Tijdstroom.

Shapin, S. (1996), The scientific revolution, Chicago: The University of Chicago Press.

Shortliffe, E.H., J.J. Cimino, M.F. Chiang, editors (2021). Biomedical informatics, computer applications in health care and biomedicine, 5th ed, Cham: Springer.

Sismondo, S. (2010), An introduction to science and technology studies, Chichester: Wiley-Blackwell.

Starr, P. (1982), The social transformation of American medicine, the rise of a sovereign profession and the making of a vast industry. New York: Basic Books.

Stevens, R. (1989), In sickness and in wealth, American hospital in the twentieth century, New York: Basic Books.

Stoop, S. (1992), De sociale fabriek, sociale politiek bij Philips Eindhoven, Bayer Leverkusen en Hoogovens IJmuiden, Leiden: Stenfert Kroeze.

Turley, J.P., S.K. Newbold, editors (1991)., Nursing informatics '91, pre-conference proceedings, Berlin: Springer-Verlag.

Wachter, R. (2015), The digital doctor, hope, hype and harm at the dawn of medicine's computer age, New York: McGaw-Hill Education.

de Wit, D. (1994). The shaping of automation, a historical analysis of the interaction between technology and organization 1950 – 1985, Hilversum: Uitgeverij Verloren.

Wootton, D. (2006), Bad medicine. Oxford: Oxford University Press.

Primary sources

Berkson, J. (1936), A system of codification of medical diagnoses for application to punch cards with a plan of operation, American Journal of Public Health, vol. 20, pp. 606-612.

Codman, E.A. (1914), Standardization of hospital records, Boston Medical and Surgical Journal, vol. 170, p.63.

Codman, E.A. (1914), The product of a hospital, Surgery, Gynecology and Obstetrics, vol. 18, pp. 492-496.

Codman, E.A., W.W. Chipman, J.G. Clark, A.B. Kanaval, M.J. Mayo (1914), Report of Committee on the Standardization of Hospitals. Boston Medical and Surgical Journal, vol. 170, pp. 71-73.

Editorial (1915), Medical education, a review of fifteen years progress, Journal of the American Medical Association, vol 65, pp. 717-718.

Flexner, A. (1911). Hospitals, medical education and research, In: Transactions of the American Hospital Association, Thirteenth Annual Conference. Toronto: American Hospital Association Office of the Secretary.

Mansholt, W.H. (1931), Wat kunnen Europeesche en Amerikaanse ziekenhuizen wederkerig van elkaar leeren? Het Ziekenhuiswezen, vol. 4, pp. 28-42.

Mulder, J. (1947), Indrukken van een studiereis naar Amerika I, clinische administratie en registratie in Amerika en Nederland, Nederlands Tijdschrift voor Geneeskunde, vol. 91, pp. 2547-2550.

Pearl, R. (1921), Modern methods in handling hospital statistics, Johns Hopkins Hospital Bulletin 32:184-94.

Slobe, F.W. (1923), Applying minimum standards to hospitals, The Modern Hospital, vol. 20(2), pp. 166-8.

Stevens, H.C. (1919), Case records and histories in the smaller hospitals, Boston Medical and Surgical Journal vol. 180, pp. 324-29.

Wortman, J.L.C. (1929), Naar het internationaal ziekenhuis-congres te Atlantic City, Het Ziekenhuiswezen, vol. 2, pp. 480-486.

Secondary sources

Aarts, J., H. Doorewaard, M. Berg (2004), Understanding implementation: the case of a computerized physician order entry system in a large Dutch university medical center, Journal of the American Medical Informatics Association, vol 11, pp. 207-216.

Aarts, J., R. Koppel (2009), Implementation of computerized physician order entry in seven countries, Health Affairs, vol 28, pp. 404-414.

Aarts, J., R.A. Bal (2011), Elektronisch voorschrijven voorbarig, Medisch Contact, vol. 66, pp. 728-730, with rebuttal: J. Vesseur (2011), Elektronisch voorschrijven nu al nuttig, Medisch Contact, vol. 66, p. 731.

Amstrong, D. (2012), Screening, mapping medicine's temporal spaces, Sociology of Health Illness, vol. 34, pp. 177-193.

Bakker, A.R., F.A. Leguit (1999), Evolution of an integrated HIS in the Netherlands, International Journal of Medical Informatics, vol. 54, pp. 209-224.

Bal, R.A. et al. (2007). The product and process of referral. Optimizing general practitioner-medical specialist interaction through information technology, International Journal of Medical Informatics, vol. 76, Suppl 1, pp. S28-S34.

Barr, M.S. (2010), The clinical record: a 200-year-old 21st -century challenge, Annals of Internal Medicine, vol. 153, pp. 682-683.

