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Infrastructural Complexity: A Mapping of Medication Management in Norway

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Abstract. Medication is key to the effective treatment of diseases but requires careful management to avoid errors that may harm patients. This study maps the Norwegian infrastructure for medication management. This infrastructure interlinks hospitals, nursing homes, home care, general practitioners, and so forth into an increasingly integrated record of each citizen's medication. In spite of its electronic components, the infrastructure is inherently sociotechnical. Considerable human work goes into bridging the components. While cumbersome, the bridging work also introduces occasions for double checking the medication information. The constant evolution of the medication-management infrastructure seeks to reduce bridging work but must also preserve the occasions for checking quality. Doing so requires coordinated changes in technology and work practices.

Introduction

Medication is key to the effective treatment of diseases but, at the same time, errors in medication administration pose a large risk to patients. To avoid errors, the medication process must be carefully managed. Many resources are devoted to medication management, including resources for documenting a patient's current medication (Zhang et al., 2022), for coordinating clinicians' medication-related activities (Reddy et al., 2001), and for designing electronic medication-management systems (Andersen, 2013). Yet, medication errors continue to be among the leading causes of mortality and morbidity in developed countries (Makary and Daniel, 2016; Phillips and Bredder, 2002). This study explores the

Norwegian healthcare system to map the infrastructural complexity that riddles medication management. With this mapping, we aim to bring out the boundary-crossing character of this complexity.

In 2012, Norway adopted the strategy "one citizen – one record" (Norwegian Directorate of eHealth, 2018) for its population of 5.5 million people. This strategy announced the goal of establishing a nationwide electronic health record (EHR) that spanned specialist healthcare (i.e., hospitals), municipal healthcare (i.e., home care and nursing homes), and primary healthcare (i.e., general practitioners – GPs). Medication management features prominently in all three healthcare sectors and in the interrelations among them. While the user should experience one integrated record, it will not be one technical system. It will be a cross-sectoral infrastructure of intercommunicating components from multiple technology vendors (Ellingsen et al., 2022a). To investigate the complexity of medication management, we conducted an interview-based study and analyzed the resulting data from an infrastructure perspective (Aanestad et al., 2017; Monteiro et al., 2013; Pipek and Wulf, 2009). Our study is the first stage of a larger research project to understand the prospects and challenges of making medication management increasingly integrated and electronic.

Method

This study is based on a total of 27 one-hour interviews. Five interviews (in 2021/2022) were with healthcare professionals in the region of Northern Norway and concerned their individual role in day-to-day medication management. The other interviews concerned, among other things, the infrastructure for medication management. These interviews were conducted in Central Norway and consisted of four interviews with informants from municipal healthcare consortia (in 2021), three interviews with representatives of EHR vendors (in 2020/2021), nine interviews with GPs (in 2019), and six interviews with managers responsible for an ongoing and large-scale EHR implementation (in 2018). The interviews were about evenly split between onsite and online interviews.

The interviews revolved around a small set of guiding questions prepared ahead of each interview. These questions served to maintain the focus of the interviews and as starting points for the interviewees' responses. The interviewees were encouraged to provide rich descriptions of their work practices, including the artifacts used in performing these practices and the rationale for performing them the way they did. All interviews were recorded and transcribed for analysis, which followed an interpretive approach (Walsham, 2006). The analysis focuses on the intersectoral and hospital levels of medication management.

Results

Intersectoral Level: An Infrastructure of Interrelated Components

The interviewees mention a lot of electronic and other systems that enter into medication management. For example, several national integration components are being developed to facilitate the "one citizen – one record" strategy. One of them is the *summary care record*, which has been under development since 2012. It is a digital solution for sharing patients' health information across the healthcare sector and includes, among other things, critical information, discharge letters, laboratory results, and pharmacy-dispensed medication prescribed through the Prescription Intermediary System (in Norwegian, "Reseptformidleren"). In 2017, the summary care record was rolled out to all hospitals, all emergency call-centers, and 85% of the GPs. In 2020, the first municipalites started to use it, and currently the possibilities of sharing various clinical documents from Norwegian hospitals are being tested at different locations in Norway.

Another national component is the *shared medication list*, which will become part of the summary care record. It has been pilot implemented in Norway's second-largest city, Bergen, since December 2021. Compared to the summary care record, which gives an overview of a patient's pharmacy-dispensed medication, the shared medication list gives the full list of a patient's medications, including prescription drugs, non-prescription drugs, and drugs that have been administered in a hospital, nursing home, or purchased abroad. To enable widespread use of the shared medication list, a national component called the Central Prescribing Module is also being developed and is currently in the test phase. The Central Prescribing Module is a medication and requisition module that (through integration with the EHRs in the healthcare institutions) facilitates the sharing of medication information among various EHRs. When this module becomes available to healthcare personnel, they will have a unified prescription user interface, irrespective of which EHR they use.

