

TAKING NOTE: A DESIGN SOLUTION FOR PHYSICIAN DOCUMENTATION TO BALANCE THE BENEFITS OF HANDWRITTEN NOTES AND ELECTRONIC HEALTH RECORDS

By: Kuan-Ting Ho

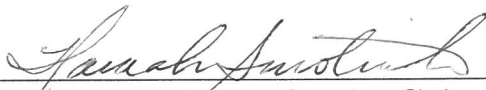
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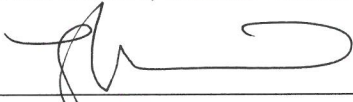
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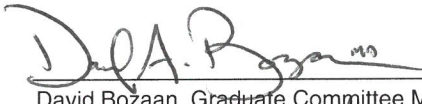
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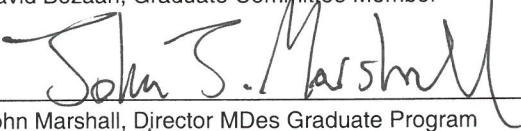
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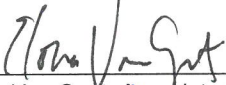
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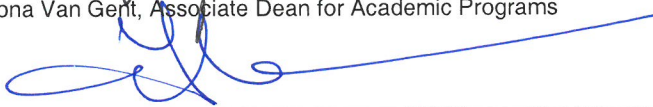
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## 21<sup>ST</sup> CENTURY HEALTHCARE

# Taking Note: A Design Solution for Physician Documentation to Balance the Benefits of Handwritten Notes and Electronic Health Records

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Spring 2017







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# Abstract

## OBJECTIVES:

### Each in Its Place / Electronic Health Records (EHR)<sup>1</sup> and Handwriting

Hospitals across the U.S. have been undergoing a decade-long transition from paper to electronic records, prompted by federal guidelines and in pursuit of a more efficient, more interoperable, and cost-effective prospect. Although electronic notes have many advantages, some challenges threaten the quality of care by taking up physician time for documentation and note sharing due to EHR-induced information redundancy. Typing as a documenting method has a comparatively shorter history of development compared to writing by hand. Studies have shown greater cognitive processing when information is recorded by hand.<sup>2</sup>

After observation of physicians capturing and communicating patient information, this thesis proposes a hybrid design solution that integrates the efficiency and accuracy of electronic health records with the cognitive benefits of handwritten bedside notes.

## DESIGN & METHODS

A design research process model—the Double Diamond—that divides the entire project into four phases, was used. Throughout discover and

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1. The seemingly interchangeable terms of **EMR** and **EHR** defined by as follows, Electronic medical records (EMRs) are a digital version of the paper charts in the clinician's office. An EMR contains the medical and treatment history of the patients in one practice. While EHRs do all EMRs functions, they focus on the total health of the patient—going beyond standard clinical data collected in the provider's office and inclusive of a broader view on a patient's care, and it emphasizes the data-shareable quality.

2. Mueller, Pam A., and Daniel M. Oppenheimer. "The pen is mightier than the keyboard advantages of longhand over laptop note taking." *Psychological science* (2014): 0956797614524581.

define phases, a thorough background and contextual study, a series of constructed observations and interviews were conducted. A total of 110 hours of observations and interviews with physicians, residents, nurses, and several other disciplines were finished; qualitative data from their conversations and daily workflow were captured via notes, and their documentation styles and artifacts were recorded mostly by sketching. The captured data was compared and analyzed, until the scope of the project converged again, which led to a focus on the clinicians that use handwritten notes in distinctive manners, or the ones that depend heavily on handwriting practice.

Entering the third quarter of the process, ideas and prototypes were generated and diverged based on a deeper understanding of the previously identified avid note taker. I then gathered feedback and finalized a design intervention that enables clinicians to utilize the positive qualities of both paper notes and an electronic interface.

## **OUTCOME & DISCUSSION**

The design is made of two parts, a digital app and its printout tools. The digital interface is used alongside existing EHR, which allows physicians to extract data from a patient's digital record and organize them before printing it out as a useful note-taking tool. The tool is designed with open spaces for physicians to address all the highlighted issues and make further plans. The design received positive feedback from most of the participants and stakeholder within a very limited timeframe, while enough feedback was gathered to make further changes. There are also many institutional and technical difficulties that need to be solved if this project were to find a way to be realized.

## **CONCLUSION**

The project sought to draw attention to the less perceived value of handwriting methods used in a clinical setting, and advocate for

integrating traditional and new technologies for a solution that retains benefits from both sides. The project provides a new potential or solution for other disciplines, within or outside of the healthcare field, that faces similar nature of jobs or tasks, which are amid a digital transition. It also provides a new way to look into cross-disciplinary collaboration on solving highly situational and complex problems that dealt with human behavior.

# Keywords

Electronic Health Records (EHR), Electronic Medical Record (EMR), Patient record, Clinical documentation, Handwritten notes, Note taking tool, Note bloat, Clinical workflow, Transitional artifact





# INTRODUCTION

Over the past 100 years, clinical documentation has evolved from plain notes of a doctor's observations to a much more organized, elaborate means of computerized combination of graphs, charts, images, and texts. Healthcare systems throughout the U.S. have been undergoing a decade-long transition from traditional paper documentation to full electronic documentation. 2016 marks the third and final stage<sup>3</sup>

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3. "Stages of Meaningful Use." HealthIT.gov. Accessed April 18, 2017. <https://www.healthit.gov/providers-professionals/meaningful-use-definition-objectives>. Meaningful Use Definition & Objectives listed by U.S.A. government

of Meaningful Use, the federally-mandated set of regulations on implementing Electronic Health Record systems (EHRs), and as of 2015, 96% of hospitals<sup>4</sup> have adopted EHRs. A general assumption<sup>5,6</sup> that associates higher value and quality with computer-based documentation have led the U.S. to set up a series of legislation (e.g., the *Health Information Technology for Economic and Clinical Health (HITECH) Act*)<sup>7</sup> on making EHRs across all health care delivery system as a critical national goal.

From the many criteria listed under the Meaningful Use's set measures,<sup>8</sup> it is noticeable that the majority of the objectives focus solely on structuring the data entry in order to support subsequent machine-readability and the tracking of targeted patient information. Adhering to the regulations generally helps healthcare providers be more accurate, the documentation more thorough,<sup>9</sup> and the generation of categorized data able to be reused for other needs (e.g., data retrieving, billing, research etc.)

For hospitals and EHR companies, their response to the current regulations are still largely targeted towards improving efficiency (e.g., data mining for real time process), quality monitoring, billing

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4. Henry, J., Pylypchuk, Y., Talisha Searcy, M. P. A., & Patel, V. *Adoption of Electronic Health Record Systems among US Non-Federal Acute Care Hospitals: 2008-2015*.

5. Makam, Anil N., et al. "Use and satisfaction with key functions of a common commercial electronic health record: a survey of primary care providers." *BMC medical informatics and decision making* 13.1 (2013): 86.

6. Friedberg, Mark W., et al. "Factors affecting physician professional satisfaction and their implications for patient care, health systems, and health policy." *RAND Health Quarterly* 3.4 (2014).

7. Petersen, Scot. "HITECH Act." *HealthIT.com*. December 2014. <http://searchhealthit.techtarget.com/definition/HITECH-Act>. HITECH Act summary

8. *Medicare and Medicaid Programs; Electronic Health Record Incentive Program- Stage 3 and Modifications to Meaningful Use in 2015 Through 2017*, § I.A.2.B *Meaningful Use Requirements, Objectives, and Measures for 2015 Through 2017* (2015).

9. Trotter, Fred, and David Uhlman. *Hacking healthcare*. Sebastopol, CA: O'Reilly Media, 2013. Chapter 7. Human Error



(justifying the level of reimbursement for given services), and providing computerized decision support algorithms (e.g. alerts or reminders for physicians, or condition-specific order sets)<sup>10</sup> However, a recent (2016) report<sup>11</sup> showed a staggering 60% of doctors say their EHR has either had no effect on the care they provide or detracted from the care they provide to some extent. Also, multiple studies indicate that there are a growing number of physicians who are not satisfied with the current EHR technology. A 2015 survey by the *American Medical Association* showed only 34% of physicians are satisfied with their current EHR, a drop from 61% five years ago.<sup>12</sup> Most complaints point towards a less user-friendly interface, and doctors are frustrated by systems that force them to enter data in unfamiliar and often time-consuming ways.<sup>13</sup> Also, the number of hours spent on using EHR remains high from several findings and surveys<sup>14, 15, 16</sup> which matches with what's being observed at the focused site of this project.

In addition to addressing feedback from providers to achieve higher satisfaction ratings, EHR companies spend most of their efforts

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10. *Medicare and Medicaid Programs; Electronic Health Record Incentive Program- Stage 3 and Modifications to Meaningful Use in 2015 Through 2017 (2015). Stage 2, Eligible Professional, Meaningful Use Core Measures: Measure 6 of 17*

11. "2016 EHR Report." *Medical Economics*. October 25, 2016. Accessed April 18, 2017. <http://medicaleconomics.modernmedicine.com/medical-economics/news/2016-ehr-report>.

12. "Physicians Use of EHR Systems 2014." Report. *AmericanEHR, American Medical Association*. AmericanEHR, 2014. Based on 1,000 responses, 940 completed surveys.

13. Bloom, Michael V., PhD, and Mark K. Huntington, PhD. "Faculty, Resident, and Clinic Staff's Evaluation of the Effects of EHR Implementation." *Family Medicine*, September 2010, 562-66.

14. Bloom "Faculty, Resident, and Clinic Staff's Evaluation"

15. Chiang, Michael F., et al. "Evaluation of electronic health record implementation in ophthalmology at an academic medical center (an American Ophthalmological Society thesis)." *Trans Am Ophthalmol Soc* 111 (2013): 70-92.

16. Poissant, L. "The Impact of Electronic Health Records on Time Efficiency of Physicians and Nurses: A Systematic Review." *Journal of the American Medical Informatics Association* 12, no. 5 (2005): 505-16.

on improving the interface and meeting government incentives requirements, which in most cases, further simplifies physician's tasks.<sup>17</sup> However, relatively little attention has been paid to the potential impact and unintended consequences of adopting this system and physicians' growing dependence of the electronic health record systems.<sup>18</sup> Throughout Stage One and Two of all Meaningful Use objectives, no criteria currently monitor the quality of documented information. (ref. appendices: table a. & b.)

Recent studies have suggested that the standardization of electronic notes and the straightforwardness of EHR functions may alter the fundamental human reasoning and decision processes involved in healthcare practice.<sup>19</sup> Misuse of templates, auto-populated data, copy and pasted information from previous entries are now new problems that may cause concerns over accuracy, data integrity, or authorship accountability.<sup>20,21</sup> Methods that were originally designed to save time are now being overused, thus creating an overflowing of data (aka "Note Bloat") that requires longer time from physicians to read through and process.

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17. Ratwani, R. M., R. J. Fairbanks, A. Z. Hettinger, and N. C. Benda. "Electronic health record usability: analysis of the user-centered design processes of eleven electronic health record vendors." *Journal of the American Medical Informatics Association* 22, no. 6 (2015): 1179-182.

18. Chou, David. "Health IT and Patient Safety: Building Safer Systems for Better Care." *Jama* 308, no. 21 (2012): 2282. doi:10.1001/jama.308.21.2282-a.

19. Saleem, Jason J., et al. "You and me and the computer makes three: variations in exam room use of the electronic health record." *Journal of the American Medical Informatics Association* 21, no.E1 (2014).

20. Weis, Justin M., and Paul C. Levy. "Copy, paste, and cloned notes in electronic health records: prevalence, benefits, risks, and best practice recommendations." *CHEST Journal* 145.3 (2014): 632-638.

21. Thornton, J. Daryl, et al. "The Prevalence of Copied Information by Attendings and Residents in Critical Care Progress Notes." *Critical care medicine* 41.2 (2013): 382.

Handwritten notes, among a spectrum of different documentation methods, were commonly found in clinical settings before the introduction of the electronic records. Despite less appeal, handwritten notes are still used among nurses and physicians alongside EHR. While before EHR, handwritten notes often constituted direct documentation that could be shared with the next provider, today handwritten notes only serve as quick jottings of data or task lists for an individual. However, the cognitive benefits of note taking through handwriting, the arrangement of texts, graphic cues and drawings have been repeatedly proven to be effective in certain learning, information acquiring and memory-recalling situations,<sup>22</sup> losing this quality amid the digitization of documentation is yet another unintended consequences.<sup>23</sup>

Although studies on the effect of physician's note taking in relation to the quality of care are limited, multiple studies done in academic settings,<sup>24, 25</sup> the Mueller and Oppenheimer study have suggested that students who took notes electronically (typing on a laptop) performed worse on conceptual questions than students who took handwritten notes. Another study<sup>26</sup> also done by Mueller et al. that looked at note taking in different settings specifically mentioned the ones done in hospital rooms. It points out that doctors and students essentially face similar competing considerations in terms of the goals of their note taking. Physicians' goals are to help understand a patient's issues and make clinical decisions – similar to students' goals to understand

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22. Kiewra, Kenneth A. "A review of note-taking: The encoding-storage paradigm and beyond." *Educational Psychology Review* 1.2 (1989): 147-172.

23. Mueller, Pam A., and Daniel M. Oppenheimer. "Technology and note-taking in the classroom, boardroom, hospital room, and courtroom." *Trends in Neuroscience and Education* 5.3 (2016): 139-145.

24. Mueller, Pam A., and Daniel M. Oppenheimer. "The pen is mightier than the keyboard advantages of longhand over laptop note taking."

25. Makany, Tamas, Jonathan Kemp, and Itiel E. Dror. "Optimising the use of note taking as an external cognitive aid for increasing learning." *British Journal of Educational Technology* 40.4 (2009): 619-635.

26. Mueller & Oppenheimer. "Technology and note-taking"

and make decisions about the lecture content. Above all, Mueller also stated that, making note taking easier actually encourages people to take more notes, and consequently impair “patient rapport.”

This project will approach the challenges of ‘Note Bloat’ caused by the implementation, misuse and the growing reliance on EHR with the belief that integrating a handwritten documentation tool into the existing EHR system would benefit physicians’ workflow and provide better information clarity.

**Major goals are:**

- Highlighting the less-perceptible value of handwritten notes, in which nuances and higher resolution of patient needs are captured.
- Look at how a design intervention could potentially be beneficial to current clinical work and how it might affect existing clinical handovers and information handovers between physicians.
- Propose a design solution that reintegrates the benefits of capturing patient information by hand in a way that supports and complements the EHR system, and could be integrated into future EHR development.

...her friends say she  
...the most emaciated.  
...Cork, Antrim.

Tumors.  
Dr. Griscom  
...Ireland admitted  
...with dislocation of the  
...delirious on the 10<sup>th</sup>  
...on the 11<sup>th</sup>.

delirium last night,  
no viscous; and is  
...this morning  
...long brandy 400 cer  
...2 or 3 times a day  
...is white; pulse 66;  
...has tremor.

...Lupulus  
...C.

Paralysis:

Dr. Griscom.  
...act 53. Madonia admitted.  
...cold if is  
...rheumatism  
...bowels regular; pulse 76.