Bates, D.W. et al. (1995), Incidence of adverse drug events and potential adverse drug events, implications for prevention, Journal of the American Medical Association, vol. 274, pp. 29-34.

Beck, N. at al. (2020), The Dutch Institute for Clinical Auditing, achieving Codman's dream on a nationwide basis. Annals of Surgery, vol. 271, pp. 627-631.

Berg, M. (1996), Practices of reading and writing: the constitutive role of the patient record in medical work. Sociology of Health and Illness, vol. 18, pp. 499-524.

Berg, M. (1999), Accumulating and coordinating: occasions for information technologies in medical work, Computer Supported Cooperative Work, vol. 8, pp. 373-401.

Boon, W.M. et al. (1987), The role of AIDA in a primary care information system, Computer Methods and Programs in Biomedicine, vol. 25, pp. 287-296.

Borst-Eilers, E. (1995), Opening address AMICE, Tijdschrift voor Medische Informatica, vol. 24, pp. 190-193.

Bowie, J., G.O. Barnett (1976), MUMPS, an economical and efficient time-sharing system for information management, Computer Programs in Biomedicine, vol. 6, pp. 11-22.

Branger, P.J., et al. (1992), Electronic communication between providers of primary and secondary care, British Medical Journal, vol. 305, pp. 1068-1070.

Brennan, T.A., L.L. Leape et al. (1991), Incidence of adverse events and negligence in hospitalized patients, New England Journal of Medicine, vol. 326, pp. 370-376.

Buijs, S. (1984), Een informatiesysteem voor huisartsen, Medisch Contact, vol. 40, pp. 1287-1288.

Castleman, P. (2006), Medical applications of computers at BBN, IEEE Annals of the History of Computing, vol. 28(1), pp. 6-16.

Collen, M.F. (1966). Periodic health examinations using an automated multitest laboratory, Journal of the American Medical Association, vol. 195, pp. 142-145.

Collen, M.F. (1970), General requirements for a medical information system (MIS), Computers and Biomedical Research, vol 3, pp. 393-406.

Cresswell, K., A. Sheikh, B.D. Franklin, et al. (2022), Benefits realization management in the context of a national digital transformation initiative in English provider organizations. Journal of the American Medical Informatics Association, vol. 29, pp. 536-45.

Cromme, P.V.M. (1985), Huisarts en informatisering, Nederlands Tijdschrift voor Geneeskunde, vol. 129, pp. 1576-1578.

Davies, S.M. (2017), The Experimental Computer Programme: the first computing initiative for the National Health Service in England, IEEE Annals of the History of Computing, vol. 39(2), pp. 65-79.

Donabedian, A. (1989), The end results of health care: Ernest Codman's contribution to quality assessment and beyond, The Milbank Quarterly, vol. 67, pp. 233-256.

Editorial (1957), Geachte collegae, Huisarts en Wetenschap, vol. 0, pp. 5-8, 11.

Ekker, W. (1980), Wat is, wat doet de Stichting Medische Registratie? Nederlands Tijdschrift voor Geneeskunde, vol. 124, pp. 1060-1065.

Fagan, L.M., J.C. Kunz, E.A. Feigenbaum (1979), A symbolic processing approach to measurement interpretation in the intensive care unit, Proceedings of the Annual Symposium on Computer Applications in Medical Care, pp. 30-33.

Franken, B., J.S. Duisterhout, F.S.C. Witte, J.H. van Bemmel (1987), AIDA's fourth-generation software functionality, Computer Methods and Programs in Biomedicine, vol. 25, pp. 245-258.

Franken, B., E.J.S. Wever (1996), Informatietechnologie in de zorgsector, feiten en opinies, Tijdschrift voor Medische Informatica, vol. 25, pp. 69-70.

Frohmann, L. (2017), Redefining medical confidentiality in the digital era: healthcare reform and the West German debate over the use of personal medical information in 1980s, Journal of the History of Medicine and Allied Sciences; vol. 72, pp. 468-499.

van Gennip, E.M.S.J., P.A.E. Sillevis Smit (2000), The Netherlands Institute for Accreditation of Hospitals, International Journal for Quality in health Care, vol. 12, pp. 259-262.

Gevers, J.K.M. (2001), Evaluatie van de Wet op de Geneeskundige Behandelingsovereenkomst (WGBO), Nederlands Tijdschrift voor Geneeskunde, vol. 145, pp. 509-512.

Goorman, E., M. Berg (2000), Modelling nursing activities: electronic patient records and their discontents, Nursing Inquiry, vol. 7, pp. 3-9.

Hasman, A. et al. (1992). Inter-institutional information exchange in healthcare, International Journal of Biomedical Computing, vol. 31, pp. 5-16.

Hogerzeil, H.H.W. (1967). De huisarts op weg van de wereld zonder, naar de wereld met computor, Huisarts en Wetenschap, vol 10, p. 375-378.