The interviewees from the municipal healthcare consortia considered the shared medication list particularly promising. One said that with the addition of this list "we will have a pretty good picture of the patient's health situation." However, the shared medication list, the Central Prescribing Module, the Prescription Intermediary System, and the summary care record are merely pieces in a big puzzle. To be functional, they must work seamlessly together with hospital EHRs (DIPS and EPIC), EHRs in municipal healthcare (DIPS FRONT, GERICA, and PROFIL), and the EHRs in GP clinics (CGM, INFODOC, PRIDOK, SYSTEM X, and 2-3 others). In addition, the different EHRs must bilaterally exchange further medication information whenever a patient crosses a sectoral boundary, such as a transfer from hospital back to home care. Figure 1 illustrates

the multidirectional flow of information in this infrastructure. Considerable work goes into keeping the information up to date. This work includes maintaining the distinction between the medication prescribed to a patient and the medication that the patient actually takes. Several interviewees emphasized the critical importance of talking with the patient to obtain accurate information about the taken medication, because the other components in the infrastructure mainly contain information about prescribed medication.

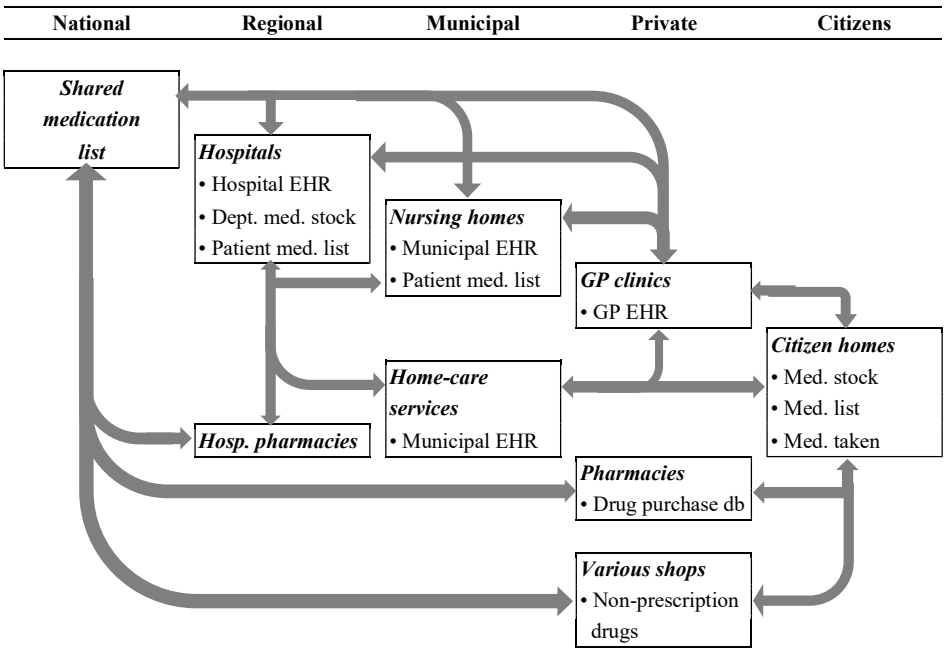

Figure 1. The Norwegian infrastructure for medication management.

Hospital Level: Working Documents vs. Electronic Documentation

Currently, the shared medication list is pilot implemented in one Norwegian city. It is still merely a vision in the rest of Norway, such as in Narvik. At Narvik Hospital in North Norway, one of the first things to do when a patient is admitted is to establish the patient's current medication. To do so, the physician must match the patient's medication list in the hospital EHR against the lists in two national components: the central prescription database and the summary care record. These three lists of the patient's medication get their content from partly overlapping sources. None of the lists can be assumed to be correct. Recently prescribed medication may not yet be on the lists; terminated medication may still be there. The physician needs to identify and remove duplicates, to determine whether old prescriptions are still in effect, and to seek additional information if left uncertain about whether something is missing from all three lists. For elderly patients, additional information may be obtained by electronic information

exchange with the EHRs in home care and nursing homes. For all patients, the merged medication list is recorded in the hospital EHR and printed on paper.