...Tuberculosis  
...182  
...Dr. Smith  
...admitted. From Bergen, sick 3 weeks; taken  
...with cold. Had 2 chills since none other  
...taken. Tongue coated white; pulse 100.  
...Has had a cough since he was first  
...taken sick; bowels irregular. On aus-  
...cultation there was detected pectoral  
...Carcinoma nodes, at the apex of the right  
...lung, with dullness on percussion. W.  
...is emaciated considerably. Hereditary ten-  
...cy to tubercles, a first cousin died  
...of consumption.  
...Dr. Mearns  
...Ood. Ferri grs viii. Glycerine ʒ  
...O. Marshmall ʒss. f. ʒ ter in die.  
...He seems to have more cough since  
...the glycerine ʒss. Discontinued.  
...Took syr. Ferri Super Phosphas ʒi ter  
...die.  
...Mar 15. Has had diarrhoea for a week or so.  
...Has used opium & is now taking  
...Ferri nit ʒttr ter in die, without  
...as yet  
...17. Diarrhoea checked.  
...Dr. Mearns  
...Vermuth. Insult ʒss  
...die

# BACKGROUND

## Contextual/Literature Review

### i. EHR DEVELOPMENT: Beginning

Record keeping in the hospital has always had a very direct connection with the quality of patient care; it has evolved rapidly alongside clinical practice, organizational development, and technology. Narratives of cures — what we might think of as case histories — were recorded in ancient Greek medical works and the practice was revived in the

fourteenth and fifteenth centuries. Early modern medical records took a variety of forms. In the 1600s in England, practices ranged from multiple cases on a few scraps of paper to vast indexed collections. More comprehensive records could include a name, date, and complaints along with a history, diagnosis, remedy/therapy and payment.<sup>27</sup> Some seem to have been written at the time of the consultation, others retrospectively. The 17<sup>th</sup> century English court physician, Theodore de Mayerne<sup>28</sup> included elaborate narratives on symptoms and conversations with patients, beautifully written with sketches and drawings<sup>29</sup> of each highly individualized and characterized patient. In format, they range from small pocketbooks to folio books; this documentation later became an integral part of modern medicine and shaped the way medical records evolved. As medicine progressed to become a more scientific-based and rigorous discipline, more tools were available for measuring objective results. Thus patient records could incorporate information beyond simple descriptions of how a patient felt.<sup>30</sup>

Similar to business settings, with the introduction of typewriters and management accounting... etc.,<sup>31</sup> the uses of tools and methods of managing and cataloging information also started to take place in hospital settings in the late 19<sup>th</sup> and early 20<sup>th</sup> century, when more

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27. Kassell, Lauren. "Casebooks in Early Modern England:: Medicine, Astrology, and Written Records." *Bulletin of the History of Medicine* 88.4 (2014): 595.

28. Casebooks Project (History of medical record-keeping), <http://www.magicandmedicine.hps.cam.ac.uk/on-astrological-medicine/further-reading/history-of-medical-record-keeping>, accessed 2017-04-19.

29. Nance, Brian. *Turquet de Mayerne as baroque physician: the art of medical portraiture*. Amsterdam: Rodopi, 2001.

30. Tripathi, Micky. "EHR Evolution: Policy and Legislation Forces Changing the EHR." *Journal of AHIMA*. Accessed April 19, 2017. <http://bok.ahima.org/doc?oid=105689#.WPbv5IPyscg>.

31. Howell, Joel D. "Chapter 2: Science, Scientific Systems, and Surgery" in *Technology in the hospital: transforming patient care in the early twentieth century*. Baltimore: The Johns Hopkins University press, 1996. 43-56

data was generated. From 1900 to 1920 at the New York Hospital, the median length of a patient record rose from five pages to eleven pages.<sup>32</sup> Within a hundred years, documentation in general gradually moved away from free narrative writing or drawing by hand and pen to typing and filling out pre-printed forms or charts. Many charts, forms, and graphs in traditional paper record files, which we now see as outdated, were once revolutionary inventions in the early years of the last century, and the development of uniform charts marks an inevitable pursuit for a more standardized, systematic, and efficient way to deal with information.

In the 1960s, the first electronic record appeared.<sup>33</sup> By 1965, approximately 73 hospitals and clinical information projects and 28 projects for the storage and retrieval of medical documents and other clinical information were underway, according to HIMSS.<sup>34</sup> The earliest model of EHR, then still called EMR2, appeared in 1972 but was too expensive for widespread use and wasn't popular among physicians. Instead the government started to implement the system in government-run hospitals, such as the VA.<sup>35</sup>

Similar to computer-based software used in many other industries, the early model of EHR solved the problems of legibility, data storing, and managing. We see steady growth and increasing adoption rate in the 90s and early 2000s.<sup>36</sup> However, the EHR had more potential.

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32. Howell, Joel D. "Chapter 2"

33. Wachter, Robert M. *The digital doctor: hope, hype, and harm at the dawn of medicine's computer age*. New York: McGraw-Hill Education, 2017.

34. Earl, Elizabeth. "A history of EHRs: 10 things to know." *Becker's Hospital Review*. Accessed April 19, 2017. <http://www.beckershospitalreview.com/healthcare-information-technology/a-history-of-ehrs-10-things-to-know.html>.

35. Earl, Elizabeth. "A history of EHRs: 10 things to know."

36. Hsiao, Chun-Ju, et al. "Electronic medical record/electronic health record systems of office-based physicians: U.S., 2009 and preliminary 2010 state estimates." *National Center for Health Statistics* (2010).

Richard Martin, MD, a family physician for three decades who has used the EHR system for nearly two decades said “When we first implemented EHR in 1999, for the first several years we basically used it as a typewriter.”<sup>37</sup>

## **Benefits of EHR**

With the legibility improvements offered by the EHR, data could become more accurate and retrieval time was reduced. Also less storage space was needed and billing procedures became easier, and all parties involved with the patient’s care could access data remotely and instantly.

As computers became more powerful and had more functionality, EHR continued to evolve. Standard modules required by EHRs now include basics such as scheduling, patient registration, documenting patient encounters, managing note entries and documents, writing prescriptions, and billing. EHR also extends its functions to now be able to monitor lab results and diagnostic imaging sharing, drug claims adjudication, CPOE (computerized physician order entry) systems, secure messaging and clinical decision support, etc. In recent years, computer ordering and messaging modules not only allow communication within a system as it becomes more synchronized, but also reduce errors by providing checks on the compatibility of specific drugs, signal alerts on critical numbers and giving clinical decision support.

The major attraction of the EHR systems is that information can now be accessed and shared from multiple places.

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37. Packer-Tursman, Judy. “EHRs through time: The early adopter story.” *Healthcare Dive*. November 17, 2014. Accessed April 19, 2017.<http://www.healthcaredive.com/news/ehrs-through-time-the-early-adopter-story/333219/>.



## Embracing ‘the Future’: Nationwide Adoption

The economics of healthcare in the past few decades, namely billing and the cost and incentives for implementation etc., has driven the transition of EHR.<sup>38</sup> If we look back, lack of available funding and incentives were one of the most prominent barriers among healthcare providers. Studies done in the early 2000s,<sup>39,40</sup> when hospital EHR adoption rate was still around 10%, all show that cost of the infrastructure, personnel, training and IT support required to install and maintain an EHR system were a barrier to implementation, especially for small to mid-sized facilities.

Progress accelerated once *The American Recovery and Reinvestment Act* was signed into law in 2009. A portion of the bill, the *Health Information Technology for Economic and Clinical Health Act*, authorized incentive payments through Medicare and Medicaid to providers that use certified electronic health records to achieve specified improvements in care delivery. To receive these incentives, providers had to meet a set of standards and objectives that were created under the name of “Meaningful Use.” An example of a “Meaningful Use” requirement would be physicians having complete documentation of each clinical encounter with patient.<sup>41</sup> Meaningful Use started in 2011, and spanned the next decade in three stages, with gradually more defined criteria and enforcement. Hospitals are

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38. Hillestad, Richard, et al. “Can Electronic Medical Record Systems Transform Health Care? Potential Health Benefits, Savings, And Costs.” *Health Affairs* 24, no. 5 (2005): 1103-117.

39. Healthcare Financial Management Association. “Overcoming Barriers to Electronic Health Record Adoption.” *Results of survey and roundtable discussions conducted by the Healthcare Financial Management Association, February 2006.* <http://www.hfma.org/NR/rdonlyres/4FE68E23-OA47-4674-ABBA-F1A4AA1E73A9/O/ehr.pdf>

40. Medical Records Institute. *Medical Records Institute’s Seventh Annual Survey of Electronic Health Record Trends and Usage for 2005.*

41. “Stages of Meaningful Use.” [HealthIT.gov](http://HealthIT.gov).

entering the last and final stage, and many now need to meet the requirements to avoid penalties.<sup>42</sup> Despite implementation difficulties and subsequent challenges, nearly all reported hospitals (96%) possessed a certified EHR technology in 2015, and 84% of hospitals adopted at least a Basic EHR system; this represents a 9-fold increase since 2008.<sup>43</sup> U.S. healthcare as a whole is undergoing a rapid system wide technological change. By 2019, an estimated 80% of physicians in large group practices, 65% in small group practices, and 66% of all other specialists are expected to have achieved meaningful use.<sup>44</sup>

## ii. CHALLENGES OF EHR

EHR adoption is widespread across most hospitals nationally, with 96% of hospitals now equipped with certified EHR systems.<sup>45</sup> Government and health IT officials' efforts that have focused on EHR adoption now are shifting to interoperability of health information, and the use of health information technology to support care delivery system reform. However out of all the criteria and objectives listed in the stage 1 and 2 of the Meaningful Use, none addresses the quality of the documented data directly, or focuses on how EHRs integrate with existing clinical workflows.<sup>46</sup> Both issues remain commonly identified

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42. "Electronic Health Record Programs: Participation Has Increased, but Action Needed to Achieve Goals, Including Improved Quality of Care." U.S. Government Accountability Office (GAO). Accessed March 4, 2014. <http://www.gao.gov/products/GAO-14-207>.

43. JaWanna, Henry, et al. "Adoption of Electronic Health Record Systems among U.S. Non-Federal Acute Care Hospitals: 2008-2015." [Dashboard.healthit.gov](https://dashboard.healthit.gov). May 2016. Accessed April 19, 2017. <https://dashboard.healthit.gov/evaluations/data-briefs/non-federal-acute-care-hospital-ehr-adoption-2008-2015.php>., Office of the National Coordinator for Health Information Technology Data Brief 35

44. Blavin, Fredric E., and Melinda B. Buntin. *Forecasting the use of electronic health records: an expert opinion approach*. Medicare Medicaid Res Rev 2013;3:E1-16.

45. JaWanna, "Adoption of Electronic Health Record"

46. Heisey-Grove, Dawn, et al. "A National Study of Challenges to Electronic Health Record Adoption and Meaningful Use." *Medical Care* 52, no. 2 (2014): 144-48.

problems. It is understandable that these components were not listed because they are not “outcome-oriented” or “quantifiable”, but if we look at clinicians’ frustrations with EHRs, many are the direct result of compulsory MU requirements that don’t necessarily lead to lighter workloads or better care for patients.<sup>47</sup>

A survey from the *American Medical Association (AMA)* and *AmericanEHR Partners* in 2014 show that about half of all respondents reported a negative impact in response to questions about how their EHR systems improved costs, efficiency or productivity, with 42% finding their EHR system difficult or very difficult in improving their efficiency and 72% difficult or very difficult in decreasing workload.<sup>48</sup> A 2013 survey by *Physicians Practice* of 1,291 physicians points out that fewer physicians (54%) reported that they are satisfied with their EHRs, down from 63% two years ago.<sup>49</sup> Another recent study done by the Mayo Clinic showed that 43.7% were dissatisfied or very dissatisfied. Of the physicians who used EHRs, only 36.3% agreed or strongly agreed that the systems improved patient care, and only 23% believed that they improved efficiency.<sup>50</sup> In addition to that, most reports also point out that the lower satisfaction rate comes from challenges that directly or indirectly lead to additional time spent on clerical tasks, and how this poses higher risks for professional burnout and clinical errors.<sup>51, 52, 53 (P.24)</sup>

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47. Zulman, Donna M., et al. “Evolutionary Pressures on the Electronic Health Record.” *JAMA* 316, no. 9 (2016): 923.

48. “Physicians Use of EHR Systems 2014.” Report. *AmericanEHR, American Medical Association*.

49. “2013 Technology Survey Results.” *Physicians Practice*. May 28, 2013. Accessed April 19, 2017. <http://www.physicianspractice.com/2013-technology-survey-results>.

50. Shanafelt, Tait D., et al. “Relationship Between Clerical Burden and Characteristics of the Electronic Environment With Physician Burnout and Professional Satisfaction.” *Mayo Clinic Proceedings* 91, no. 7 (2016): 836-48.

The challenges of the existing EHR systems can be categorized into these three main areas:

- **Efficiency:** Longer documentation time, longer reviewing and preparation time for physicians was not only caused by more standardized reporting routine and style requirements, but a great deal of clerical work consists of documentation sometimes for the sake of billing, with all this work needed to be done under a poor user-friendly system.
- **Usability:** The complexity of the information display, poor user interface, and wireframe design leads to the need for more clicks to get to the useful information and more time navigating the system to find the right functions.
- **Interoperability problems:** Information across different hospitals and between disparate workgroups within the same hospital, such as doctors and nurses, or different departments, including emergency rooms and cardiology, is still not fully and concisely shared. Having to wait for the transfer of medical records creates delays in medical decision-making.

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51. Studer, Quint, and George Ford. *Healing physician burnout: diagnosing, preventing, and treating*. Pensacola, FL: FireStarter Publishing, 2015.

52. Wike, Katie. "EHRs Stress Physicians." *Health IT Outcomes*. Accessed April 19, 2017. <https://www.healthitoutcomes.com/doc/ehrs-stress-physician-0001>.

53. Silberman, Eve. "The Trouble with EHR." *Ann Arbor Observer*, March 2017.

### iii. TIME-CONSUMING NATURE OF EXISTING SOLUTION TO EHR

Apart from the government incentives to aid implementation, hospitals and EHR vendors have also been trying to improve the transition from paper to computer and overall EHR experience.

The main focus of EHR vendors has been to optimize the interface and functionality to improve usability and physicians' efficiency. Similar to many electronic-based systems, EHRs have long developed and utilized various methods and automatic functions that support documentation, including 'copy and paste,' 'key commands,' 'templates,' (e.g. 'smart phrase' in the Epic system) 'auto-population,' etc.

For hospitals and clinicians, EHRs' capacity to adapt to an existing workflow is determined by the amount of investment and internal IT supports, at most times they come as a fully-packaged system with very few changes made by the vendor to adapt to the existing clinical workflow.<sup>54</sup> Hospitals took action by providing more training and internal coordination.<sup>55</sup> For physicians, alternative solutions to reduce the documenting workload included dictating, hiring medical scribes, or in most cases, gaining greater proficiency with the system and making full use of the automatic functions in the EHRs. However, these solutions have led to unintended consequences that still cause problems for clinicians and poses threats to patient care.

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54. Burns, Ed. "System-wide EHR integration limits flexibility in care." *SearchHealthIT*. September 2012. Accessed April 29, 2017. <http://searchhealthit.techtarget.com/feature/System-wide-EHR-integration-limits-flexibility-in-care>.

55. Bass, Robert L., FAAO. "Ease Your Transition to EHR with Comprehensive Training." *Review of Optometric Business*. July 23, 2013. Accessed April 19, 2017. <http://reviewob.com/ease-your-transition-to-ehr-with-comprehensive-training/>.

#### iv. KEY CHALLENGES: The Unintended Consequences of Time-Saving Measures in EHR Documentation

##### Note Bloat and Data Integrity

Poor design and improper use of EHR are now causing Note Bloat—when overflowing information threatens the quality of the information (or data integrity). In one 2013 interview, Jody Cervenak, principle of a health-IT consulting firm—*Aspen Advisor*, said “It’s been challenging for docs and healthcare systems in general... to produce a document that reflects the patient story in the most concise, complete and informational way.” She goes on and quote from a 17<sup>th</sup> Century French mathematician and philosopher Blaise Pascal, who wrote, “I have made this letter longer than usual, only because I have not had the time to make it shorter,” which pointed out the major problem behind this challenge.<sup>56</sup> Often time, copy and paste, or what many physicians now also call ‘sloppy and paste’, can lead to other members of the care team spending more time on a record, and it also raises the question of whether a physician is thoughtfully analyzing the plan for the patient. At the 2016 *Society of Hospital Medicine Annual Meeting*, experts pointed out that this phenomenon has surfaced from all the conveniences the EHR systems now provide, along with related issues such as the ‘Alert Fatigue’, and disagreements about what to include in the patient portal.<sup>57</sup>

One research study<sup>58</sup> that attempts to quantify the narrative

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56. Versel, Neil. “‘Note bloat’ putting patients at risk.” *Healthcare IT News*. October 11, 2013. Accessed April 19, 2017. <http://www.healthcareitnews.com/news/note-bloat-putting-patients-risk>.