Kahn, L.G., A. Morabia (2015), Using the numerical method in 1836, James Jackson bridged French epistemology and American medical pragmatism. Journal of Clinical Epidemiology, vol. 68, pp. 397-404.

Kalmeijer, M.D., W. Holtzer, R. van Dongen, H.J. Guchelaar (2003), Implementation of a computerized physician medication order entry system at the Academic Medical Centre in Amsterdam, Pharmacy World & Science, vol. 25, pp. 88-93

Kaplan, B. (1995), The computer prescription: medical computing, public policy, and view of history, Science, Technology and Human Values, vol. 20, pp. 5-38.

Kling, R., W. Scacchi (1982), The web of computing: computer technology as social organization, Advances in Computing, vol. 21, p. 29.

Lea, A. (2019), Computerizing diagnosis: Keeve Brodman and the Medical Data Screen, Isis, vol. 110, pp. 228-49.

van der Lei, J., J.S. Duisterhout, H.P. Westerhof, E. Van der Does, P.V.M. Cromme, W.M. Boon, J.H. van Bemmel (1993), The introduction of computer-based patient records in the Netherlands, Annals of Internal Medicine, vol. 119, pp. 1036-1041.

Levelink, H., W.A. Meyboom (1979), Probleemgeoriënteerd registreren in de huisartspraktijk, Huisarts en Wetenschap, vol. 22, pp. 6-8.

Mahoney, M.S. (2005), The histories of computing(s), Interdisciplinary Science Reviews, vol. 30, pp. 119-35.

Melton, l.J. (1996), History of the Rochester epidemiology project. Mayo Clinic Proceedings, vol. 71, pp. 266-274.

Meyboom, W.A. (1979), Handleiding voor het A-5 model, probleemgeoriënteerde registratiekaart, Huisarts en Wetenschap, vol. 22, pp. 13-21.

NHG (1990), Medische verslaglegging, Huisarts en Wetenschap, vol. 33. pp. 114-117.

November, J. (2011), Early biomedical computing and the roots of evidence-based medicine, IEEE Annals of the History of Computing, vol. 33(2), pp. 9-23.

November, J. (2016), Ask your doctor … about computers, IEEE Annals of the History of Computing, vol. 38, no. 1, pp. 3-5.

van Osselen, E. et al. (2016), Achter de schermen: de praktijkvoering, Huisarts en Wetenschap, vol. 59, p. 364-368.

Reiser, S.J. (1991), The clinical record in medicine, part 1: learning from cases, Annals of Internal Medicine, vol 114, p. 902-907.

Reiser, S.J. (1991), The clinical record in medicine, part 2: reforming content and purpose, Annals of Internal Medicine, vol. 114, p. 980-985.

van Rijen, O. (1985), Een kwart van ziekenhuizen ontwikkelt eigen deelsystemen voor informatieverwerking, Het Ziekenhuis, vol. 15(9), pp. 310-313.

Roemer, M.I. (1961), Bed supply and hospital utilization: a “natural” experiment, Hospitals 35 (Nov. 1): 36-42.

Sittig, D.F., W.W. Stead (1994), Computer-based physician order entry: the state of the art, Journal of the American Medical Informatics Association, vol. 1, pp. 108-123.

Studiegroep patiëntenregistratie (1957), Huisarts en Wetenschap, vol. 0, pp. 9-11.

Studiegroep Patiëntenregistratie (1958), De werkkaart, Huisarts en Wetenschap, vol. 1, pp. 86-92.

Tamboer, T., R.M.J. Schepers, N.S. Klazinga, A.F. Casparie (2002). De veranderende positie en rol van de medische staf in het Nederlandse ziekenhuis sinds de Tweede Wereldoorlog, Tijdschrift voor Sociale Geneeskunde, vol. 80, pp. 49-57.

Triantafillou, P. (2014), Against all odds? Understanding the emergence of accreditation of the Danish hospitals, Social Science and Medicine, vol. 101, pp. 78-85.

WCIA (1987), Declamed en MicroHIS, Huisarts en Wetenschap, vol. 30, pp. 84-85.

Weed, L.L. (1968), Medical records that guide and teach, New England Journal of Medicine, vol. 278, pp. 593-600.

Wiedemann, J. (2019), Web design, the evolution of the digital world 1990 – today, Köln, Taschen.

Wright, A., D.F. Sittig, J. McGowan, J.S. Ash, L.L. Weed (2014), Bringing science to medicine: an interview with Larry Weed, inventor of the problem-oriented medical record, Journal of the American Medical Informatics Association, vol. 21, pp. 964-968.

Zwaan, Z.W. (1985). Huisarts met computer, een goede zaak? Nederlands Tijdschrift voor Geneeskunde, vol. 129, pp. 297-300.