During the admission, this paper printout – the paper chart – is the authoritative record of the patient's medication. Changes to the medication are written on the chart, including a reason for the change. The paper chart has preprinted fields for five days of use. If a patient stays longer, a new paper chart is printed and the changes on the old chart are manually transferred to the new chart. The paper chart is accessed repeatedly and, therefore, passed from clinician to clinician: (a) During the night shift, the nurse on duty uses the charts for all patients to dispense their medication for the next day. Patients get medication at four daily medication rounds and the nurse prepares each patient's medication for each of these rounds. (b) During the day shift, the nurses check the prepared medication against the paper chart before each medication round. This check involves adding and removing medication that has been changed by the physicians during the day. It also involves adding class A and B drugs, which for safety reasons must only be dispensed by the nurse who will be giving them to the patient. The nurses must make a separate record of the dispensed amount of these drugs. For class A drugs, the hospital pharmacy checks this record against their database of the drugs delivered to the hospital departments to discover shrinkage. For class B drugs, the record is kept by the head of department for auditing purposes. (c) During their ward rounds, the physicians use the paper chart in assessing the patient and to record any changes in medication. (d) Finally, the clinical pharmacists use the paper chart in talking with the patients about which medication and which doses they actually take, especially for the medication they also used prior to their hospital admission. The interviewed pharmacist states that these talks "almost always reveal one thing or another that does not match [the contents of the paper chart]".

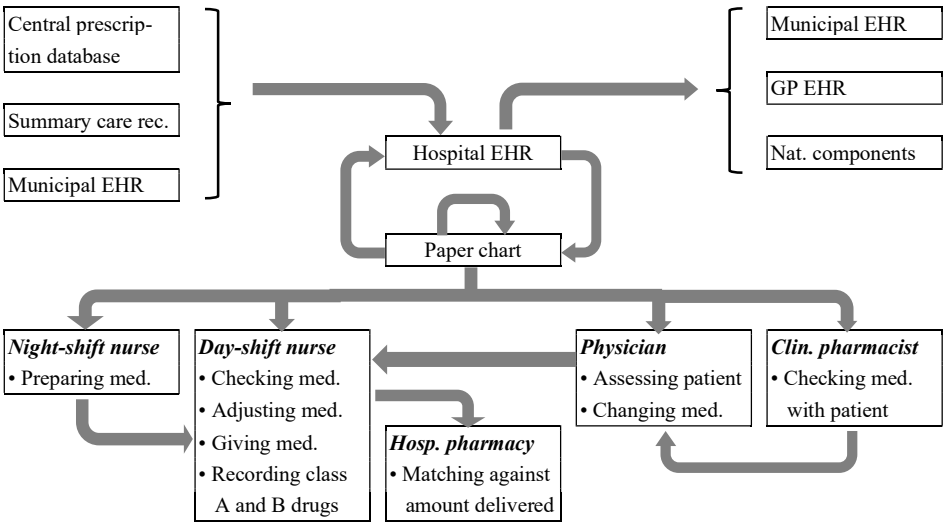

Figure 2. The process of medication management at Narvik Hospital.

At discharge, the medication list in the hospital EHR is updated with the information on the paper chart. The updated list is automatically transferred to nursing homes, home-care services, and GP clinics. However, the nursing homes often contact the hospital to verify changes in a patient's medication, especially when the reasons for prescribing it are unclearly described. Figure 2 illustrates the within-hospital medication-management process.

Discussion

Medication management is a boundary-crossing activity. As an infrastructure, it operates at multiple organizational and temporal scales, thereby connecting heterogeneous entities across various boundaries. It crosses boundaries between healthcare sectors (e.g., hospitals and nursing homes), between within-sector departments (e.g., medical wards and intensive care units), between professional groups (e.g., nurses and pharmacists), between artifacts (e.g., EHRs and paper charts), between work shifts (e.g., day and night), between vendors (e.g., DIPS and EPIC), between tasks (e.g., administering medication and recording class A drugs), and between technology and people. Any within-boundary activity is merely a component in the larger infrastructure for medication management. The complexity of this infrastructure defies automation but calls for extensive technological support to assist the healthcare professionals in spanning the boundaries. The many troubled EHR implementations documented in the literature attest to the challenges involved in supplying such support (e.g., Aarts et al., 2004; Greenhalgh et al., 2011; Hertzum et al., 2022).