57. Cole, Chris. “Conference Highlights: Hospital Medicine 2016.” *Physician’s Weekly*. March 15, 2016. Accessed April 19, 2017. <http://www.physiciansweekly.com/conference-highlights-hospital-medicine-2016/>.

58. Wrenn, Jesse O., et al. “Quantifying clinical narrative redundancy in an electronic health record.” *Journal of the American Medical Informatics Association* 17.1 (2010): 49-53.

redundancy in EHRs was conducted in 2010 at New York-Presbyterian Hospital. During a six months period, the researchers randomly selected 100 admitted patients and their electronic note entries and measured the amount of duplicated text from previous notes. The results showed an average 78% duplicated content in handover and 54% in progress notes. Duplicating information also appears to be more prominent from an admission note to a progress note, suggesting that information were not constantly updated from as early as patients' admission.

In a 2016 survey, 31% of physicians say they use their EHR's copy and paste functions "often," while 24% do so "occasionally" and 11% use it "always."<sup>59</sup> In another study,<sup>60</sup> published in the *Journal of General Internal Medicine* of surveyed physicians that use EHRs, 90% utilized copy and paste functions, and 70% used it almost always or most of the time while writing their daily progress notes. While 71% of the respondents notice that inconsistencies and outdated information were more common in notes containing copy and pasted data, only a small number (19%) felt that copy and paste functions had a negative impact on patient documentation or might led to mistakes in patient care (24%).

One 2009 article,<sup>61</sup> published in *The American Journal of Medicine*, identifies the hazards in electronic documentation as reduced credibility of recorded findings, clouded clinical thinking, and limited proper coding. One of the major problems it pointed out is the never

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59. Peckham, Carol. "Medscape EHR Report 2016: Physicians Rate Top EHRs." *Medscape EHR Report 2016: Physicians Rate Top EHRs*. August 25, 2016. Accessed April 19, 2017. <http://www.medscape.com/features/slideshow/public/ehr2016>.

60. O'Donnell, Heather C., et al. "Physicians' Attitudes Towards Copy and Pasting in Electronic Note Writing." *Journal of General Internal Medicine* 24, no. 1 (2008): 63-68.

61. Siegler, Eugenia L., and Ronald Adelman. "Copy and Paste: A Remediable Hazard of Electronic Health Records." *The American Journal of Medicine* 122, no. 6 (2009): 495-96. doi:10.1016/j.amjmed.2009.02.010.

changing ‘problem lists.’ Many times, physicians can copy and paste the same problem list day after day even if new diagnoses appear or priorities change. When updated information is added, it is difficult to view, and notes lengthen and errors accumulate. Dr. Drew K. Siegel, a clinical documentation improvement specialist, mentioned this problem in a 2016 interview,<sup>62</sup> saying most doctors will copy case notes from previous days into the daily note. “You’ll see four or five days where the same note is being copied and pasted,” he said, and when it’s time to read back through the chart, the information is unwieldy and the chronological history of the patient is lost.

In one review on *KevinMD.com*,<sup>63</sup> an insight sharing site for medical professionals, an anonymous medical scribe recently shared his experience on how physicians can make “macros” which auto-populate certain parts of the chart, such as the physical exam. Doing so ensures that there are enough areas input to the physical exam for the chart to be ‘level 5’, meaning that the provider offers a higher level of care that can be billed at the top price. While the chart can be usually accurate, the problem is that the physicians do not always do everything their macro says they have done. In those cases, the scribe would go in and spend additional time taking out the inaccurate information, or at times, would be told to just leave it.

### **More Time, More Stress**

Poor information quality and Note Bloat can lead to longer documentation time, and cause physicians’ distress. The short-term benefit of certain automated and shortcut features is eventually outweighed by more time on reviewing, retrieving and making sense

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62. Knudson, Julie. “The Long and Short of EHR Documentation.” *For the Record*, January 2016, 18.

63. “The Disturbing Confessions of A Medical Scribe.” *KevinMD.com*. July 31, 2014. Accessed April 19, 2017. <http://www.kevinmd.com/blog/2014/03/confessions-medical-scribe.html>.



of the existing data due to the overflowing of information and poorly-designed interface (e.g. continuous stream of text). The information is often times repetitious, less clear, and contains error or outdated data. Later when care-transition and handovers occur, overwhelming data could lead to the incoming physicians spending more time reviewing, maintaining, and updating patient data, and could lead to higher risk.<sup>64</sup> A 2014 survey<sup>65</sup> published in *Journal of the American Medical Association* showed that of the physicians that had EHRs in their practice for more than a year, 59.4% of them lost time after moving to an EHR from paper. 63.9% of physicians said note writing took longer with EHR, while a third said it took longer to review EHR charts than paper (33.9%) and to read other clinicians' notes (32.9%).

According to a 2016 study<sup>66</sup> conducted by the *American Medical Association and Dartmouth-Hitchcock Health Care*, physicians spend approximately half of their time inputting EHR data. More specifically, physicians spend 27% of their time on direct clinical face time with patients and 49.2% of their time on EHR and deskwork activities. In other words, for every hour of direct clinical face time with patients, physicians spend nearly two hours on EHR and administrative tasks. In addition to that, physicians spend another one to two hours each night on data-entry demands outside of office hours. A 2015 study<sup>67</sup> done by *Medscape Physician Lifestyle Report* suggests that 46% of all surveyed physicians say they are burned out, a seven percent increase

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64. Wachter, Robert M. *The digital doctor: hope, hype, and harm at the dawn of medicine's computer age*. New York: McGraw-Hill Education, 2017. Chapter 9, 115-123

65. McDonald, Clement J., et al. "Use of Internist's Free Time by Ambulatory Care Electronic Medical Record Systems." *JAMA Internal Medicine* 174, no. 11 (2014): 1860. doi:10.1001/jamainternmed.2014.4506.

66. Sinsky, Christine, et al. "Allocation of Physician Time in Ambulatory Practice: A Time and Motion Study in 4 Specialties." *Annals of Internal Medicine* 165, no. 11 (2016): 753.

67. Peckham, Carol. "Medscape Physician Lifestyle Report 2015." *Medscape*. January 26, 2015. Accessed April 19, 2017. <http://www.medscape.com/features/slideshow/lifestyle/2015/public/overview>.

in two years, while ‘increased use of EHRs and computers’ are among the top factors.<sup>68</sup>

### **Ineffective Handover**

“Hospital handover” (also called handoff) is the responsibility transfer between members of medical teams, with the term “signout” used to refer to the act of transmitting information about the patient. It is known that effective communication among health professionals is key to ensuring the quality of care in these transitions. So when documentation is not done in a concise and timely manner, the accumulated data only create more burdens for the next provider. A study<sup>69</sup> done at Ohio State University shows that although physicians were satisfied with the readability and accuracy of their own documentation, only 33% of respondents were satisfied with the accuracy of their peers’ note on EHR.

It is common for hospitals and clinicians within a department to have standardized handover tools and procedures. Many now use EHRs and its extensional functions during handovers, most commonly system-generated printouts of patient information that can be physically passed between physicians.<sup>70</sup> One of the most extensive studies on handover tools was published in 2012,<sup>71</sup> in which the researchers analyzed 22 nurses’ and physicians’ handover artifacts at a large

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68. Peckham, Carol. “Physician Burnout: It Just Keeps Getting Worse.” *Medscape*. January 26, 2015. Accessed April 19, 2017. <http://www.medscape.com/viewarticle/838437>.

69. Allen J, Knight et al. “Battling ‘Note Bloat’: An Intervention to Improve Electronic Documentation Accuracy, Readability, and Compliance, While Preserving Provider Efficiency” [abstract]. *Journal of Hospital Medicine*. 2014; 9 (suppl 2).

70. HealthLeaders Media Staff. “Hospital Uses EMR to Improve Handoff Process and Create Electronic ‘Hall Pass’” *Health Leader Media*. May 29, 2009. Accessed April 19, 2017. <http://www.healthleadersmedia.com/quality/hospital-uses-emr-improve-handoff-process-and-create-electronic-hall-pass>.

71. Collins, Sarah A., et al. “In search of common ground in handoff documentation in an Intensive Care Unit.” *Journal of biomedical informatics* 45.2 (2012): 307-315.

urban medical center (unstated). The researcher points out that many tools are still paper-based. In fact all three artifacts discussed (nurse standard admission sheet, nurse personal handoff sheet, and PA/resident handoff sheet) are primarily printout sheets that are used during the transition and to facilitate conversation. For physicians, these sheets become the main tool they use and carry around for recording and referencing.

While many hospitals are currently working on different models of the handover process, many face the same problems. Since practices<sup>72</sup> vary dramatically from location to location, the system limits, and individual preferences strongly affect the outcome of successful continuity of care. Moreover, outcomes are often hard to measure. Studies and analysis on physicians' handover tools are still limited.

### **Effects on Physicians' Practice and Patient-Engaging Care**

Efficiency, growing reliance on and misuse of the automatic functions, along with the growing belief in the accuracy of a digital database could potentially lead to less patient-physician interaction time. It also places less focus on patient-advocacy and patient representation during the treatment, and thus may result in higher risk for clinical error. In the 2016 Medscape's report,<sup>73</sup> 57% of respondents said that EHRs reduce face-to-face time with patients, and 50% noted a reduction in the number of patients they can see. The report, along with another study<sup>74</sup> addressing the clinician's perspective on EHR and how they can affect patient care, both mentioned how most

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72. Collins, Sarah A., et al. "Content overlap in nurse and physician handoff artifacts and the potential role of electronic health records: a systematic review." *Journal of biomedical informatics* 44.4 (2011): 704-712.

73. Peckham "Medscape EHR Report 2016"

74. Walsh, Stephen H. "The clinician's perspective on electronic health records and how they can affect patient care." *Bmj* 328.7449 (2004): 1184-1187.

patients passively accept the use of computers in clinical settings, while Medscape's survey showed almost half (45%) of the physicians said that patient never made comments about their use of EHR (e.g. complaining about lack of eye contact, or focuses more on the equipment...etc.)

As for the computer-familiar generation of clinicians that enters the healthcare systems, challenges also remain.<sup>75</sup> In one study,<sup>76</sup> researchers found that current interns spend the majority of their time in activities only indirectly related to patient care, like reading patient charts, writing notes, entering orders, speaking with other team members and transporting patients. When calculating the time they spent with each patient, the researchers found that interns were devoting about eight minutes each day to each patient, only about 12% of their time.

### Summary Points

- Improper use of EHRs' automation functions could lead to data overflowing (Note Bloat) and threaten patient data quality; it not only requires longer time for physicians to process and manage data, but creates more burdens for the next physician, and thus overall distress with the EHRs.
- The design and success of handover procedures is largely determined by the quality and clarity of information and usage of the artifacts.
- Longer documentation and review time means less patient interaction time and could lead to fewer patient narratives being captured and greater risk for clinical error.

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75. Dugdale, David C., Ronald Epstein, and Steven Z. Pantilat. "Time and the patient-physician relationship." *Journal of General Internal Medicine* 14.S1 (1999): 34-40.

76. Chen, M.D. Pauline W. "For New Doctors, 8 Minutes Per Patient." *The New York Times*, May 30, 2013. Accessed April 19, 2017. <https://well.blogs.nytimes.com/2013/05/30/for-new-doctors-8-minutes-per-patient/>.

## **v. INITIAL OBSERVATION:**

Two initial observations were made in the early 2016. The main purpose of the observation was to get a firsthand look at how clinicians operate in a real hospital setting, as this will be a project done using design approaches by a non medically-trained or affiliated designers, using a mash-up of design thinking and system thinking to analyze and synthesize the problems and refine design solutions. The observations identified the existing gap in current EHR development and eventually led to this project focus.

### **Site**

The initial observations were conducted at the University of Michigan Hospital (UMHS/Michigan Medicine) Medical Short-Stay Unit (MSSU), which consists 2 separate units with a total of 40 beds.

### **Methods**

Observation is holistic, unstructured, and with minimal focus on what determined the whole picture of clinicians' work, in an attempt to document as much as possible about the setting and its participants in order to discover a more focused theme.

The observer was assigned to follow clinicians (nurses, physicians) around and observe their workflows. General ideas of what might be salient in the environment were acquired through small briefings by different physicians, one of whom later became this project's primary stakeholder. Each of the two observations lasted around seven hours, from 7:00 am when a new shift started till around 3:00 pm.

### **Observation Findings**

In addition to clinical and operational workflows related to

documentation and handovers, both units have well-structured rounding and handover routines, with the time, roles involved, and conversations subjects (addressing problems, care plan etc.), although both units' have noticeable differences in human interaction details due to the differences in their physical settings and established workflows.

Both units' clinicians spend an extensive amount of time on record keeping. A full understanding of their record keeping process (EHR interface and functions, operation procedures, etc.) would require further observation. The majority of clinicians, nurses especially, carry either the standard printout patient form (used specifically in the MSSU) or self-made paper charts for note taking during patient rounding and throughout the day.

### **Point of Entry**

The observations spark questions and discussions on how the information in a clinical setting is being captured and shared. Even in a setting where most data is considerably digitized, the most approachable and available methods —handwritten notes— are still widely practiced alongside a system that promises to rid all clinicians of paper-based documentation to make things easier.

These observations led to an exploration of the potential of handwritten notes and their relationship to the human cognitive process.

## vi. BENEFITS OF HANDWRITTEN NOTES

Increasingly researchers accept that a complex cognitive process involving neuro-sensory experiences and motor action take place in our brains when we write down information by hand, which is commonly referred to as “embodied cognition.”<sup>77</sup> The feeling of the writing surface, holding the writing instrument, and directing the movement all take place at the same time that we decide what to write down. Typing on a keyboard is a much simpler memory-based movement in which executing key strokes are repetitive motions based on letter placement.<sup>78</sup> Studies have also shown that human brains process information differently and more thoroughly when writing down notes compared to typing; handwriting activates a unique neural circuit, which makes learning easier.<sup>79, 80</sup>

Strong writers and avid readers have been proven to be non-linear thinkers,<sup>81</sup> and drawings and sketches help them draw connections and develop solutions to complex problems.<sup>82, 83</sup> Researchers have pointed out how humans are more able to distinguish information hierarchically from a sorted, flexible format when compared to a continuum of typed text. Especially, it is proven that the visual attention of the writer

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77. Mangen, Anne, and Jean-Luc Velay. *Digitizing literacy: reflections on the haptics of writing*. INTECH Open Access Publisher, 2010. Chapter 20.

78. Mangen, “Digitizing literacy”

79. Dehaene, Stanislas. “Reading in the brain revised and extended: response to comments.” *Mind & Language* 29.3 (2014): 320-335.

80. Dehaene, Stanislas. *Reading in the brain: The new science of how we read*. Penguin, 2009. Chapter 4 “Inventing Reading” 171-194

81. Makany, Tamas, Jonathan Kemp, and Itiel E. Dror. “Optimising the use of note-taking as an external cognitive aid for increasing learning.” *British Journal of Educational Technology* 40.4 (2009): 619-635.

82. Friedman, Michael C. “Notes on note-taking: Review of research and insights for students and instructors.” *Harvard Initiative for Learning and Teaching*, 2014.

83. Makany, Tamas. “Optimising the use of notetaking”

is strongly concentrated during handwriting.<sup>84</sup> When writing, the intentional focus of the writer is dedicated to the tip of the pen, while during typewriting visual attention is detached from the haptic input when just hitting the keys.

Through scientific experiments, it is now commonly believed that the brain better summarizes and comprehends information when committing notes to paper by hand. When writers know how to translate and organize complex ideas in writing, it increases their ability to read and understand them. One of the most popular findings<sup>85</sup> in recent years, published in 2014 *Psychological Science* by Mueller and Oppenheimer from UCLA, was surprising. In the study, done in a series of some structured experiments, two sets of students—one group using laptops, the other using traditional paper and pen—listened to lectures and then were given tests on factual and conceptual ideas. The study found that those who took note by hand and were able to study, did significantly better on the test than the others, even those who transcribed the whole lectures. Compared to the students who typed their notes, the ones using pen and paper recorded less information, but learned both factual and conceptual knowledge better in general. These results suggest that handwritten notes not only lead to higher quality learning in the first place; they are also a better approach for storing new learning for later memory recall. In fact, one of the most popular and widely adopted note-taking methods, the Cornell Note,<sup>86</sup> uses a simple organizational layout to help note takers be systematically processing the information all the while of writing down notes.

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84. Mangen, "Digitizing literacy"

85. Mueller & Oppenheimer. "The pen is mightier than the keyboard"

86. "The Cornell Note-taking System." Cornell University Learning Strategies Center. Accessed April 19, 2017. <http://lsc.cornell.edu/study-skills/cornell-note-taking-system/>.



## Handwritten Notes in Clinical Settings

While most of this research has been done in academic settings, only few studies have looked at the effect and value of handwritten documentation to physicians in clinical settings. Among the studies that evaluate EHR efficacy on clinical workflow, several<sup>87,88</sup> pointed out that clinicians are still using paper-based documenting tools. Park et al. especially called out this post-EHR phenomenon as the “paper persistence,” caused by the incomplete integration of health information technologies with existing workflow. Park et al. continued to observe and analyze the informal documentation used by ED physicians, e.g. patient worksheets, rounding sheets, notes jotted on scraps of paper etc., and point out these notes are the direct results of delayed documentation occurrence, more detailed standards required by EHR, and physicians’ dislike of using computers amid patient encounters. Thus, personal notes become a tool to bridge the gap between seeing the patient and completing detailed documentation in the EHR. The study pointed out that the artifacts share certain ‘universal needs,’ a way to abstract key information from highly detailed patient information that resides in multiple systems, including the EHR; most notes contain and serve three main types of purposes: memory work, abstraction work, and future work.

In another study<sup>89</sup> that looks at the gap between EHR and real clinical flow in the ED, Chen points out the same informal documentation, and calls these as the “Transitional Artifacts,” to transit data from the highly sequentially structured and complex EHR to a portable and

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87. Park, S.Y., S.Y. Lee, and Yunan Chen., “The effects of EMR Deployment on Doctors’ Work Practice: A Qualitative Study in the Emergency Department of a Teaching Hospital” *International Journal of Medical Informatics*, 81 (2012) 204-217

88. Park, S.Y., Kathlenn H. Pine, and Yunan Chen. (2013). “Local-universality: designing EMR to support localized informal documentation practices.” *CSCW* ‘13 February 2013. doi:10.1145/2441776.2441786.

89. Chen, Yunan. “Documenting Transitional Information in EMR.” *SciVee*, 2010. doi:10.4016/17458.01.

quickly accessible tool, when clinicians are unable to navigate back and forth from EHR to patient, and need information from multiple tabs within the system. These artifacts become a tool to carry and retain information physicians or nurses gathered that is not yet ready to be formally entered into the EHR.

Both Park et al. and Chen highlighted the memory-retaining factor of these notes, and the critical needs for these artifacts given the gap between EHR and clinicians' actual workflow. Another study<sup>90</sup> that looked closely at note taking in different situations (classroom, boardroom, hospital room, and courtroom) by Mueller and Oppenheimer stated that the trend of using digital tools to make note taking easy may actually lead to "ironic negative consequences." Tasks that are too easy can undermine learning, and "desirable difficulties," such as slower note taking have been shown to be more effective. Mueller and Oppenheimer point out that that doctors and students have similar goals for their note taking. Similar to students' goals to understand and make sense of the lecture content, doctors' goals are to help understand a patient's issues and make clinical decisions.

### Summary Points

- Initial observations confirmed that EHR documentation and reviewing comprises a large portion of clinicians' daily tasks
- Initial observations and studies showed that paper documentation is still used in clinical settings as "transitional artifacts" that carry highlighted information from the EHR and allow clinicians to write down informal information gathered at patient bedside for later EHR documentation
- Studies on handwriting and note-taking prove a certain cognitive value in information acquiring, retaining, and processing

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90. Mueller & Oppenheimer. "Technology and note-taking in the classroom, boardroom, hospital room, and courtroom."



# PROBLEM STATEMENT

## Comparison and Gap

Through initial observations and research findings, it is noticed that one of the many ways physicians and nurses deal with complex and multi-mediums of information is to write down (pull out) crucial information from reviewed data, as “transitional artifacts”. These paper-based tools are not official documentation, but help clinicians immensely in aiding memory and later EHR documentation. Since very few studies have looked into handwritten notes or paper

documentation as a solution to existing EHR challenges and not enough have looked at or emphasize the value of physicians' handwritten notes, this project will focus on this aspect, both as a targeted research focus and as a potential to provide design solution.

## **Hypothesis**

Handwritten note taking tools that organize and gather crucial information would benefit physicians when dealing with complex and large data, and eventually help them spend less time, improve processing, and hence make better clinical decisions.

By looking closely at how physicians capture and communicate patient information, this project will map out the strengths and weaknesses of EHR being used in a focused hospital setting. The goal will be to propose a hybrid design solution that integrates the efficiency and accuracy of a computer-based system with the cognitive benefits of handwritten notes, and to foster a better understanding and appreciation of the handwritten documentation.

## **Identified Targets for Further Observation**

- EHR usage in relation to physicians' daily workflow (incl. data reviewing, entering habit and documentation style)
- Personal note taking habit and style and its relation to later EHR documentation
- Artifacts used for standard or informal handover procedure or instances as communication tools



# DESIGN PROCESS

## Research Background

### Design Research Methodology: The Double Diamond<sup>91</sup>

Undertaking a research-driven project while in search of a design solution, a design process model —the Double Diamond, created by Design Council in 2005 — was used. The model depicts a graphic

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91. "A study of the design process – The Double Diamond." Design Council (2005), chapter "The Design Process"

representation of a design research process. It was based on case studies gathered from the design departments at 11 global firms, with four equivalence stages identified across their project developing phases.

The model showed four main stages across two adjacent diamonds. Through a series of convergence or divergence of thinking, analyzing, ideating, and finalizing, the model is particularly well suited for structuring a process with problem identification and user involvement in the development of solutions. Below is the model (figure 1.) and all the methods used in this project.

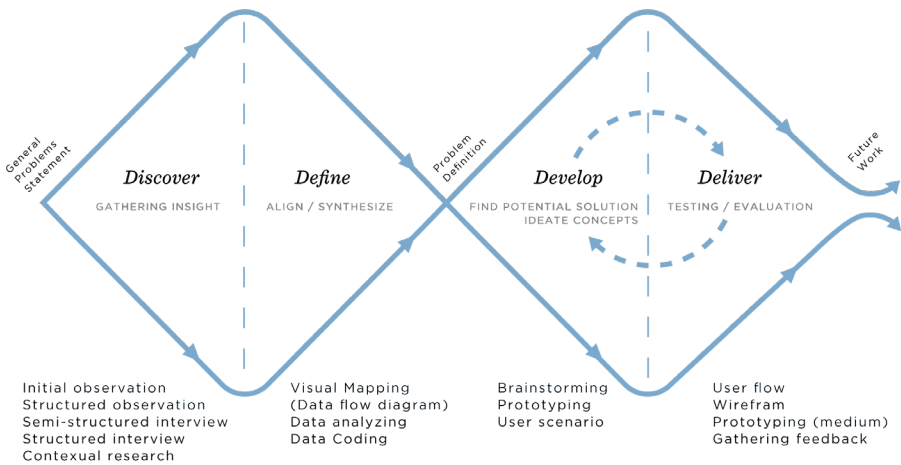


Figure 1. Double Diamond and the methods used

## Target Sites Analysis

Observations and interviews were done mainly in the University of Michigan Health System (UMHS/Michigan Medicine) and Saint Joseph Mercy Hospital in Ann Arbor. A total of 19 observations on multiple sites were completed. The main focus groups were physicians in the Medicine Faculty Hospitalist service team (MFH) under the division of General Medicine at UMHS. Additional observations at similar

settings, including the short stay unit, 2 resident teams (GenMed and Newburgh team) unit at UMHS were also conducted. A control group that served as a comparison model was the inpatient cardiovascular unit at Saint Joseph Mercy Hospital. The findings were then compared and analyzed.

UMHS, a teaching and research hospital, consists of multiple medical divisions and services. MFH has a highly generalized patient population (it includes a variety of acuity, a wide range of social backgrounds and age). The MFH team primarily consists of attending physicians and represents a higher chance of looking at pure physician practice (instead of a teaching environment). While a non-resident service, many of the physicians who regularly attend this service are actively involved in quality improvement projects benefitting patients throughout the institution, such as the LEAN discharge project etc., and many perform teaching service from time to time.

Medical record system wise, UMHS originally used its homegrown EHR system—CareWeb, which was deployed in 1998. In 2012, Epic (Epic Systems Corporation, Verona, WI) was implemented, locally renamed MiChart. As of 2015, the two systems now host 81.7 million clinical documents: 36.4 million from CareWeb, 10.6 million from Epic (MiChart), 10.4 million radiology reports, 23.2 million narrative pathology reports, and 1.2 million other genres of documents.<sup>92</sup>

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92. Hanauer, David A., et al. "Supporting information retrieval from electronic health records: A report of University of Michigan's nine-year experience in developing and using the Electronic Medical Record Search Engine (EMERSE)." *Journal of biomedical informatics* 55 (2015): 290-300.

## Site Overview

University of Michigan Hospital (UMHS/Michigan Medicine), MFH

MFH= faculty members were hired to staff a non-resident in-patient service

*Location: Univ. Hospital Floor 5-8*

MFH are in charge of 80 to 110 patients and have around 19 to 27 daily admissions. Yearly they admit around 10,000 patients, which make up over half of the total admission of the entire Internal Medicine division

The teams on MFH are made up of 20-25 physicians on weekly rotation, 5 discharge-planners (case manager), 5 social workers, and 3 clinical assistants, with occasionally on-site training fourth-year medical school students.

### Comparison site:

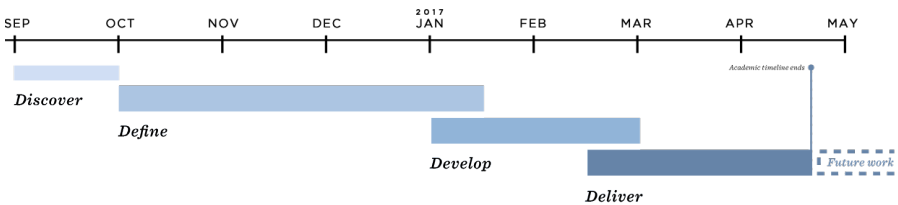
St. Joseph Mercy Hospital Ann Arbor, Cardiology Unit

*Location: Floor 6*

St. Joseph Mercy Hospital Ann Arbor is a 537-bed teaching hospital in Ann Arbor; it is an affiliated hospital under Trinity Health and Saint Joseph Mercy Health System. The cardiac unit provides inpatient services with assigned hospitalists or physicians attending along with cardiologists provided by Michigan Heart services on the floor.

## Research Plan and Timeline

### *Project Timeline*





# Design Research Process

## i. DISCOVER

### Observation

Methods: Structured observation

Structured to semi-structured observations were done in UMHS and St. Joseph Mercy Hospital in Ann Arbor. (table 1.) Data were gathered without direct involvement of the participants (the researchers watch from afar/aside, shadowing the participant, as shown in figure 2.)

During observations, physicians and nurses' note taking templates (whether existing in system-generated printouts or personal notes) were captured (by quick sketches/ copying w/sensitive patient information removed) and compared.

The layout and organization of the information, individual format on chart designs, phrases, icons, callout styles, etc. are the main focus instead of the actual detail of the captured information, since most content is under strict HIPAA protection. Conversations of physicians between patients or other clinicians (e.g. nurses, case managers, pharmacists) were also captured, if related to data documentation.

Site	Focused site UMHS (Michigan Medicine)				Comparison site St. Joseph Mercy Ann Arbor	
	MFH Physicians	Unit 6B Nurses	Newburgh Resident Team	Pharmacist	Cardiovascular Floor Physicians **	Nurses
<i>Observed times (no.)</i>	10	4	2	1	1	3
<i>Observed participant</i>	5 *	4	5 Residents 1 Pharmacy Student 1 Attending	1	2	3
<i>Hours</i>	51 <sub>hr</sub>	16 <sub>hr</sub>	10 <sub>hr</sub>	4 <sub>hr</sub>	10 <sub>hr</sub>	16 <sub>hr</sub>

\* Focused on 1 participant for 6 times

\*\* Attendings physicians are part of the shared service

Table 1. Observations completed in both sites



Figure 2. Physicians observed in all sites spend long hours on EHR documentation

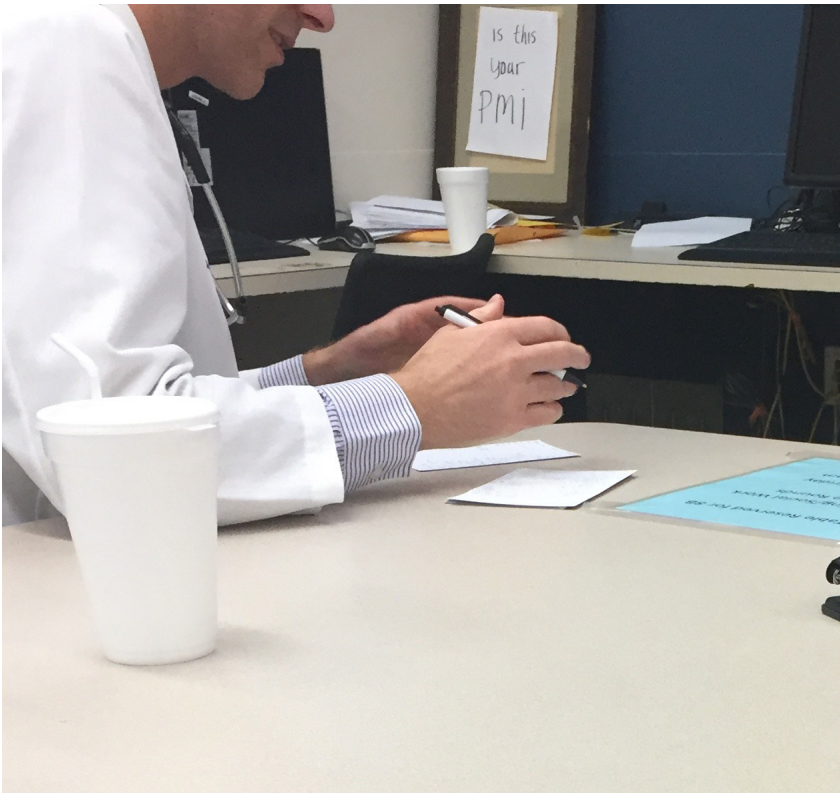


Figure 3. An attending physician in resident team uses note cards as “transitional artifact” to take notes

## Contextual Inquiry

Methods: Unstructured and structured interviews

A more focused one-on-one conversation of the functioning of the EMR (MiChart at UMHS) and on medical notes format was arranged on several separate days with physicians during their shift.

Two additional interviews were conducted, including getting feedback from one of the senior attending physician and teaching professors in the Internal Medicine who also serves as the Chief of Staff in the Office of Clinical Affairs (OCA) at University Hospital and one younger physician that does teaching services at the resident team. (figure 3.)

Other unstructured interviews were conducted either on the same day during downtime of physicians/nurses or during quick intervals between their task. (e.g. many EHR operational questions were asked during the time physicians finishing their daily notes, as shown in figure 4.)

### The interview topics are targeted towards:

1. Information acquiring methods and process, and feedback on the efficacy of current methods



*Figure 4.  
Interviews were conducted during the time when physicians were using the EHR*

Interviews with physicians and nurses about their information collecting habits and documenting methods (on both personal notes and EHR), their thought process during note taking and how members within and outside of the care teams establish common ground or mutual understanding on patient information in the record system and during handovers.