In Norway, initiatives are currently ongoing to supply technological support in terms of nationwide integration components and regionwide EHRs. At the municipal level, there are also initiatives to stimulate technological innovation by increasingly opening the current infrastructure to add-on components from third parties (Ellingsen et al., 2022a). All these initiatives should strike a delicate balance between reducing bridging work and preserving quality:

- *Bridging work*: While many components in the infrastructure for medication management are electronically connected, the flow of information among the components involves considerable human work. This bridging work is cumbersome and increasingly prone to errors with more degrees of separation between the involved healthcare professionals (Hertzum, 2010).
- *Quality checks*: At the same time, the bridging work introduces multiple occasions for double checking the correctness of the medication information. These repeated checks lead to the correction of many errors. A more technologically integrated process might appear more efficient but in effect do away with these quality checks, which show that some redundancy may be useful (Cabitza et al., 2019).

Currently, suboptimal technological integration necessitates considerable bridging work and quality checks. However, the infrastructure for medication management is constantly evolving – at multiple levels. At the national level, the central prescription database and the summary care record are recent technological initiatives to integrate otherwise fragmented information. At the regional level, the new EHR in Central Norway comes with the expectation of increased cross-sectoral collaboration, but the GPs express concerns about the accompanying increase in their workload (Ellingsen et al., 2022b). At the hospital level, the clinical pharmacists are taking on new responsibilities, thereby causing task drift in the division of labor between physicians and clinical pharmacists. These initiatives wrestle with the installed base, which merely evolves slowly because of its long history and many interdependencies (Aanestad et al., 2017). The paper chart is a prime example.

The paper chart is in widespread use at Narvik Hospital and, probably, hard to replace due to its tight integration in daily practices (Figure 2). Paper has valuable qualities that are acknowledged in research but sometimes not in design efforts, as illustrated by the discussion of paper flight strips in air traffic control (Mackay, 1999). For the paper chart, the valued qualities include flexibility, portability, and at-a-glance overview. However, the paper chart also comes with the risk of manual transfer errors and information loss when the chart is full and must be replaced with a new one after five days. In addition, the paper chart precludes technology support such as automatic drug-interaction warnings when hospital physicians prescribe new medication to admitted patients. Unless the clinicians are prepared to let go of the paper chart, the support they get from their EHR will remain limited when it comes to managing medication. At the same time, changes to the infrastructure should be made cautiously because abrupt changes may cause uncertainty and perceived complexity that detracts from the intention to streamline medication management.

Pipek and Wulf (2009) advocate an integrated perspective on the design and use of information technology. A key proposition in this perspective is to get beyond the traditional design-method focus on developing individual products, because users accomplish their tasks by combining multiple products. The boundary-crossing character of medication management shows the inadequacy of a design focus on individual products. Medication management extends across many systems, each merely a component in the overall infrastructure for medication management. To meet the strategic goal of “one citizen – one record”, it must be a principal design objective to bring the components together in a unified user experience. This requires a consistent focus on evolving the infrastructure, rather than solely on designing the individual component products.

This study has investigated medication management at the intersectoral and hospital levels. We envisage that including municipal healthcare and GP clinics will add further complexity. For example, nursing homes provide long-term care,

which entails different conditions for medication management than the acute care administered at hospitals. Home care supports and follows up on medication management in the citizen's home, which is a less controlled environment than hospitals and nursing homes. And GP clinics are private businesses that must generate an income from their contributions to medication management, whereas hospitals and municipal healthcare in Norway are funded via taxes. In future work, we will also investigate medication management in municipal healthcare and GP clinics.

Conclusion

The infrastructure that is in place to support medication management is far-reaching and inherently sociotechnical. It spans all levels of the healthcare system, diverse technological components, and various healthcare professionals. This study has mapped the intersectoral and hospital levels of the Norwegian infrastructure for medication management. While this infrastructure supplies an increasingly integrated record of each citizen's medication, considerable human work goes into bridging the technological components of the infrastructure. Ongoing initiatives seek to reduce the need for such bridging work through increased technological integration. However, the bridging work also creates occasions for double checking the correctness of the medication information. These occasions must be preserved unless we can be certain that the increased integration makes the double checking superfluous. At each step in the evolution of the medication-management infrastructure, coordinated changes in technology and work practices are required.