For ones who use self-made tools or design personal forms, questions were also focused on their design rationale and user experience or their tool.

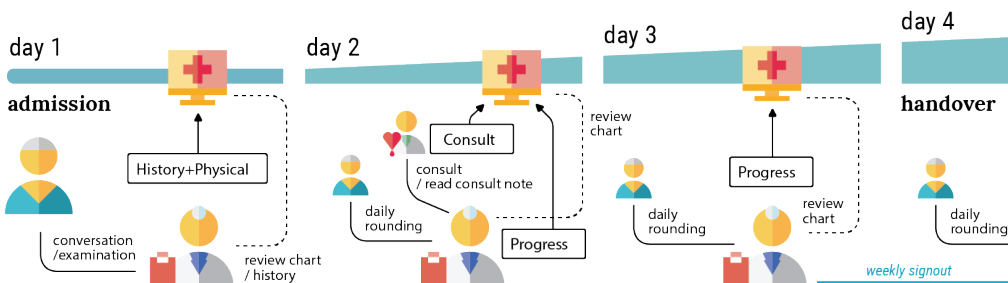
## 2. Operational feedback of current EHR system (challenges) and suggestions

Focusing on their feedback, individual's comment and assessment on current EHR system (including functions, operational fluency, UI interface design etc.) and opinions on data quality

## 3. Problems identified with observation and research, and discussion on this with stakeholders

Addressing observation insights and raising questions around existing problems in research findings

\* This is what your health record would look like if you spend 7 days in the hospital.



## ii. DEFINE

### Mapping

A visualization (figure 5.) of a patient's record generated and accumulated over the course of stay in hospital (this is a made-up scenario of a patient that stayed in hospital for seven days). All additional information on how, when, and what kind of information were captured by physicians were also included on the map. A more refined digital illustration was made based on this map. (figure 6.)

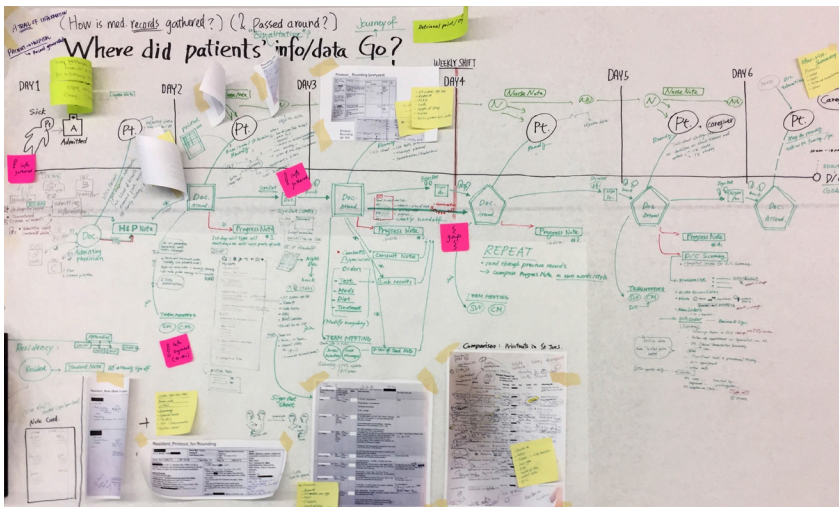


Figure 5. Key insights from observation and interviews

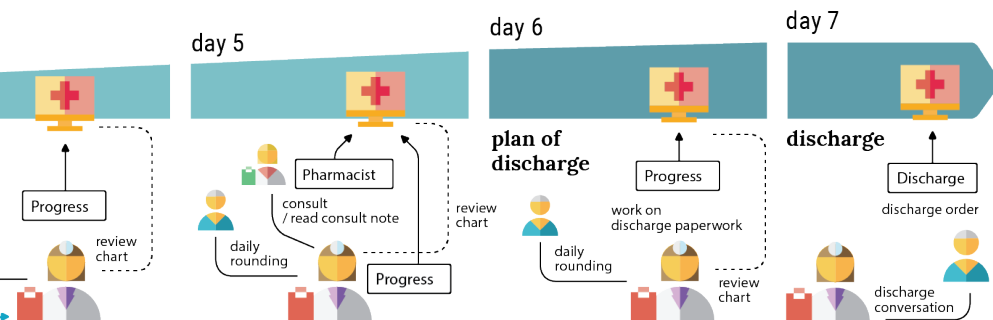


Figure 6. A refined illustration of the map depicting accumulated patient information during a patient's seven days of hospital stay

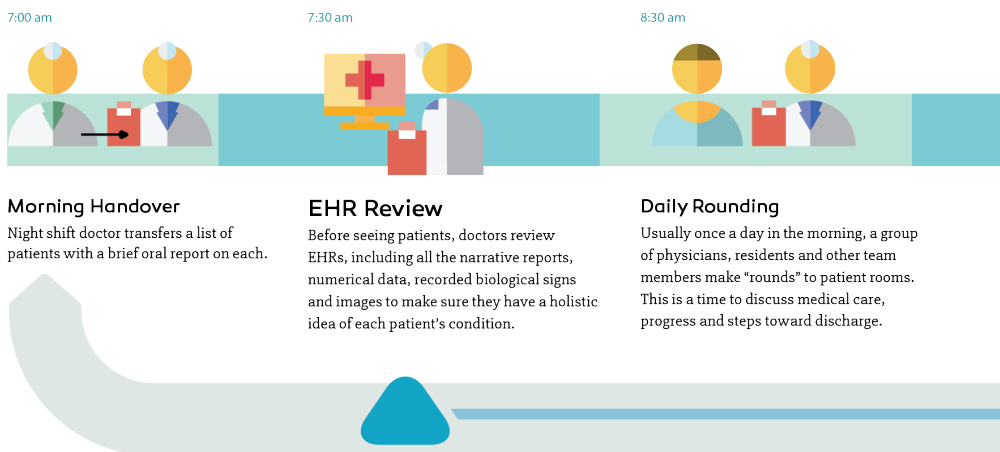


Figure 7. A closer look into a day in the map; two critical moments were highlighted

## Identifying Critical Point

Once look closer into each day, the two highlighted moments were pinpointed, (figure 7.) since they are the moment when physicians have direct contact, access, and entry point with the EHR systems, and in between is the direct patient-physicians interaction time.

## Physicians' Daily Workflow in Relation to Documentation

### 1. Reviewing data and rounding habit

Reviewing the EHR is an essential part of physicians' daily tasks. After the morning handover, physicians start their day by going over all the labs, vitals, and previous notes for listed patients. This determines all the treatment plans of the day. This, however, is not an one-time task, as patients' lab results and vitals gets updated, rounding and conversations with patients take place, physicians constantly have to go back to the computer to make assessments and update plans based on the most recent progressions. Often, physicians keep a temporary working document (a temporary progress note in UMHS's case) while reviewing the data; sentences

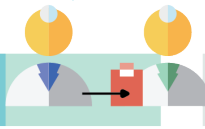
11:00 am



### Charting /Documentation

After rounds and meetings with other clinicians (case managers, social workers, etc.), physicians will often spend the rest of the day “charting.” During this time, they will write orders, type up notes, change prescriptions, review charts and make discharge plans.

7:00 pm



### Evening Handover

Day shift doctor transfers a list of patients with a brief oral report on each.

7:00 am



### Weekly Handover

Every week, a new attending physician takes over the care of a group of patients. The outgoing doctor will give the incoming doctor a full report on the status of the patients. This handover can happen by e-mail, telephone or a face-to-face conversation.



or bullet points are put in as placeholders, to save time on later documentation.

Depending on the systems, complexity of patients, and individual practices, rounding can take up to a few hours to the whole morning; some rounds with a full resident team can even go longer. Rounding starts in the morning after physicians have reviewed the EHR. The ones observed with MFH physicians bears significant difference with the ones at short stay unit during the initial observation and in St. Joseph Mercy’s cardiac floor. St. Joseph Mercy’s interdisciplinary rounds made up of physicians, nurses, PAs, case managers, etc. took place, and the whole team rounds each patient room together. This is largely due to the vastness of UMHS, and lack of designated area for specific services. When physicians have a list of eight patients to round, they would often prioritize the order based on the criticalness, patients’ location, and their discharge potential. A physician’s list of patients can be scattered all throughout the floors and at different zones. On some occasions, physicians can walk up to 10 minutes from between patients. This means not only travel time is wasted, but internal face-to-face communications between care team members are nearly impossible.

Physicians constantly need to find a working station (access to computer) to send out orders or paging messages to other

clinicians and nurses, or to quickly input information for later EHR documentation, particularly those who doesn't have a strong note taking habits.

In comparison with St. Joseph Mercy, where every nurse (and most physicians, if preferred) is equipped with a COW (Computer on Wheels) and moves around with it, UMHS clinicians use stationed computers more often. However, this doesn't seem to affect the use of handwritten notes. The nurses at St. Joseph Mercy keeps all types of self-made note sheets and printouts on the COW desktop, which they'd lean on and transcribe lab results from EHR or check off their to-do list. The efficiency of the portable computer station, having access to EHR at hand at all time is notable.

## 2. Handwritten note-taking habit

Based on observations, multiple styles of handwritten notes were identified when clinicians were reviewing the EHR and rounding the patients. Aside from only a few physicians who take no written form of documentation at all (in fact, only one physician in the MFH office mentioned not taking any handwritten notes during an open conversation), all the observed clinicians, and from conversations, most of their acquainted colleagues, take some form of personal notes.

As many physicians and nurses confirmed, taking notes simply lets them know what they're doing, whether it's a small or big things they've written down. It gives them an extra reminder before they move on to the next task, as previously identified and specified by Chen<sup>93</sup> as "transitional artifacts." For people doing highly mentally loaded and stressful jobs, the more items in our working (temporal) memory with similar features overlapped. For intense, similar

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90. Chen, "Documenting Transitional," 1787-96





*Figure 8. Physicians using the back of a printout sheet as note taking tool. Informations from reviewing of EHR, as well as conversations with patients or other care team members were written down.*

medication or dosage for patients with similar condition, the more likely each items' quality will be affected.

Reviewing EHR could include clicking through the tabs and browsing through endless information, but for each discipline, the importance and level of attention paid to each section is different. For clinicians, composing a thorough and clear narrative based on all the gathered data is their main priority; for nurses, making sure all the vitals are taken and medications are distributed at the ordered time are on the top of their list; for case managers, social workers, pharmacists, the items they look into are even more detailed.

As a result, the forms and note-taking styles are accordingly different. For clinicians, who focus mainly on the bigger picture and are in charge of making clinical decisions based on all perspectives, their notes cover just about everything, and can sometimes be hard to put into a highly-structured chart styled design. Many use less systematic ways to take their notes, (figure 8.) from utilizing white spaces on a printed form or list (computer generated), using the entire white space on the back of that sheet, to note cards. Compared to the nurses, who have a much stronger intent to take notes and use a wide variety of carefully designed forms and sheets, physicians are the ones who cutback from pen and paper during the digitization of patient record.

### 3. Note-taking styles

\* all patient identifiers on images were removed/blurred

#### A. Note and reminders on printed patient list

Printout form as note taking tool is one of the most commonly seen styles throughout the observed settings. Of eight observed physicians (5 from MFH, 2 attending physicians from the resident service, and 1 from St. Joseph Mercy). Six uses existing printout sheet from the computer. (Figure 9.) Printout sheets are styled similarly cross-systems, since the ones seen in St. Joseph Mercy look similar to the ones used in MFH, and is frequently used by the physicians as well. Most lists are system-generated templates with enough patient information on it that are easy to carry around. Although, at UMHS, the template can be customized with different tabs of information, only some use this option as the page becomes cramped under a table form format. While standard ones used as a handover printout most commonly becomes a note-taking tool for MFH physicians.

It is also worth mentioning that a much more detailed patient information sheet (which can be generated from EHR) was used in both resident services and the short stay unit. (Figure 10.) And for residents, the printout later also serves as a handover tool.

An avid note-taker that uses this method or tool can easily end up with a very cramped sheet of paper full of written notes. (Figure 11.)

Medicine Faculty Hospitalist	MFH - Last Refreshed 01/00/17 1923	On Call To Do List				
Location	Patient Name	Age	MRN	Code Status	Code	Code
58-644-01						
68-6123-01				Full-Code		
68-6126-02				Full-Code		
68-6141-01				Code		
74-7109-02				Code		
78-7430-01				Code		
78-7431-01				Full-Code		
88-8432-01				Full-Code		

*Handwritten notes:*  
 - 28-7  
 - News - no path, w/ w/infected  
 - 28-7  
 - 11/27/16  
 - 27  
 - 4/17  
 - 1/10

Figure 9. General printout sheet used for notes and handovers at MFH team in UMHS, used as a handwritten note taking artifact by physician

Doing/WT Code Status, Full Code	Medicine	Key Meds:
EP 124-09	Heart Rate: 97 RPR: 16 SpO2: 96%	atorvastatin, hydrocortisone, bumetanide, doxycycline, fentanyl, gabapentin, hydralazine, insulin, morphine, nifedipine, pantoprazole, tramadol, valproic acid, vitamin D
Room 602-01	Service: Medicine Hewlett (Internal Medicine) POD: "No surgery found"	Notes: Key Meds: Reglan, Aspirin, oral vancomycin, IV vancomycin, Pain None, IVIG/RTT, none
EP 105-84	Heart Rate: 71 RPR: 16 SpO2: 96%	Notes: Allergies: Bacitrimin, Lisin, Dabigatran, Riv, O2, RA
Room 602-01	Service: Medicine Hewlett (Internal Medicine) POD: "No surgery found"	Notes: Key Meds: Aspirin, Lisin, topical atezizumab, insulin, Aspirin, Pain, Tylenol, Noreco
EP 120-79	Heart Rate: 65 RPR: 20 SpO2: 99%	Notes: Allergies: None, Pain, Tylenol, Noreco

*Handwritten notes:*  
 - Tfs escalator  
 - MSA - effluent  
 - 1g 8s  
 - ? ID consult  
 - Nanc + effluent  
 - Card Res to echo + mtd  
 - consult - RBC consult

Figure 10. Short-stay, resident team standard printouts at UMHS, with resident's handwritten notes

Location	MR/FIN	Name	Sex/Age	DOB	Day	Admit	D/C	Attending MD
(AA) E008 0624-01		Corey J	M	40	11/22/76			Dr. [unclear]
(AA) E077 0701-01		Dealo	M	77	11/22/16			Dr. [unclear]
(AA) E077 0702-01		Home Care	M	81	11/22/16			Dr. [unclear]
(AA) E077 0726-01		Chronic Bronchitis	M	83	11/16/16			Dr. [unclear]
(AA) E077 0730-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0731-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0732-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0733-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0734-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0735-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0736-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0737-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0738-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0739-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0740-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0741-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0742-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0743-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0744-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0745-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0746-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0747-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0748-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0749-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]
(AA) E077 0750-01		Chronic Bronchitis	M	83	11/19/16			Dr. [unclear]

*Handwritten notes:*  
 - Coreg  
 - Lisinopril 40mg  
 - Humalog 6-80  
 - 58 unit  
 - Home Care  
 - Chronic Bronchitis  
 - D/C  
 - 4pm  
 - 3/6  
 - 4/17  
 - 1/10

Figure 11. A printed patient list used as a note taking tool by a physician in St. Joseph Mercy Hospital

## **B. Designed note-taking form**

Designed forms (see Figure 12. as an example) include all styles of personally designed note-taking tools, or any online-shared physician note template open for download, to recent years H&P notebook clinicians can purchase. However, this particular type of note-taking method is significantly less seen among physicians, especially as their practiced-years increase and become more experienced. This was made obvious during the observations in the resident service, where residents carry many types of self-designed forms (or designs that have been passed down from the senior residents) form. Conversations with residents often show a general belief that as they become a seasoned medical professional, they should rely on as little written notes as possible, and many responded that they will, hopefully, one day be experienced enough to not need notes, or only need a minimal number of, notes.

The designed note-taking form by physicians, overall, bears similarities, with most categories listed being universal across units, services, and even hospitals. Most covers general patient information, brief summary, sections to put in past histories, lab results, vital signs, to sections where they can put in notes for internal events, to do items, etc., and ends with additional information on medications, allergies, etc.

Nurses, on the other hand, use a wide variety of self-designed note-taking forms and sheets to document patient information, much more so than physicians in both the facilities being observed. (Figure 13. and 14.) One reason may be because nurses still document more measured numbers, patient activities and descriptive events, compared to physicians. Many of the forms are designed particularly for these purposes. It is common to find spaces where they can fill in results, numbers, and patients' condition changes, whereas physicians mostly focus on finding the cause, determine the diagnosis and make plans based on all the collected data.

Overall, the nurses being observed were all very willing to share their note-taking style and routines, and are extremely open to sharing their self-designed sheets, as well as giving feedback on how to optimize the future design.

Name	Age	MRN:	Room	PCP	PE	Intern:
Code Status: Admitted on: Creatinine Clearance: Allergies: Lines/Access:					Any decub ulcers? Any lines/foreign objects? Rashes? General: HEENT: Cardio: Pulm: Abdomen: Extremities: Skin: Neuro	
Vitals:		Dry/Baseline wt: Wt/Ht:		I/O Totals		UOP
ED COURSE					Cultures/Studies	
					Cultures/Studies	
					Cultures/Studies	
					Cultures/Studies	
					Cultures/Studies	

Figure 12. A blank sheet of resident-designed form used by few individuals at one UMHS resident team

Name: _____ Room: 774 Code Status: Full	
Rhythm: <u>CP</u>	O2: <u>12</u> Mobility: <u>I</u> Precautions
DX: <u>CP</u>	Prism: _____ HX: <u>CP, MG</u>
Diet: <u>Neuro</u>	Cardiac: _____ Resp: _____
Wt: _____	Skin: _____ Musc: _____
Cardiac: _____	Tun: _____
Skin: _____	Med: _____ Pain: <u>prn q4</u>
GI/GU: _____	Report: <u>R/S</u>
LABS	PLAN: <u>Stress C 07:00</u>
WBC 10.7 Na 137	
HGB 14.3 K 4.1	
PLTs _____ Mag 2.0	
PTT 51.2 Cr 1.3	
PT _____ TROP _____	
INR _____ Zolp _____	
Additional/Repeat Labs:	

Figure 13. A single page per patient form used by a nurse at St. Joseph Mercy

Name/Room:	Name/Room:
Age: _____	Age: _____
Sex: _____	Sex: _____
Diagnosis: _____	Diagnosis: _____
Allergies: _____	Allergies: _____
Code Status: _____	Code Status: _____
Abnormal Vitals: _____	Abnormal Vitals: _____
Abnormal Labs: _____	Abnormal Labs: _____
Med Admin Times:	Med Admin Times:
Last Pain Med: _____	Last Pain Med: _____
Pain reassess: <input type="checkbox"/>	Pain reassess: <input type="checkbox"/>
Pain reassess: <input type="checkbox"/>	Pain reassess: <input type="checkbox"/>
Pain reassess: <input type="checkbox"/>	Pain reassess: <input type="checkbox"/>
IV line date verified: <input type="checkbox"/>	IV line date verified: <input type="checkbox"/>
IV location: _____	IV location: _____
Last BM: _____	Last BM: _____
O2: _____	O2: _____
SCDs: _____	SCDs: _____
Notes: _____	Notes: _____
Documentation	Documentation
IV access every hour: <input type="checkbox"/>	IV access every hour: <input type="checkbox"/>
Position change every hour: <input type="checkbox"/>	Position change every hour: <input type="checkbox"/>
Goal for shift set: <input type="checkbox"/>	Goal for shift set: <input type="checkbox"/>
Intake/Output every hour: <input type="checkbox"/>	Intake/Output every hour: <input type="checkbox"/>
CPG progress: <input type="checkbox"/>	CPG progress: <input type="checkbox"/>
EOS note: <input type="checkbox"/>	EOS note: <input type="checkbox"/>
IV fluid total intake @ end of shift: _____	IV fluid total intake @ end of shift: _____

Figure 14. This design features four patients per page with less white spaces

### C. Note card

Note cards as a note taking tool were also observed, this particular style of capturing information has its history in clinical practices as it has been introduced and mentioned in many healthcare professional training materials, and is still being passed down by senior physicians. I still found a handful of physicians (despite years of experience) using note cards, which are easy to carry around and very organized. On each of the cards, information is laid out pretty consistently, and bears strong similarity between different users. It is unclear whether all note card method originates from similar training. Here's a modeled sample of how data are written on a typical note card. (Figure 15.)

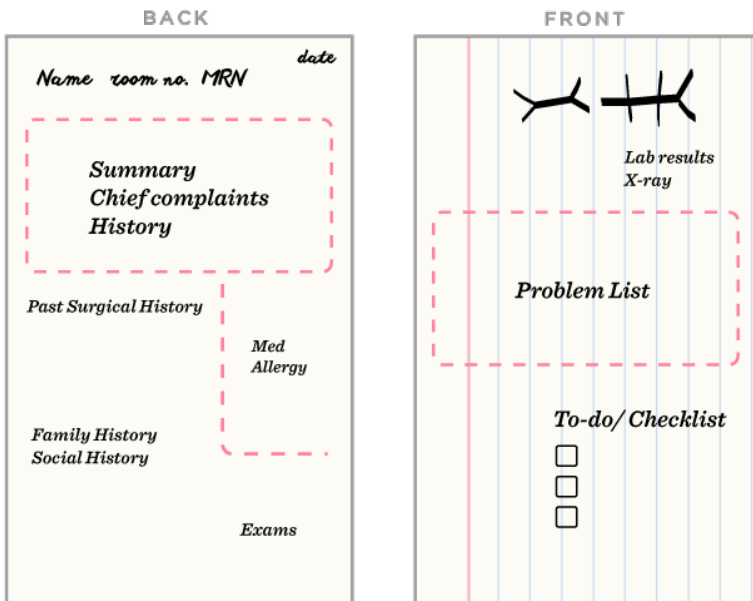


Figure 15. Note card (front and back) modeled after observed sample at UMHS

## D. Pre-typed and printed

One of the more uncommon practices I discovered included a particular physician who creates a separate word document to capture and organize useful data from the EHRs, and then uses a printout of the document as a note-taking tool later during the rounding. (Figure 16.) The majority of my subsequent focused observations (6 times) were done with him as the observed participant.

This was a self-developed method by the physician, the benefit being having a much clearer organized form with sufficient and salient patient information to carry around, and enough space to take personal notes, compare with the EHR generated printout template. Throughout the day, the physician would cross out to-dos, check off highlights, and jot down lab numbers, new to-dos, and questions. He would then go back to the computer and update EHR notes with his printout open next to the computer as a reference.

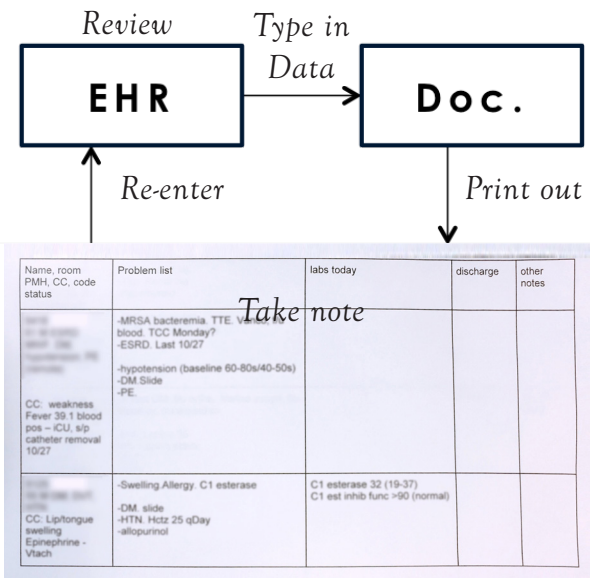


Figure 16.  
The way to use  
the pre-entered  
printout note form

“The overall idea is simple,” he said, “If I can copy and paste (existing text) into a template, I don’t have to write down (transcribe) every single items with hand, it saves a lot of time.”

#### **4. Documentation (Inputting Data to EHR)**

##### **EHR Documentation habit and tasks**

Generally, physicians go back to their office or find computer stations near patient rooms to do quick documentation or page messages during the rounding. Some go back and forth in between seeing two to three patients, and there are ones who don’t go back to their office until all patients on the list are seen.

There are many types of notes input daily into the patients’ record. Starting from the H&P (history and physics) note when a patient is admitted, a progress note is added daily by the physician. A patient will also have nurses’ note, a consult note from a specialist or a surgeon, and notes by social workers, case managers, etc. In this project we’ll be looking at the physicians’ daily progress notes, since they are required to be updated daily. They can be brief or long, yet they have to highlight important data and clearly express clinical impressions, and must be done within the context of physician’s knowledge base. They are an actual descriptive document that chronologically captures the patient’s course in hospital. And, they are a learning tool that allows physicians to think about what’s going on and express organized thoughts.

The most common form of note taking observed is referred to as a “SOAP” note. This stands for the major categories included within the note: Subjective information, Objective data, Assessment, and Plan. However, people also use different styles of free form notes. DAP note format, comprised of Data, Assessment and Responses, and Plan, can be found occasionally, and even within the same



format, each physician might still compose their note differently; one might have appointed plans under each assessed problem; another might have all the plans listed under a separate section.

In a document with free flowing text, most of the categories and style can still be formatted. Physicians can set up their own template with each section heading already in place; data can also be pulled in from other parts of the EHR, for instance, when type in “.HPROBL”, it automatically pulls in a patient’s list of active hospital problems, though it’s seldom updated after admission.

During the observations, physicians constantly brought up the importance of keeping a good record, or a good progress note. Occasional complaints on their previous caregiver’s (physicians, and sometimes other disciplines such as a specialist) note were noticeable.

Some physicians prefer to compose their own new note after taking on a transferred or handed over patient, despite the fact that their predecessor’s note was available for extracting content. “I prefer reading my own words,” one physician proclaimed.

### **Documentation styles analysis**

Documentation styles can be roughly categorized into the ones that rely heavily on computer and EHR access, and the ones that prefer and use paper-based printouts and documenting tools. The preference largely determines what kind of artifacts and the amount of physical (portable) data they would carry.

For physicians who go back and forth between patient and computer stations, their note can be less systemized, and the amount of information captured is significantly less than the ones who finish all or more patients at once. This doesn’t necessary affect the final quality and completeness of the note on EHR, but

the handwritten piece holds much less value and subsequently is less informative when used as a handover tool.

## 5. Handovers

The handover process in the MFH (Medicine Faculty Hospitalist service) is noticeably different from other services (units) and disciplines, such as the nurses and residents.

For the MFH \*daily handover (“sign out protocol”) in the morning and in the evening, the process was not strictly structured. The daily handover commonly consists of a conversation between the physician from the previous shift (i.e., outgoing physician) and the physician from the next shift (i.e., oncoming physician) and is supported primarily by paper-based artifacts (a printout patient list, including a list of maximum 11 patients, with their basic information, room number, MRN, code status, a brief overview, and an on call to-do list). The entire conversation lasts around 10-15 minutes, with emphasis on patients with higher LACE scores (severity of condition). While many still use the printout list as a note-taking tool for the rest of the day, most do not share the fully scribbled page as their handover sheet, and instead use a freshly printed version with additional highlights.

\* [In this case, we focused on the day-time physicians, since they play the active role in maintaining and updating their list of patients throughout the patients’ stay in the hospital, while night-shift physicians mainly performs on-call duties when emergencies occurred, and do not maintain the EHR notes.]

The observations also reveal that nurses and residents have much stronger handover protocols being implemented, compare with the physicians at MFH. The resident team currently uses the form (see Figure 7) generated from EHR, with more detailed information

about each patient than the basic MFH list. Their notes are taken on both their personal tools and on this printout sheets, with clearer and higher legibility (almost printed) on the printout sheets. These sheets are then used as a handover tool for the next resident.

The nursing handovers usually took place within sight of the patient's room and involved visual references to the patient and therapies provided. Nursing handover tools used in Saint Joseph utilize many paper-formatted artifacts. A purple sheet of paper —Communication Form— used for both handover and rounding is an actively implemented tool on the cardiac floor. It is used as a communication tool between nightshift nurses to daytime nurses, for recording overnight events, as well as a tool to write down any questions for next morning's team rounding. One other noteworthy tool used across unit is a detailed sheet of all the room numbers on the floor with detailed patient information written with pencil and updated by all nurses, managed by a nurse coordinator. This sheet is printed to all nurses across the floor in the morning, and constantly gets updated (using eraser and written again by pencil).

### iii. DEVELOP

#### Prototype and Iteration

##### Prototype A.

##### “Design inspired by ‘Pre-typed and printed’ style”

Prototype A (figure 17.) was designed for the focused physician— Dr. Chiang, who uses the note taking *method D*, by pre-typing highlighted data from reviewing EHR and printout the pre-typed form for bedside note taking. The design was a formatted/locked word document, with fixed spaces for pre-typing and later handwritten notes, and various drop-downs of a fixed set of predetermined values and items the physician was already using.

**Bedside Note** Drop-down box  
UMHS | MFH | Dr. Stephan Chiang ← Grey areas are drop-downs or can be edited Date is automated update daily  
Date: 2017-01-20

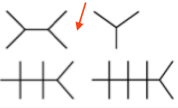
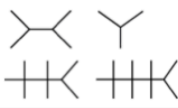
Patient 1 (Room/ Name/ PMH/ CC/ Code status)		Patient 2 (Room/ Name/ PMH/ CC/ Code status)	
Rm#, Name, Age, Gender <span style="color: red;">can be edited</span>	CC: [Grey] (Chief Complaints)	Rm#, Name, Age, Gender	CC: [Grey]
<b>Problem List</b> • [Grey] <span style="color: red;">Can add multiple points (free-type available)</span>		<b>Problem List</b> • [Grey]	
<b>Labs Today   To-Dos</b> [Grey] <span style="color: red;">Can add multiple points (free-type available)</span>	<b>Discharge</b> • PTOT- SNF <span style="color: red;">Drop-down</span> • [Grey]	<b>Labs Today   To-Dos</b> [Grey]	<b>Discharge</b> • PTOT- SNF • [Grey]
<b>Other Notes</b> <span style="color: red;">(for general lab results)</span> <span style="color: red;">Standard chemistry &amp; hematology fishbones</span> 		<b>Other Notes</b> 	

Figure 17. A two patients per page prototype designed using microsoft word developer tool as a word document with fixed drop-downs and free-typing categories

## Feedback:

The physician expressed favorable attitudes towards this solution, yet expressed that the design, although it nicely organizes all the data and has some thoughtful features to save some data entering time, doesn't make significant differences (e.g. time spent on pre-typing and reviewing) to his existing practice.

## Prototype B.

### “Design for clinicians to design their own note-taking form”

Prototype B (figure 18.) was designed for physicians and nurses as a web-based or app-based tool to design their own note-taking form. Users can select and personalize the way they like to carry or fold their printouts, the number of patients they would like to have on one sheet, and the items and size of the boxes. They can then use this as a free-typing document on a computer or download it as a PDF file and a printable note-taking tool.