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References

Aanestad, M., Grisot, M., Hanseth, O. and Vassilakopoulou, P. (eds.) (2017): *Information infrastructures within European health care: Working with the installed base*, Springer, Cham, 2017. https://doi.org/10.1007/978-3-319-51020-0

Aarts, J., Doorewaard, H. and Berg, M. (2004): 'Understanding implementation: The case of a computerized physician order entry system in a large Dutch university medical center', *Journal of the American Medical Association*, vol. 11, no. 3 (2004), pp. 207–216. https://doi.org/10.1197/jamia.M1372

Andersen, T.O. (2013): 'Medication management in the making: On ethnography-design relations', in: *Proceedings of the CSCW2013 Conference on Computer Supported Cooperative Work*, ACM, New York, 2013, pp. 1103–1112. https://doi.org/10.1145/2441776.2441901

Cabitza, F., Ellingsen, G., Locoro, A. and Simone, C. (2019): 'Repetita iuvant: Exploring and supporting redundancy in hospital practices', *Computer Supported Cooperative Work*, vol. 28, nos. 1-2 (2019), pp. 61–94. https://doi.org/10.1007/s10606-017-9303-z

Ellingsen, G., Hertzum, M., Christensen, B. and Wynn, R. (2022a): 'National integration components challenge the Epic implementation in Central Norway', in: *MIE2022: Proceedings of the 32nd Medical Informatics Europe Conference*, IOS Press, Amsterdam, 2022, pp. 500–504. https://doi.org/10.3233/SHTI220509

Ellingsen, G., Hertzum, M. and Melby, L. (2022b): 'The tension between national and local concerns in preparing for large-scale generic systems in healthcare', *Computer Supported Cooperative Work*, vol. 31, no. 3 (2022), pp. 411–441. https://doi.org/10.1007/s10606-022-09424-9

Greenhalgh, T., Russell, J., Ashcroft, R.E. and Parsons, W. (2011): 'Why national ehealth programs need dead philosophers: Wittgensteinian reflections on policymakers' reluctance to learn from history', *Milbank Quarterly*, vol. 89, no. 4 (2011), pp. 533–563. https://doi.org/10.1111/j.1468-0009.2011.00642.x

Hertzum, M. (2010): 'Breakdowns in collaborative information seeking: A study of the medication process', *Information Processing & Management*, vol. 46, no. 6 (2010), pp. 646–655. https://doi.org/10.1016/j.ipm.2009.10.005

Hertzum, M., Ellingsen, G. and Cajander, Å. (2022): 'Implementing large-scale electronic health records: Experiences from implementations of Epic in Denmark and Finland', *International Journal of Medical Informatics*, vol. 167 (2022), article 104868. https://doi.org/10.1016/j.ijmedinf.2022.104868

Mackay, W.E. (1999): 'Is paper safer? The role of paper flight strips in air traffic control', *ACM Transactions on Computer-Human Interaction*, vol. 6, no. 4 (1999), pp. 311–340. https://doi.org/10.1145/331490.331491

Makary, M.A. and Daniel, M. (2016): 'Medical error - The third leading cause of death in the US', *BMJ*, vol. 353 (2016), article i2139. https://doi.org/10.1136/bmj.i2139

Monteiro, E., Pollock, N., Hanseth, O. and Williams, R. (2013): 'From artefacts to infrastructures', *Computer Supported Cooperative Work*, vol. 22, nos. 4–6 (2013), pp. 575–607. https://doi.org/10.1007/s10606-012-9167-1

Norwegian Directorate of eHealth (2018): Development trend 2018. Description of drivers and trends relevant for e-health, version 1.0, Norwegian Directorate of eHealth, Oslo, Norway, 2018.

Phillips, D.P. and Bredder, C.C. (2002): 'Morbidity and mortality from medical errors: An increasingly serious public health problem', *Annual Review of Public Health*, vol. 23 (2002), pp. 135–150.

Pipek, V. and Wulf, V. (2009): 'Infrastructuring: Toward an integrated perspective on the design and use of information technology', *Journal of the Association for Information Systems*, vol. 10, no. 5 (2009), pp. 447–473. https://doi.org/10.17705/1jais.00195

Reddy, M.C., Dourish, P. and Pratt, W. (2001): 'Coordinating heterogeneous work: Information and representation in medical care', in: *ECSCW2001: Proceedings of the European Conference on Computer Supported Cooperative Work*, Kluwer, Dordrecht, 2001, pp. 239–258. https://doi.org/10.1007/0-306-48019-0_13

Walsham, G. (2006): ‘Doing interpretive research’, *European Journal of Information Systems*, vol. 15, no. 3 (2006), pp. 320–330. https://doi.org/10.1057/palgrave.ejis.3000589

Zhang, Z., Joy, K., Harris, R. and Park, S.Y. (2022): ‘Characteristics and challenges of clinical documentation in self-organized fast-paced medical work’, *Proceedings of the ACM on Human-Computer Interaction*, vol. 6, no. CSCW2 (2022), paper 386. https://doi.org/10.1145/3555111