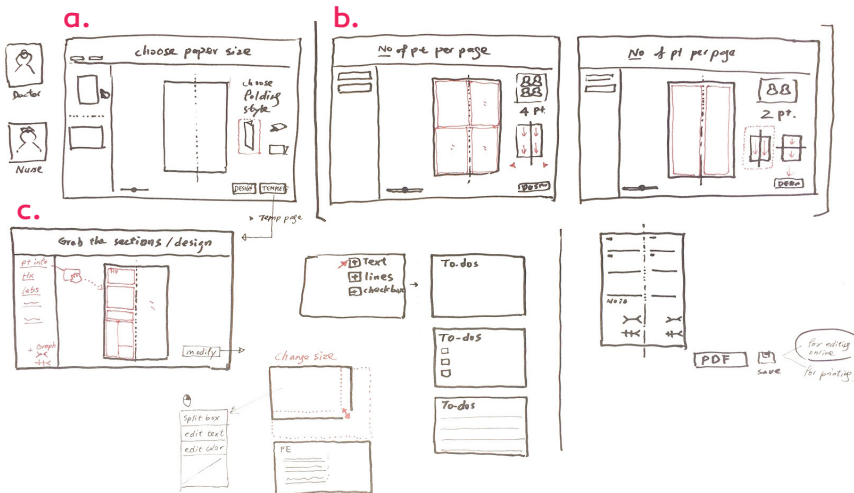


Figure 18. Users start with selecting ways they would like to fold and carry their sheets of paper (a.), the number of patients per page (b.), and options to customize the tabs and boxes (c.)

**Feedback:**

Feedback for this design was mixed: physicians have no particular fondness or dislike of this design. While most felt this is a thoughtful design, very few expressed willingness to use it. Some of the reasons suggested that this “note design tool” would only be useful for the first time when actually used to design. While the initial goal was for users to go back to this design tool and modify their form based on personal using habit or preferences, most physicians who take personal notes affirmed that they’ve grown quite used to their existing note taking styles, and to make them switch to a new system or style would require a significant efficiency value.

Comments from residents and nurses, on the other hand, were generally favorable. Residents who take handwritten notes expressed their interests by stating the fact that they use and constantly try out new types of personal note taking tools to find the most-suited one.

#### iv. DELIVER

Based on the observations, interviews, and some early prototypes, it was evident that the effective design need not only to be flexible enough to write on for physicians, whose note taking style and preference can vary greatly, but also appealing enough to even consider using, with certain features that need to be efficient (time-saving). Therefore, the generated design concept would ideally be part of an integrated platform that could be used alongside the current EHR systems. Preferably, when the information is transferred from the digital interface to the “transitional artifact,” the steps would be simpler and require less time, much like pulling existing data from the EHR systems as printouts is a preferred strategy for physicians to save time, compared to transcribing everything by hand. The design would consist of several features: a pop-up/plug-in window that floats aside the main EHR screen, allowing physicians to select and extract important information from the EHR systems, which may include vital signs or lab numbers, texts from previous notes, and move them into each sorted categories for a note taking printout.

The final prototype was sketched out, using low-fi drawings with multiple sticky notes and small cutouts to explain and go through user scenarios with the physicians, to test its usability, and to observe how future users might interact with the final design. (figure 19., 20.)

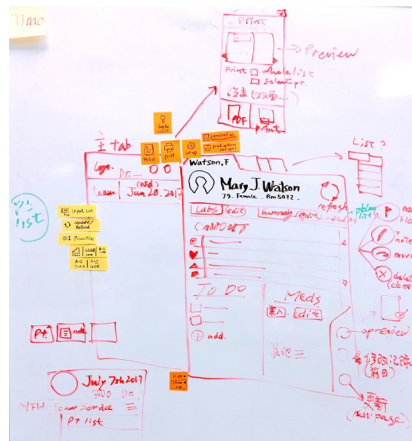


Figure 19. Wireframe prototype for deciding setups for the function tabs

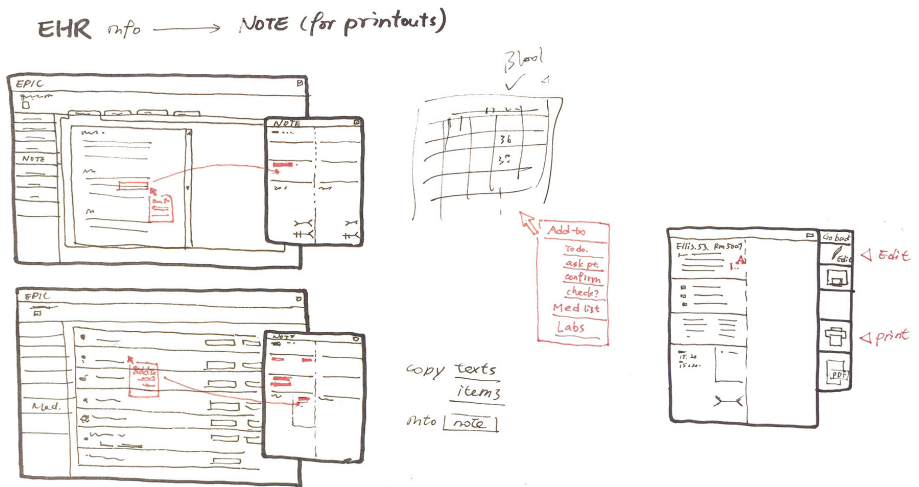


Figure 20. Sketches showing how the design functions and operates

Based on the research conducted, I finalized some design principles for the note taking tool.

### Design principles

1. Change the nature of first-level data copying tasks—to decrease time spent recopying patient data to notes and lists, and increase time spent in direct patient care activities, and later note taking
2. Facilitate transition of information for physicians by organizing patient information and forwarding clinical data from hospital information systems to improve workflow efficiency
3. Improve patient care by providing a flexible, yet organized system for prioritized patient information to enhance handover/sign-out communication quality



# Final Design

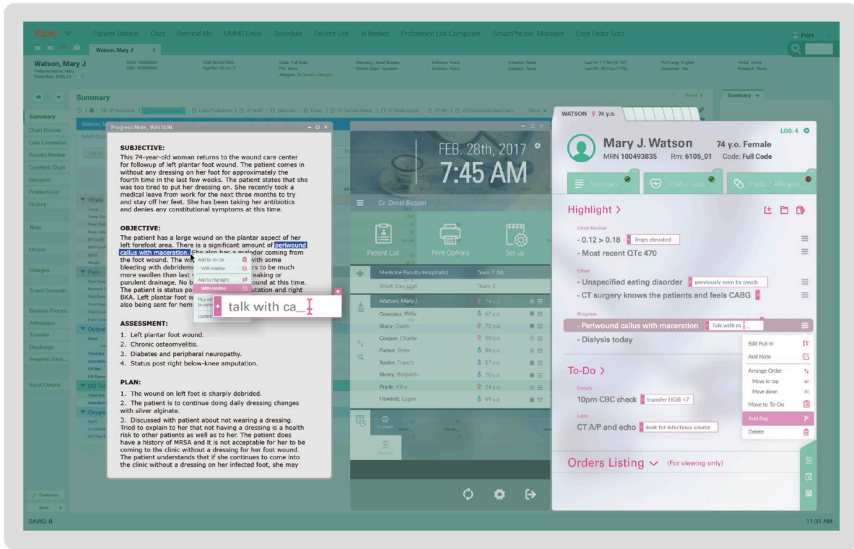


Figure 21. The digital interface when in use with EHR system

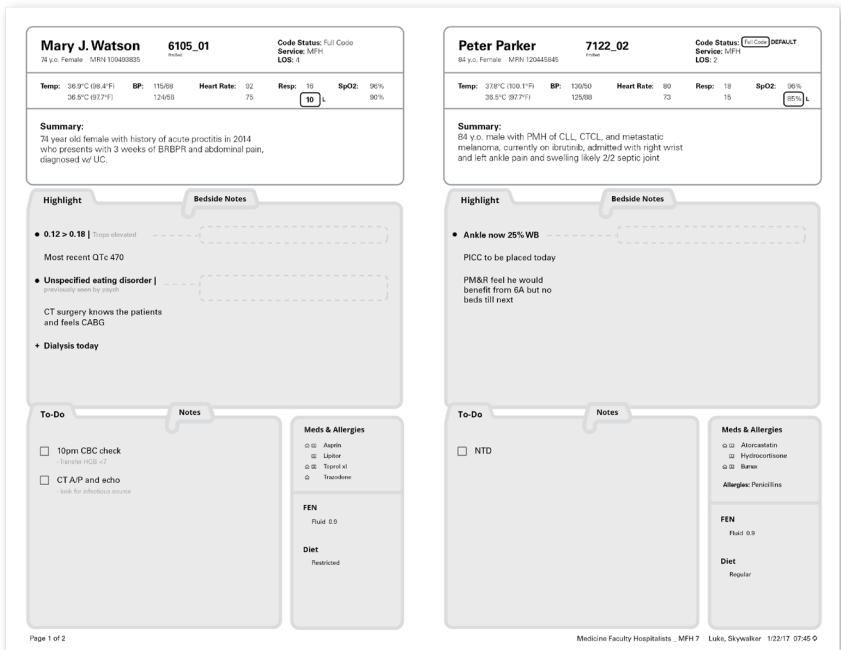


Figure 22. Printout patient sheet for note taking (letter size, two patients per page)

## User Scenario



### Review EHR, Select Highlights & Print

During the EHR review at the start of a shift, a physician can select important text or data from a patient's record to send to a *Patient Information Sheet*. Selections can be filed under one of two categories—*Highlight* or *To-Do*—with added notations as needed. Once the review is complete, the physician can print the custom *Patient Information Sheet* to bring with them on rounds.

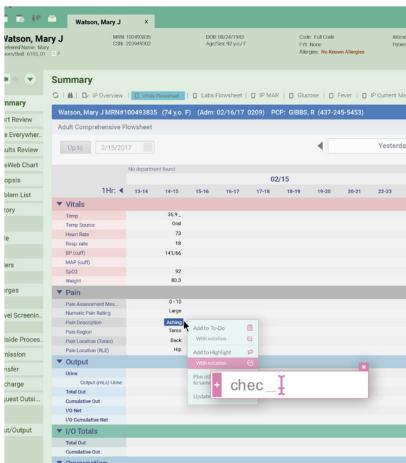


Figure 23. Selecting from lab results

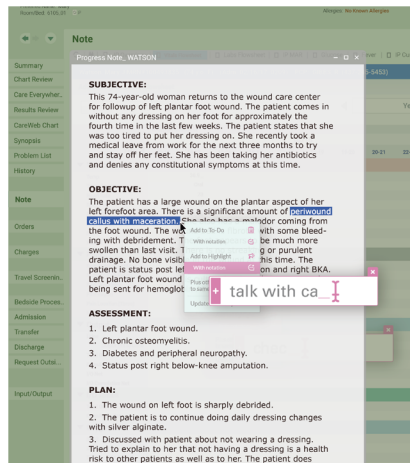
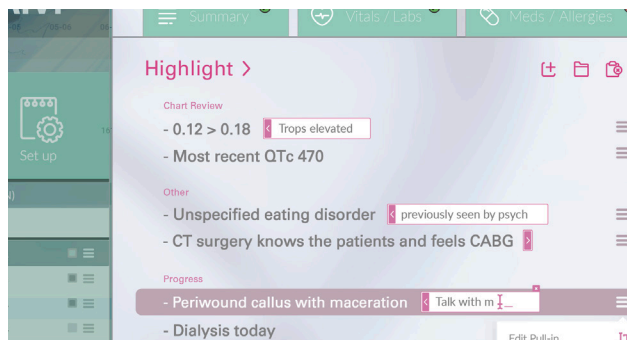


Figure 24. Selecting from progress note

Figure 25. Selected and noted items will be populated into the sorted categories in the main tab, which can be reorganized and noted once again before printing





## Bedside Visit Notes

The *Patient Information Sheet* becomes a useful note-taking tool for the physicians during rounds to patient rooms. The open space adjacent to the *Highlight* area can be used for quick jotting, sketching, revised to-do items or any other updated information that needs to be considered.

<b>Mary J. Watson</b>		<b>6105_01</b>	<b>Code Status:</b> Full Code	
74 y.o. Female    MRN 100493835		<small>11/20/2014</small>	<b>Service:</b> MFH	
			<b>LOS:</b> 4	
<b>Temp:</b> 36.9°C (98.4°F)	<b>BP:</b> 115/68	<b>Heart Rate:</b> 92	<b>Resp:</b> 16	<b>SpO2:</b> 96%
36.5°C (97.7°F)	124/58	75	12 L	90%
<b>Summary:</b> 74 year old female with history of acute proctitis in 2014 who presents with 3 weeks of BRBPR and abdominal pain, diagnosed w/ UC.				

(left)  
Upper patient information tab can be customized, where crucial numbers and texts can be pulled directly from EHR

**Highlight**

- **0.12 > 0.18** | TropS elevated  
Most recent QTc 470
- **Unspecified eating disorder** |  
previously seen by psych
- CT surgery knows the patients and feels CABG
- + **Dialysis today**

**Bedside Notes**

(left)  
Bedside note and additional updates addressing the highlighted items can be written in the blank space besides

**To-Do**

- 10pm CBC check  
- Transfer HGB <7
- CT A/P and echo  
- look for infectious source

**Notes**

(left)  
To-do items or reminders can be added to this box

(right)  
Medications, and additional information are pulled from the EHR to the lower right box

**Meds & Allergies**

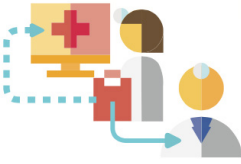
- Aspirin
- Lipitor
- Toprol xl
- Trazodone

---

**FEN**  
Fluid 0.9

---

**Diet**  
Restricted



## Input Updates to EHR

After rounds and meetings with other practitioners, the *Patient Information Sheet* serves as a thorough documentation (Figure 26.) for physicians and creates understanding of each patient. Physicians can use the information captured for finishing remaining tasks and submitting daily progress notes.

The Patient Information Sheet can then be potentially used as a sign-out/handover tool for the physician teams.

**Mary J. Watson**      **6105\_01**

74 y.o. Female    MRN 100493835

Code Status: Full Code  
Service: MFH  
LOS: 4

<b>Temp:</b> 36.9°C (98.4°F)	<b>BP:</b> 115/68	<b>Heart Rate:</b> 92	<b>Resp:</b> 16	<b>SpO2:</b> 96%
36.5°C (97.7°F)	124/58	75	<span style="border: 1px solid black; padding: 2px;">10</span> L	90%

**Summary:**  
74 year old female with history of acute proctitis in 2014 who presents with 3 weeks of BRBPR and abdominal pain, diagnosed w/ UC.

**Highlight**

- **0.12 > 0.18** | Trophs elevated
- Most recent QTc 470
- **Unspecified eating disorder** | previously seen by psych
- CT surgery knows the patients and feels CABG
- + Dialysis today

**Bedside Notes**

138 / 103 / 16  
4.5 / 27 / .96

- generalized weakness
- Urinary incontin + Frequency
- Asymmetric exam + Facial
- ↳ old stroke
- Altered -
- UTI
- CT head Neg on RA

**To-Do**

- 10pm CBC check - Transfer HGS <7
- CT AP and echo - look for infectious source
- Psych
- Social work
- DC Proton
- CXR
- DC code status

**Notes**

Fed in bathroom

- Philex 400mg + RA

Social

- live w/ son + live at - 4 pm

Family

Mass

- humira / play a week

**Meds & Allergies**

- Aspirin
- Lipitor
- Toprol xl
- Trazodone

**FEN**

Fluid 0.9

**Diet**

Restricted

Page 1 of 2

Figure 26.

## Design evaluation

Computers should enable clinicians to capture narratives easily, yet EHR somehow hasn't achieved that yet. From all the post-interviews with clinicians, it is important to understand the difficulty to design a set that fit all patients or patients with certain diagnosis, because patients are very different, and it's hard to put their narrative into a standard set of box or modules/templates. Even if we designed a very crafted set of formats for each diagnosis, we wouldn't necessarily achieve 100% clarity and succinctness. Any attempt to make it a highly-structured set of categories awaiting to be filled out might just fall into many of the design intents we now find in EHR systems.

Conversations with a primary participant (a physician at MFH service) after the final iteration of the design showed that the participant is greatly interested and asked if the project will continue towards becoming a functional model. "I think I will give it a shot if it's a real thing," commented by Dr. Chiang, whose note-taking model was really the main inspiration for the project's final design. For some other physicians, the willingness to tryout a system like this is mixed; one physician pointed out that, "I would give it a try, because I think it looks very user friendly and anything that might make our life a little easier I'm willing to give it a try... but mostly it's because I'm young." In fact, all that showed disinterest in using this model mentioned that they've already developed a system that suits well with their workflow, and adapting to a new system might just take them longer to get used to. Dr. David Bozaan, this project's main stakeholder and a practicing physician, suggested the possibility of making it available for portable-devices. He highlighted the fact that many physicians now use their phones or tablets to review patient data, and features allowing them to easily extract EHR data and take notes would be equally useful. Although studies<sup>94</sup> have shown that people continue to prefer paper

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94. Oviatt, S., Arthur, A., Cohen, J., 2006 "Quiet interfaces that help students think." *Proceedings of the 19th annual ACM symposium on User interface software and technology*. pp. 191-200

compared to writing on a digital tool, an interesting study<sup>95</sup> done in teaching settings with children by Hammond et al. suggests that digital touch-screens might retain the similar cognitive value and provide more visual and haptic feedback by simulating the feedback we receive from writing, namely technologies like WACOM tablet or Livescribe pen.

Overall, most respondents, as well as some teaching faculty, suggested that this would be a great tool for young professionals (residents or interns) and medical students. And as predicted, interviews that were conducted with the residents do show that the potential of the tool lies with healthcare beginners and younger clinicians, which had not yet developed a strong habit. All six members in a resident team said they're willing to use the tool when inquired.

Nurses gave a very positive feedback on this tool, in particular on the proposed function of making modifications on the layout. Since this current design isn't directly targeted for nursing usage, and from the observations nurses do practice handwritten note-taking more rigorously than all other disciplines, an interface/printout design specifically modeled for nurses is a goal worth further development.

As for using the written printout as a handoff tool, the majority of the clinicians see potentials in the printout tool, since similar paper tools are used in current environments across systems. A few physicians pointed out that if they knew ahead that this would be used as a handover tool, the documentation, whether pulling data, editing to-dos, or filling out written notes, would be done more carefully and considerately. "I would go back to the app and edit mine (patient sheet), and then print it out for the next person," a physician stated. During the observation, it is not uncommon to see a strong overlap between note-taking artifacts and handover tools. On many occasions, the artifact directly serves as a handover tool after it has achieved

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95. Mann, Ann-Marie, Uta Hinrichs, Aaron Quigley, 2016 "Revolutionizing Education with Digital Ink: The Impact of Pen and Touch Technology on Education" Cham: Springer International Publishing, Chapter 2., pp.7-22

its initial purpose— to retain clinicians’ working memory. This is an interesting area to be further explored; however, our project and delivered solution has not focused on this particular potentiality, and more studies on this would be required if the current design (printout patient sheet) were to be used as a proper handover tool.

During my last conversation and sharing of the project with Dr. Robert Lash, physician and professor who also serves as the Chief of Staff in the *Office of Clinical Affairs* (OCA) at University of Michigan Hospital and Health Center, not only did he like the design solution and appreciate the retained handwritten quality, but also decided to share the project with the *House Officer Quality & Safety Committee* (HOQSC), a multidisciplinary, resident-led committee focused on improving clinical care across UMHS, on potential future development.

It has been proven to be possible to implement homegrown systems to existing EHRs that extend the EHRs’ functionality —such as the case at the University of Washington Hospital by introducing its own EHR app —UWCores, a physician rounding and handover system, to its Cerner system. Improved physician work efficiency was found following implementation of the tool,<sup>96</sup> as self-reported time spent on hand-copying patient information was reduced by 50%. It is safe to say that frontline clinicians and their user experience are, and will be the direct driven force of future EHR improvements.

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96. Van Eaton, Erik G., et al. “A randomized, controlled trial evaluating the impact of a computerized rounding and sign-out system on continuity of care and resident work hours.” *Journal of the American College of Surgeons* 200.4 (2005): 538-545.



# DISCUSSION

## Project Discussion

At first glance, this project aims at finding a successful design solution to current EHR challenges. Despite the design haven't been realized in the real clinical setting, many respondents seem to agree that it managed to achieve better documentation workflow by discovering and highlighting some of the existing practices that were not regarded as comparable solutions at the present state.





The design, although comprised of two interfaces— the digital add-on and its generated printout— has its primary intended goal to serve as a “transitional artifact” that aids and eases physicians’ memory workload. As mentioned by Chen,<sup>97</sup> despite the value and cruciality of these artifacts, the disconnection between them and the EHR has more or less increased clinicians’ workload; it specifically calls out for design opportunities that support this transitional clinical documentation. This

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97. Chen, Yunan. 2010 “Documenting Transitional Information in EMR

project offered an alternative solution for physicians to reduce time by swiftly extracting useful information from the EHR, along with adding personal feedback on highlighted information and categorizing these callouts into current (**highlights**) or future work (**To-Do**), all within the same task and on the same interface. The generated printout serves as the “transitional artifact,” then allows physicians to address or cross out, as well as add further comments or reminders to the information or notes that were carried on the sheet.

This process of using the artifact, although not clearly specified or standardized, holds the same if not greater value for physicians in between the review and later documentation point on EHR. We recognize that any supposition will need to be validated through further study; but the intent for the intervention successfully bridges the gap between current physicians’ workflow and their use of EHR. As Park et al. mentioned in their study<sup>98</sup> on informal documentation in clinical settings, the informal documentation and note taking as a method is not commonly considered as an essential component of medical practice, as evidenced by the fact that features to support this informal documentation are not included in current EHR systems.

The design received positive feedback from most of the participants and stakeholders within a very limited timeframe, while enough feedback was gathered to make further changes and iterations. There are also many institutional and technical difficulties that need to be solved if this project were to find a way to be realized, such as the intergenerational feeling towards the tool and reservation from the administrative level or government regulations. One of the most valuable qualities about taking handwritten notes is the freedom it gives to writers. A huge revelation for designers when attempting to create a standardized or universal solution is that despite having the same diagnosis and similar background, each patient is fundamentally

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98. Park, S.Y. et al. (2013). “Local-universality”

different and shouldn't be completely generalized in categorized forms. The design of this note-taking tool is finding that fine line between providing an organizational guidance without confining physicians' freedom to be narrative and intuitive.

## Risk and Limitation

As Levin et al. introduced the difference between “wicked problems” and “super wicked problems,” one of the items is “Those seeking to solve the problem are also causing it.”<sup>99</sup> The scope of this project expands beyond simply health IT, or user interface design, as the project progressed and as research went in deeper. To be able to untangle the problem of current clinical records in their digital form, we need to understand the history of clinical documentations, and the background of medical knowledge and a general knowledge of physicians' practice. This project also touches on subjects like human behavior and neuroscience. I faced strong difficulties with this project, due to the lack of medical proficiency. Being a non-clinically trained and non-healthcare affiliated individual that enters a field that is highly professional and regulated, this project can only achieve a certain level of proximity and reflect the closest reality. Under the HIPAA patient privacy protection, gathering patient records, understanding and analyzing of the data were also limited, many of the artifacts were either impossible to obtain, due to the privacy protection, or difficult to interpret, due to the intricate and abstruse character of the data.

Under an academic timeline, the time limitation also pose insufficient research depth and not enough design evaluation and further modification. As more solid feedback only starts to appear after a more refined design solution has been presented, and actual user testing

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99. Levin, Kelly, et al. “Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change.” *Policy Sciences* 45.2 (2012): 123-152.

could take longer to initiate, it is clear that this project is not entirely evaluated.

Furthermore, at the current stage, it would be difficult to assess the level of interest across UMHS/Michigan Medicine, other correspondents and stakeholders. Having this project as a functional system would require much more involvement from hospitals across all levels than just some positive feedback.

...and cost-effective, yet we are now facing new challenges created by the growing reliance on EHRs.

...this project looks at how physicians capture and communicate patient information and proposes a hybrid design solution that integrates the efficiency and accuracy of electronic health records with the cognitive benefits of handwritten bedside notes.

"I think handwritten notes are going away anytime soon." — Dr. Paul Grant

**The Hidden Benefits of Handwritten Notes**  
 The cognitive processes associated with handwritten note taking have been repeatedly shown to be effective in a number of learning, information processing, and memory recall scenarios. With the flexibility to arrange items or add graphic cues or drawings, bedside notes can capture subtle nuances and higher-level details about patient needs.

**Proposed Design Solution**  
 The proposed design solution integrates the benefits of capturing patient information by hand in a way that supports and complements the EHR system.

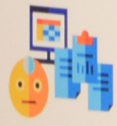


**Electronic Health Records**

EHRs are a complex accumulation of information including past medical history, prescriptions, test results and images from examinations, as well as an ever-growing archive of note entries from doctors and other care team clinicians.

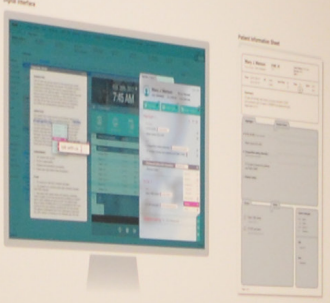
A patient's EHR is referred to and updated multiple times during the day by several different members of the care team.

- BENEFITS**
- Practice Efficiencies & Cost Savings**  
 Quick access to patient records from registries and remote locations for more coordinated, efficient care. Reduced transcription costs, chart pull, storage and paperwork.
  - Interoperability**  
 Providers have accurate and up-to-date information about patients and can easily exchange data and enhance communication with other clinicians, labs and health systems.
  - Automation**  
 Auto-generation, auto-population, copy and paste, function save time.
  - Legibility & Accuracy**  
 Legible, complete documentation facilitates accurate coding and billing, clinical alerts and minimizes subsequent diagnosis and prescription decisions.



**KEY PROBLEM "Note-bleed"**

EHR features like auto-generation can lead to unnecessary data. Copying and pasting saves time, but can create redundancy. All of this adds up to an excessive amount of information that needs to be shared and understood. Physicians now have more available data but spend a significant amount of time reviewing previous notes, preventing, storing and finding information. The more time spent on record keeping, the less time physicians can spend treating patients.



**Doctors Spend 49.2% of Their Work Day on EHRs**



- Review EHR, Select Highlights & Print**  
 During the EHR review at the start of a shift, a physician can select important text or data from a patient's record to send to a **Patient Information Sheet**. Selections can be filed under one of two categories — **Highlight or To-Do** — with added notations as needed. Once the review is complete, the physician can print the custom Patient Information Sheet to bring with them on rounds.
- Bedside Visit Notes**  
 The **Patient Information Sheet** becomes a useful note-taking tool for physicians during rounds in patient rooms. The open **Highlight** area can be used for quick printing, sketching, or any other updated information that needs to be shared.
- Input Updates to EHR & Handover**  
 After rounds and meetings with patients, a physician can update the **Patient Information Sheet** across a thorough review of each patient. Physicians can also use the remaining space and additional notes to capture information that needs to be shared in a handover.

# CONCLUSION & FUTURE WORK

## Conclusion

We as humans adapt and embrace new technology and tools, and the good and bad they bring along, just as we embrace the EHR. "Humans are the reproductive organs of technology," as Kelly<sup>100</sup> famously said, he argued that banning technology never works, while being honest about the trade-off: The greater the promise of a new technology,

100. Kelly, Kevin. *What technology Wants*. London: Penguin, 2011., 246

the greater its potential for harm as well. The project sought to advocate for the less perceived value of handwriting methods and artifacts used in a clinical setting, and offered a solution by integrating traditional and new technologies that retain benefits from both sides and complement each other. In Carr's book<sup>101</sup> which he discussed how automation is affecting our ability to solve problems, forge memories and acquire skills, he stated "If we're not careful, the automation of mental labor, by changing the nature and focus of intellectual endeavor, may end up eroding one of the foundations of culture itself: our desire to understand the world." The problem with EHR is essentially a very humanistic and behavioral problem with no definitive best solutions, but keeping mindful of the unperceptive value and the evergrowing depreciation of these "desirable difficulties," as well as the advantages technology can bring, will ensure a more comprehensive and proportionate development of future EHRs.

From extensive and long hours of observation and conversation with clinicians, I, as a designer and design researcher, approached this problem first not as a solution provider, but as a problem seeker. In the end, the project not only seeks the middle ground between old and new technologies, it also offers a new potential for other disciplines, within or outside the healthcare field, that face a similar nature of jobs or tasks, which are amid a digital transition. It offers a new way to look into cross-disciplinary collaboration on solving highly situational and complex problems that dealt with human behavior, and a new perspective to reexamine the impact of digitization and technology's role in our life.

From a design standpoint, it is important to note that the fundamental core value of the project is not to provide a solution in and of itself, but to strengthen the less or imperceptible value of the role of the "transitional artifact" and the handwriting element that coincides with

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101. Carr, Nicholas G. *The Glass Cage: How Our Computers Are Changing Us*. New York: W. W. Norton & Company, 2015.

it. The solution shouldn't necessarily be limited to paper form; instead, digital tools that allow humans to perform the same 'motor movement' when writing, such as a touch screen, a tablet or phone screen interface, all have a high potential in substituting the traditional paper and pen. As mentioned previously, the designed tool as a note-taking artifact is to be used mainly from the point it is generated and printed out; its integration with EHR during reviewing time serves as a major attraction to clinicians as a result of its efficient design; its succeeding use and potential as a handover tool is another area to be researched in the future.

## Future Work

Future work can be conducted by setting up short term and long term goals. Short term goals would include making more design changes based on current feedback, and could also involve getting feedback from and doing more user-testing with nurses, as more designed tools and an overall openness towards trying new tools were found among nurses. If applicable, an interface would then need to be specifically designed for nurses' practice. As previously noted that residents and doctors in training are much-targeted potential users, more research and conversations with residents and medical students would be beneficial for further development.

As this project becomes more finalized, getting insights from across management level in hospital systems and evaluating implementation challenges should be the next steps. The long-term goal would be to seek out implementing opportunities, as working towards it would potentially provide more insights on the problem of humanity, cognition, texture, and individuality within ubiquitous digital systems. In their book "Are We Human?" Colomina and Wigley offer a quick

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102. Colomina, Beatriz, and Mark Wigley. "Are We Human?: Notes on an Archaeology of Design." Zurich: Lars Müller Publishers, 2016, 76

history of design to argue its pursuit of numbness was no accident: “Design was formed as a way to deal with the increasingly dominant logic of the industrialized and globalized world while resisting the perceived dehumanizing impact of the world.”<sup>102</sup> The designers’ role should always be to first understand the nature of human behavior before finding what is technologically feasible, as theories of the post-digital suggest, computer systems are great for some things and unacceptable for others.



Figure 27. MDes Graduate Thesis Exhibition



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# Appendices

## *Meaningful Use Stage 1*

**CORE:** *Must do all*

- USE CPOE (Computerized physician  
-order entry)  
e-Prescribing  
Drug-drug/drug allergy checks  
Medication list  
Problem list  
Decision support

- RECORD Demographics  
Smoking status  
Vital signs
- Clinical summaries to patient  
Electronic exchange  
Health info to patients  
Protect health information

**MENU:** *Must do FIVE*

- Incorporate Clinical labs  
Medication reconciliation  
Implement drug-formulary checks  
Generate patient list  
Patient electronic access  
Follow-up reminder  
Patient-specific education  
Clinical summaries to provider

- Immunization registry  
Biosurveillance

*1 of the 5 must be 1 of these*

Appendix a.

## *Meaningful Use Stage 2*

**CORE:** *Must do all*

- USE CPOE  
e-Prescribing  
Decision support  
Medication reconciliation

- RECORD Demographics  
Smoking screening  
Vital signs  
Lab values
- Generate patient lists  
Clinical summaries to patient  
Follow-up reminders  
Patient view, transmit, download  
Patient education  
Patient email  
Immunization  
Care transitions  
Protect health information

**MENU:** *Must do THREE*

- Incorporate imaging  
Family history  
Public health surveillance  
Cancer registry  
Other registries

**REPORT: 12 Clinical Metrics**

*3 options for reporting 12 measures*

**Option 1**

Choose at least 1 measure  
from 6 categories

**Option 2**

Submit 11 "Core" measures  
plus one additional measure

**Option 3**

Submit PQRI measures

Appendix b.



